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Take this Supplement to San Antonio and use it as a guide to the Free Communications Sessions

Dear NATA Members and Friends:

We are pleased to present the annual *Supplement* to the *Journal of Athletic Training*. This Supplement contains abstracts presented at the 2009 NATA Annual Meeting & Clinical Symposia as part of the NATA Foundation Free Communications Program.

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

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

Support from NATA members, corporations, and other affiliated groups make this supplement and all of the Foundation's programs possible. Please note projects funded by the NATA Foundation and by the generous contributions of our donors are specified in this Supplement. To make an investment in the future of the profession, please contact the Foundation today at 800-TRY-NATA, extension 142. NATA and its Foundation are pleased to offer this supplement as a service to NATA members. We hope that it provides theoretical and practical information you can use to improve your effectiveness as a certified athletic trainer. Thank you for your support!

Sincerely,



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



Marjorie J. Albohm, MS, ATC
President, NATA

Dear Colleagues:

We have now gone through our 2nd year of online abstract submission process and Student Exchange Track to our Peer Review Track. We appreciate the authors support of these two programs. We hope to continue to improve the process and make it more transparent. We want to acknowledge a special thank you to the NATA Foundation staff of Patsy Brown, Velma Meza, and John Oliver, CAE, CFRE whose attention to detail and dedication has again made this year go so well. As many of you all know John will be retiring only July 31, 2009. He has been invaluable to the Foundation and will be missed. We look forward to the guidance Teresa Foster-Welch, CAE will provide and welcome her input to our program. We hope each of you finds something new in this year's Free Communications Program and *Supplement*. We had another great year of submissions, providing the latest in athletic training research and case studies that address many of the challenges of clinical practice. To all who participate, thank you!

Several individuals have worked very hard to review submissions, schedule presentations, and produce this *Supplement*. We would like to take this opportunity to thank and recognize the efforts of Karrie Hamstra-Wright, PhD, ATC; Lisa Jutte, PhD, ATC; Tom Kaminski, EdD, ATC; Darin Padua, PhD, ATC; Kim Peer, EdD, LAT, ATC; William Pitney, EdD, ATC; Brian Ragan, PhD, ATC; Susan Saliba PhD, ATC, PT; Stephen Straub, PhD, ATC; Erik Swartz, PhD, ATC; and Susan Walker-Yeargin, PhD, ATC, for their long hours of abstract reviews and preparation for the Free Communications programming. Finally, thank you to Leslie Neistadt and the staff at the editorial office of the *Journal of Athletic Training*.

We look forward to our meeting in San Antonio. Please take the opportunity to attend the Free Communications Peer Review Track, case studies, poster sessions, evidenced-based forums, and Student Exchange Track poster presentations. Please note that projects funded by the NATA Foundation are specified in this *Supplement*. Finally, if you have the opportunity, offer your thanks to those recognized above.

Sincerely,



Tom Dompier PhD ATC
Co-Vice Chairs for Free Communications
NATA Research & Education Foundation Research Committee



Tim L. Uhl, PhD, ATC, PT, FNATA

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**The New Investigator Award
Presented in Honor of Freddie H. Fu, MD
Sponsored by University of Pittsburgh
Medical Center**

**J. Troy Blackburn, PhD, ATC
University of North Carolina at Chapel Hill**

For J. Troy Blackburn, PhD, ATC, what was supposed to be an exciting high school ski trip became an introduction to world of athletic training when a knee injury cut his skiing experience short. While recovering from his injury, Blackburn began his involvement in the sports medicine field through physical therapy. He also began volunteering in the sports medicine field, and it was his volunteer experiences, in addition to his interest in simply learning more about rehabilitation in general, that further increased his desire to have a career in the athletic training profession.

Blackburn earned his bachelor of arts degree in exercise and sports science with a specialization in athletic training from the University of North Carolina at Chapel Hill. He received a master of science degree in sports medicine/athletic training from the University of Pittsburgh and returned to the University of North Carolina at Chapel Hill to earn his PhD in human movement science with a specialization in biomechanics.

Blackburn currently serves as the Director of the Neuromuscular Research Laboratory at the University of North Carolina at Chapel Hill and is also an assistant professor, teaching courses in “Research in Exercise and Sport Science” and “Neuromuscular Control and Learning.” Blackburn enjoys his teaching responsibilities because they allow him to witness his students grasp the concepts that he teaches.

Blackburn’s research focuses on the prevention of joint instability, and he hopes to identify factors that cause injuries and determine if those factors can be changed. His interest in joint stability began when he noticed that he and his athletic training peers treated many joint injuries, and he began wondering what could be done to *prevent* joint injuries. Ultimately, Blackburn’s goal is to use basic science to figure out what things contribute to joint instability and reduce injury risk.

Outside of the lab, Blackburn reviews manuscripts and grants and acts as a guest lecturer. His work has been published in *Clinical Biomechanics*, the *Journal of Athletic Training*, and the *Journal of Electromyography and Kinesiology*. In addition to reviewing grants for the NATA Research & Education Foundation, Blackburn has reviewed for several publications, including the *Journal of Biomechanics*, the *Journal of Sport Rehabilitation*, and the *Journal of Sports Sciences*.

Blackburn credits Bryan Riemann, PhD, ATC; Joe Myers, PhD, ATC; Darin Padua, PhD, ATC; and Kevin Guskiewicz, PhD, ATC, as being influential in helping to shape his athletic training career. Blackburn would also like to thank his wife, Sara, for supporting his career.



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 Orthopedic 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**

**Patrick O. McKeon, PhD, ATC, CSCS
University of Kentucky**

“On my honor, I will do my best.” Words taken from the Eagle Scout oath and words Patrick McKeon, PhD, ATC, CSCS, recipient of the 2009 Doctoral Dissertation Award, says influenced him throughout his career. Looking back, receiving the Eagle Scout Award at the age of 18 was one of the highlights of his life. This achievement spurred his dedication to and enthusiasm for his work and research in sports medicine.

McKeon’s interest in sports medicine began in high school. His athletic trainer, Scott Ellis, MS, ATC, encouraged him to take a sports medicine class for high school students interested in athletic training, an outreach program provided by a local hospital. From there, Ellis urged him to pursue a bachelor’s degree in athletic training and McKeon’s baseball coach, a Springfield College graduate, persuaded him to check out his alma mater’s athletic training program.

McKeon has come a long way from that high school teenager who developed a fascination for sports medicine. He earned his bachelor’s degree from Springfield College, his master’s from the Arizona School of Health Sciences, and his doctorate in sports medicine from the University of Virginia.

As his primary research interest, McKeon examines sensorimotor alterations associated with chronic ankle instability. He uses a novel theory of motor control, the dynamic systems theory, to explore, understand, and explain these alterations. McKeon is continuing with his research by examining how postural control relates to lower extremity injury risk in high school athletes, a project he is pursuing in conjunction with his wife, Jennifer Medina McKeon, PhD, ATC, and Phillip Gribble, PhD, ATC.

Currently, McKeon is an assistant professor in the Division of Athletic Training at the University of Kentucky. He is also a reviewer for the *Journal of Athletic Training* and on the Editorial Boards for the *Journal of Sport Rehabilitation* and *Athletic Training & Sports Health Care*. He is affiliated with the National Athletic Trainers’ Association, American College of Sports Medicine, and National Strength and Conditioning Association.

McKeon is grateful for sharing his life with his best friend, who is also his most influential colleague, his wife Jennifer. He thanks his parents, Owen and Marie, and his family and friends for their inspiration, love, and support throughout his academic and research endeavors. McKeon gives special thanks to his doctoral mentor, Jay Hertel, PhD, ATC, for his insight and guidance throughout his doctoral experience. He also credits many other people for mentoring him and influencing him throughout his career, including Scott Ellis, MS, ATC; Mary Barnum, EdD, ATC; Charles Redmond, MED, MSPT, ATC; Jackie Kingma, MS, ATC, PA-C, PT; Eric Sauers, PhD, ATC; and Peter Koehneke, MS, ATC. In addition, McKeon thanks his doctoral committee for their leadership and direction.

“I am truly honored to receive this award and thankful to all the mentors, friends, and colleagues who have influenced who I am and where I am now,” McKeon exclaims, “Being recognized by my peers as doing good work means the most to me.”



David H. Perrin, PhD, ATC

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.

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

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

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

Free Communications, Oral Presentations: Youth & Adolescent Injuries

Thursday, June 18, 2009, 8:15AM-9:15AM, Room 214A; Moderator: Mary J. Barron, PhD, ATC

Deficits In Health-Related Quality Of Life Following Sport-Related Musculoskeletal Injury In Adolescent Athletes

Bay RC, Snyder AR, Parsons JT, Sauers EL, Valovich McLeod TC: A.T. Still University, Mesa, AZ

Context: Measures of health-related quality of life (HRQOL) assess physical, psychological, and social domains of health. This global view considers the whole-person, extending beyond physiological and psychosocial components of health by addressing patients' disability and societal limitations. HRQOL is a patient-oriented outcome that may be altered by sport-related injury, and may influence recovery.

Objective: To examine HRQOL in adolescent athletes 3 and 10 days post-injury using the Medical Outcomes Short Form (SF-36) and the Pediatric Outcomes Data Collection Instrument (PDOCI).

Design: Cohort. **Setting:** Athletic Training Facilities. **Patients or Other Participants:** Convenience sample of injured adolescents ($n=41$ age= 15.7 ± 1.2) participating in interscholastic athletics.

Interventions: Athletes completed the SF-36, and PODOI on days 3 (D3) and 10 (D10) post-injury. Reliability of the SF-36 subscales in the general population has been estimated as 0.84-0.95; PODOI subscale reliability coefficients range from 0.76-0.97. Single-sample t-tests ($\alpha=0.05$, two-tailed) were used to test differences in subscale scores between sample means and published normative values at D3 and D10. Wilcoxon Signed-Ranks test ($\alpha=0.05$, two-tailed) were used to test changes in patient self-report scores over time. **Main Outcome Measures:** Eight subscales (Physical Functioning-PF, Role Physical-RP, Bodily Pain-BP, General Health-GH, Vitality-VT, Social Functioning-SF, Role Emotional-RE, Mental Health-MH) and two composite scales (Physical Composite Score-PCS, Mental Composite Score-MCS) of the SF-36; five subscales (Upper Extremity/Physical Functioning-UE/PF, Transfer-TR, Sports-S, Pain/Comfort-PC, Happiness-H) and one global scale of the PODOI. **Results:** Scores are expressed in standard deviation units (effect size) relative to published normative values. (One SD = 10 points on the SF-36 and between 4 and 17 points on the PODOI.) On D3, athletes scored significantly below population normative means on 5 of 8 SF-36 subscales: PF -1.1, RP -1.0, BP -1.2, SF -0.8, RE -0.6 and the PCS, -1.0 (all $p<0.005$). On D10 post-injury, these scores remained significantly below normative means: PF -0.5, RP -0.8, BP -0.4, SF -0.4, RE

-0.5, PCS -0.4 (all $p<0.02$). However, on D10, scores on PF, BP, VT, SF and PCS increased significantly from D3 (all $p<0.05$). On D3, athletes scored significantly below the standardized population means on 3 of the 5 PODOI subscales: TR -2.9, S -3.0, PC -2.5 and the global score, -3.2 (all $p<0.001$). At D10, scores remained significantly below normative means: TR -1.8, S -2.1, PC -1.8 and the global score, -2.2 (all $p<0.001$). By D10, all PODOI scores increased significantly from D3 (all $p<0.05$). **Conclusions:** The SF-36 and the PODOI measured deficits in HRQOL in athletes with sport-related injury across most subscales compared to normative values. They also reflected improvements in each of these subscales across a 7-day follow-up. Clinicians should incorporate these patient self-report measures to determine the impact of sport-related injury on HRQOL.

A Comparison Of Health-Related Quality Of Life Between Male And Female Adolescent Athletes

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

Context: Health-related quality of life (HRQOL) is an important patient-oriented outcome necessary for providing whole person healthcare; however, little is known about the HRQOL of adolescent athletes and whether differences exist between males and females. Better understanding of HRQOL in adolescents may increase our appreciation of the impact of events, such as injury, on overall health status and ultimately assist in providing appropriate comprehensive healthcare to these individuals. Differences between males and females would suggest the need to consider these individuals differently during injury evaluation and management. **Objective:** To determine whether the HRQOL of male and female adolescent athletes differs as evaluated with the Medical Outcomes Short Form (SF-36) and Pediatric Outcomes Data Collection Instrument (PODOI). **Design:** Cross sectional. **Setting:** High school classrooms and athletic training facilities. **Patients or Other Participants:** Convenience sample of male ($n=98$, age= 15.8 ± 1.2 , grade= 10.6 ± 1.1) and female ($n=121$, age= 16.1 ± 1.0 , grade= 11.0 ± 0.9) adolescent athletes participating in interscholastic athletics. **Interventions:** The independent variable was sex. All subjects individually completed a health status questionnaire, SF-36, and PODOI during a single testing period. The reliability of the

SF-36 in the general population has been reported as .84-.95 and the PODOI subscale reliability coefficients range from .76-.97. All analyses were exploratory and no adjustments for multiplicity were made. The Kolmogorov-Smirnov test ($p<0.05$) was run to determine the normality of the data. Pairwise tests [Mann-Whitney U (test of mean ranks); $p<0.05$] were conducted to identify gender differences and are reported as p-value, mean $\pm$ standard deviation. **Main Outcome Measures:** Dependent variables included 8 subscale scores of the SF-36 [physical functioning (PF), role limitations due to physical health issues (RP), bodily pain (BP), general health perceptions (GH), vitality (VT), social functioning (SF), role limitations due to emotional problems (RE), and mental health (MH)], the two composite scores of the SF-36 [physical (PCS), mental (MCS)], the 5 subscale scores of the PODOI [upper extremity and physical functioning (UE), transfer and basic mobility (TBM), sports and physical functioning (SPF), pain/comfort (PC), happiness (HAP)] and the PODOI global score. **Results:** Male athletes demonstrated better HRQOL than female athletes on the SF-36 VT ($p=.035$, male= 53.2 ± 9.9 , female= 50.7 ± 9.4) and MCS ($p=.024$, male= 51.1 ± 8.8 , female= 48.5 ± 10.0) scores. Male athletes also demonstrated better HRQOL than female athletes on the PODOI HAP score ($p<.001$, male= 53.8 ± 8.9 , female= 49.8 ± 8.9). **Conclusions:** Male adolescent athletes scored higher on the vitality component and mental composite score of the SF-36 and happiness subscale on the PODOI, indicating a trend towards better overall health status in males than females. These findings were similar to previous studies that demonstrated higher HRQOL in males than females, both pre-injury and post-injury. Our results suggest that unique care for each sex should be considered during injury evaluation and management.

Adolescents Demonstrate Lower Spatiotemporal Postural Control Compared To Healthy Adults

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Context: Time-to-boundary (TTB) is a spatiotemporal measurement technique that has been shown to be effective in detecting postural control alterations. There is no evidence whether adolescents display similar TTB values as adults. **Objective:** To examine

postural control in adolescents and healthy adults using TTB measures. **Design:** Cross-sectional study. **Setting:** Research Laboratory. **Participants:** 64 healthy adolescents (30 males, 34 females, age: 15.52 ± 1.05 years, range: 13-17 years) participated. Inclusion criteria were no history of lower extremity injury in the past six weeks or history of balance disorders. A reference group of 50 healthy adults (25 males, 25 females, age: 25.38 ± 5.99 years, range: 18-45 years) was used for comparisons of postural control measures. **Intervention(s):** All subjects performed three, ten-second trials of barefoot single-limb stance on a forceplate with eyes open (EO) and eyes closed (EC) on their left limb. The mean of each measure for the three trials was used for analysis. **Main Outcome Measures:** The mean of TTB minima(s) and the standard deviation of TTB minima(s) in the mediolateral (ML) and anteroposterior (AP) directions were the dependent variables. The independent variables included group (adolescent, adult) and vision (EO, EC). Separate group by vision ANOVAs with repeated measures were used to compare each TTB variable. Post hoc Tukey HSD tests were calculated to explain any significant interactions. The alpha level was set *a priori* at $p \leq 0.05$. **Results:** Significant group by vision interactions were found for the mean of TTBML minima ($p < .001$), the mean of TTBAP minima ($p < .001$), the standard deviation of TTBML minima ($p = .02$), and the standard deviation of TTBAP ($p < .001$). For both groups, TTB-EO values were significantly higher than TTB-EC values ($p < 0.05$). For the mean of TTB minima, adolescents (TTBML-EO: 1.49 ± 0.45 s, TTBML-EC: 0.74 ± 0.22 s, TTBAP-EO: 4.48 ± 1.26 s, TTBAP-EC: 1.99 ± 0.56) performed significantly worse than adults (TTBML-EO: 2.93 ± 1.69 s, TTBML-EC: 1.46 ± 0.67 s, TTBAP-EO: 9.14 ± 4.37 s, TTBAP-EC: 4.06 ± 1.72 s) for EO and EC trials in both directions ($p < 0.05$). There were no differences between adolescent EO values and adult EC values in either direction. Similar significant differences were found between groups for the standard deviation of TTB minima where adolescents (TTBML-EO: 1.11 ± 0.48 s, TTBML-EC: 0.69 ± 0.37 s, TTBAP-EO: 2.75 ± 0.95 s, TTBAP-EC: 1.30 ± 0.49 s) performed significantly worse than adults (MLEO: 2.31 ± 1.72 s, MLEC: 1.40 ± 0.84 s, APEO: 5.57 ± 2.77 s, APEC: 2.68 ± 1.23 s) on all measures ($p < 0.05$). There were no differences between the adolescent EO values and adult EC values in either direction. **Conclusions:** Adolescents displayed significantly lower TTB magnitude and variability in the ML and AP directions compared to healthy adults. This suggests sensorimotor function may not

be fully developed until adulthood. The reduction in magnitude and variability of TTB minima indicated that the adolescent group had significantly less time and fewer strategies to make postural corrections compared to adults. Therefore, level of maturity appears to be a constraint on sensorimotor function.

The Influence of Leg Dominance And Quadriceps Dominance On Vertical Ground Reaction Forces In Adolescent Female And Male Athletes

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Context: A recent study by Myer et al. (2004) suggested that three neuromuscular imbalances in the lower extremity may place athletes, particularly female athletes, at greater risk of ACL injury. These authors went on to describe clinical methods to identify and correct leg dominance and quadriceps dominance. **Objective:** To determine the extent to which leg dominance, defined as side-to-side differences in quadriceps and hamstring isokinetic peak torque values of $\geq 20\%$, and quadriceps dominance, defined as hamstring-to-quadriceps ratios $\leq 60\%$, influence peak vertical ground reaction forces (GRF) during two-legged drop landings from 30.5 cm height, and two-legged drop landings followed by a maximum vertical jump. **Design:** Cohort design. **Setting:** Research laboratory. **Patients or Other Participants:** 35 high school female and male soccer and basketball players participated in this study (18 females, age = 16.1 ± 1.5 yrs, ht = 167.4 ± 6.3 cm, wt = 59.7 ± 5.3 kg; 17 males, age = 16.2 ± 1.3 yrs, ht = 180.3 ± 6.5 cm, wt = 77.5 ± 12.3 kg). **Interventions:** One 2 x 2 ANOVA, Sex (female vs. male) x Condition (two-legged drop landing vs. drop landing with maximum vertical jump) and two 2 x 2 x 2 ANOVAs, Sex x Condition x Group (leg/quadriceps dominant vs. not leg/quadriceps dominant). **Main Outcome Measures:** The primary outcome measure was peak vertical GRF measured at 200 Hz (3-trial average), normalized to kg/BW. Quadriceps and hamstring eccentric and concentric peak torque values and hamstring-to-quadriceps ratios were obtained with an isokinetic dynamometer set at 60 deg/s. **Results:** Using the previously defined criteria, 13 of 35 subjects (7 females, 6 males, 37%) were classified as having quadriceps dominance; 6 of 35 subjects (3 females, 3 males, 17%) were identified as having leg dominance. There were no significant sex differences between the peak vertical GRFs ground reaction forces ($P = 0.78$), nor were differences noted between those who were classified as leg dominant ($P = 0.62$) or quadriceps dominant ($P = 0.82$).

In every comparison, we found significantly higher vertical GRFs with 2-legged drop landings (57.9 ± 14.5 N/kg) than with drop landings followed by a maximum vertical jump (44.9 ± 14.9 N/kg) ($P < .001$). **Conclusions:** We observed better than anticipated lower extremity bilateral symmetry in this group of high school athletes, but were surprised by the lack of differences between the sexes. The absence of significant differences in vertical GRFs in the quadriceps dominant group was equally surprising. However, it is possible that given our sample size, and an even smaller sample of those with quadriceps dominance ($n = 6$) that this experiment was simply incapable of identifying significant group differences. Funded by the John C. Erkkila, MD, Endowment for Health and Human Performance.

Free Communications, Oral Presentations: Shoulder & Scapula Interventions

Thursday, June 18, 2009, 9:30AM-10:30AM, Room 214A; Moderator: Laura Miller, MS, ATC

The Immediate Effects Of Warm-Up With Sling Exercise Therapy Compared With Traditional Shoulder Exercise On The Velocity And Accuracy Of Throwing

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Context: Warm-up prepares the body for work and can enhance performance. Slingbased exercise therapy (SET) has been theorized to activate muscles in a manner beneficial for pre-activity warm-up, yet this hypothesis has not been tested. Proximal muscle function is required for SET, perhaps resulting in an improvement of throwing performance.

Objective: To determine if a warm-up utilizing SET would increase throwing velocity and accuracy compared to a the Thrower's Ten program, a standard warm-up program in baseball players. **Design:** Crossover design. **Setting:** Collegiate baseball field and facilities.

Patients or Other Participants: Sixteen healthy male (19.6 ± 1.3 yrs, 184.2 ± 6.2 cm, 76.9 ± 19.2 kg), division I baseball position players (non-pitchers) volunteered for the study. **Intervention(s):** All subjects underwent both a warm-up routine using the Thrower's Ten exercises, as well as a warm-up routine using SET methods on different days separated by 72 hours. Exercise programs were performed under the supervision of a certified athletic trainer. SET consisted of closed chain shoulder and core exercises using body weight adjusted with a series of slings as resistance, while the Throwers' Ten used dumbbells and Therabands for open chain resistance. The order of warm-ups was randomly selected and subjects were allowed a series of progressive warm-up throws prior to data collection. **Main Outcome Measures:** Throwing velocity and accuracy measures were obtained on 10 throws following each warm-up method. Velocity was recorded using a standard Jugs radar gun (JUGS; Tualatin, OR) and accuracy was recorded using a custom inkblot target. The scores for velocity and accuracy of the three most accurate trials were used for data analysis. Two way analysis of covariance (ANCOVA) was used to detect differences between groups using an *a priori* level $P \leq 0.05$. The number of warm-up throws was used as a covariate. **Results.** There was no statistical difference between the SET warm-up and Thrower's Ten warm-up for throwing velocity (SET: 74.7 ± 7.5 mph, Thrower's Ten: 74.6 ± 7.3 mph $P = .874$) or accuracy (SET: 115.6 ± 53.7 cm, Thrower's

Ten: 91.8 ± 55 cm $P = .136$). **Conclusions:** There were no immediate differences between SET and Throwers' Ten warm ups on accuracy and velocity of throws. Although time needed to complete the intervention was not collected, clinical observations suggest that the SET intervention took less time to complete compared to the Throwers' Ten. Both interventions were equivalent in affecting immediate performance, yet the SET warm-up may be preferred because due to time efficiency. It remains unknown whether one type of exercise may be superior in affecting performance over time or injury prevention.

Effects Of Handheld Vibration On Glenohumeral Range Of Motion In Throwers

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Context: Research observing range of motion (ROM) in overhead-throwers suggests glenohumeral internal rotation deficits (GIRD) are associated with shoulder pathology. To facilitate the prevention and treatment of pathology in throwers, research should identify interventions that restore or maintain glenohumeral ROM. Recent research suggests whole body vibration training may enhance lower-extremity flexibility after a few short bouts of exposure. The effect of handheld vibration (HV) on upper-extremity ROM has not been investigated. **Objective:** To observe effects of HV on glenohumeral ROM in competitive overhead-throwing athletes.

Design: We used a randomized, blinded pre-test post-test crossover design. Each arm of each participant experienced 2 conditions (1-control, 1-experimental), each of which included pre-test and post-test measures; the order of conditions was randomized. **Setting:** Division-I baseball and softball athletic training clinic. **Participants:** Thirty-five healthy Division-I baseball ($n=23$) and softball ($n=12$) players (age= 20 ± 2 yr, height = 178 ± 9 cm, mass= 84 ± 12 kg) volunteered. **Interventions:** We measured participants before their participation in activity. Participants laid supine on a standard treatment table for the intervention and measure. We measured glenohumeral rotational ROM immediately before and following the intervention. During each intervention-condition, participants held a 2.55kg (5.62lbs) Mini-VibraFlex dumbbell (Orthometric, New York, NY) in neutral glenohumeral rotation (forearm vertical) for

three 20s-trials with 1-min. rest between each trial. During the experimental-condition the dumbbell vibrated (amplitude= 2.2 mm, frequency= 15 Hz); during the control-condition the dumbbell did not vibrate (amplitude= 0 mm, frequency= 0 Hz). **Main Outcome Measures:** We used a digital protractor to assess ROM bilaterally, employing the standard procedure for goniometry measures of maximal passive glenohumeral internal (IR) and external rotation (ER). We considered maximal motion achieved when rotation ceased with a firm capsular end-feel or the position immediately before appreciable scapula motion. We measured ROM in each arm twice and included the average in repeated-measures analyses of variance (RM-ANOVA) to assess the effects of HV on ROM. **Results:** The RM-ANOVA indicated dominant IR ROM increased significantly after HV (pre= $51.5 \pm 8.2^\circ$, post= $55.2 \pm 10.9^\circ$; $p=0.001$, ES= 0.16). We identified an interaction effect ($p=0.032$, ES= 0.073) between treatment conditions and time for dominant IR ROM, but no significant between-group effects ($p=0.55$, $1-\beta=0.09$). The RM-ANOVA suggested HV did not significantly effect dominant ER ROM (pre= $107.1 \pm 13.4^\circ$, post= $109.4 \pm 13.4^\circ$; $p=0.26$, $1-\beta=0.20$), non-dominant IR (pre= $64.1 \pm 12.2^\circ$, post= $65.7 \pm 11.5^\circ$; $p=0.09$, $1-\beta=0.41$), or non-dominant ER (pre= $104.5 \pm 12.1^\circ$, post= $106.1 \pm 12.3^\circ$; $p=0.95$, $1-\beta=0.05$). **Conclusions:** We measured dominant and non-dominant glenohumeral IR and ER ROM in collegiate baseball and softball athletes before and after short bouts of HV. We observed acute gains in dominant IR after HV while all other motions remained unchanged. Although our results suggest this population may benefit from the HV, incorporating HV into warm-up or stretching programs should be done with caution in a supervised clinical setting. Further research should identify specific mechanisms by which HV enhances flexibility in this population and examine long-term effects of its use.

The Acute Effect Of A Myofascial Release Intervention On Resting Scapula Position And Three Dimensional Scapula Kinematics
Harrington SE, McLeod MM, Prentice WE, Padua DA: University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Overhead athletes have been shown to exhibit altered resting scapula position and motion. Interventions able to successfully modify these variables may be important for injury prevention and rehabilitation of shoulder pain in overhead athletes. Myofascial restriction may be addressed through myofascial release techniques (MRT), yet little research addresses the effectiveness of MRT in the shoulder. **Objective:** To determine the acute effects of a MRT on resting scapula position and dynamic scapula upward rotation during humeral flexion in overhead athletes. **Design:** Randomized control trial. **Setting:** Research laboratory. **Participants:** Twenty-two participants were randomly assigned to either the control (CON) (6 males, 5 females age= 21±3 yrs, ht=171 ±15 cm, mass= 74±13 kg) or intervention (INT) (5 males, 6 females age= 20±1 yrs, ht=172 ±10 cm, mass= 72±15 kg) group. Inclusion criteria: participated in a Division I or recreational club overhead sport, no current shoulder pain, and had not received shoulder rehabilitation during the past 6 months. **Interventions:** The INT group used a 6" diameter dense foam roll to implement the MRT on the dominant arm. The MRT intervention consisted of each participant rolling over the foam roll until an area of restriction for the pectoralis minor, latissimus dorsi, and posterior rotator cuff musculature for duration of 2 minutes per muscle group. The CON group sat at rest in a comfortable position, with their arms at their sides for 6 minutes, the same amount of time it took the INT group to complete the MRT. Measures of resting scapula position and 3D scapula kinematics during a flexion task were taken using an electromagnetic tracking system before and after the 6 minutes of intervention or rest. **Main Outcome Measures:** The dependent variables measured at rest were scapula upward rotation, anterior tipping, and internal rotation while scapula upward rotation was measured for the flexion task. Separate mixed-model repeated measure ANOVAs were used to compare the dependent variables between groups (CON, INT) and across time (pre-test, post-test) ($\alpha \leq 0.05$). **Results:** No group x test differences were found for the resting scapula variables as a result of the intervention, internal rotation ($P=.492$), upward rotation ($P=.977$), and anterior tipping ($P=.200$). There was no

group x test interaction ($P=.217$) for dynamic scapula upward rotation (Pre-Test CON=33.05, 95%CI=26.70, 39.39; Pre-Test INT=31.16, 95%CI=26.82, 37.50; Post-Test CON=31.87, 95%CI=26.20, 37.54; Post-Test INT=30.35, 95%CI=24.68, 36.02). **Conclusions:** A single bout of MRT was not effective in altering scapula resting position or dynamic scapula upward rotation. While the results do not show evidence to support the theory behind MRT technique for acute changes, this study may serve as a steppingstone towards future research. Future studies should investigate the effects of MRT when used for a longer duration and combined with other therapeutic interventions.

The Effect Of The Spine And Scapula Stabilizing (S3) Brace On Posture And Muscle Activity In Overhead Athletes With Poor Posture

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Context: Many overhead athletes suffer from shoulder pain due to poor posture. The S3 brace, a compression shirt and elastic straps that apply tension to retract the shoulders and scapulae, is designed to improve posture by re-educating the muscles surrounding the shoulders and spine. **Objective:** To determine whether the S3 scapular stabilizing brace alters posture and muscle activity in participants with forward head rounded shoulder posture (FHRSP). **Design:** Randomized control study. **Setting:** Research laboratory. **Patients or Other Participants:** Thirty-eight NCAA Division I, club, and recreational overhead athletes (9 males, 29 females) with FHRSP (age=19.5±1.2yrs, mass=75.41±15.45kg). **Interventions:** Individuals classified as having FHRSP displayed a forward head angle (FHA) $\geq 46^\circ$ and a forward shoulder angle (FSA) $\geq 46^\circ$. Lateral photographs utilizing reflective markers were used to assess FHA (angle between a vertical line from C7 to the external auditory meatus) and FSA (angle between a vertical line from C7 to the posterior acromion). Muscle activity of the upper (UT), middle (MT), and lower trapezius (LT), and serratus anterior (SA) on the dominant arm were measured using EMG during shoulder extension (SE), forward flexion (FF), and four scapular exercises (W's, Y's, T's, and serratus punches). All posture and exercise EMG measurements were taken with and without the brace applied. Participants were randomly assigned to groups: one wore the compression shirt with

no tension on the straps (S), and one had the straps fully tensioned (S+T). This allowed for differentiation between the effects of the compression shirt and the effects of the strap tension. **Main Outcome Measures:** Muscle activity of the UT, MT, LT and SA was normalized to a 3-second MVIC. Normalized EMG was averaged for FF, SE, and the 4 exercises. FHA and FSA were compared using separate 2 (S vs. S+T) x 2 (brace vs. no-brace) repeated-measures ANOVAs. Mean EMG for each muscle and exercise was compared using separate 2x2 RM-ANOVAs ($\alpha=0.05$). **Results:** Application of the S3 brace significantly decreased FSA for both groups (S+T: 8.00±7.78°, S: 1.63±6.55°; $F_{1,38}=5.106$, $P=0.030$). Both groups exhibited an increase of 3.55% in LT EMG during FF ($F_{1,33}=12.563$, $P=0.001$), and decreases of 2.97% in UT EMG ($F_{1,34}=12.837$, $P=0.001$) and 0.95% in MT EMG ($F_{1,33}=7.282$, $P=0.011$) during SE. During the W exercise, the S group increased UT EMG by 4.13%, while the S+T group decreased UT EMG by 6.80%, when the brace was applied ($F_{1,36}=4.710$, $p=0.037$). **Conclusions:** This study suggests that using the S3 brace may alter posture and muscle activity. However, these changes appear to be the result of the compression shirt, and not strap tension, as there were few differences between the S and S+T groups. Further research should focus on whether these posture and muscle activity changes are due to scapular repositioning or proprioceptive changes.

Control Strategies During Gait Termination Differ Among Control, Coper, And Chronic Ankle Instability Subjects

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Context: The underlying neurophysiologic mechanism of chronic ankle instability (CAI) is unknown. Yet, some people (copers) maintain dynamic activities after a lateral ankle sprain and are thought to possess a mechanism that limits the impairments seen in CAI. Control strategies during gait termination have detected significant differences in feed-forward and feedback neuromuscular control between subjects with CAI and controls. Potentially, control strategies during gait termination could elucidate the coping mechanism present in copers but absent in CAI patients. **Objective:** To examine neuromuscular control differences among control, coper, and CAI subjects using a gait termination (GT) model. **Design:** A single session mixed model design was used for this investigation. **Setting:** Controlled laboratory setting. **Participants:** Sixty subjects, 20 controls (20.85±1.6yr, 164.3±7.9cm, 64.2±10.62kg), 20 copers (21.93±2.9yr, 168.77±8.9cm, 64.97±14.8kg), and 20 CAI subjects (20.5±1.0yrs, 169.8±9.8cm, 74.2±20.2kg) participated. Copers and CAI patients had a previous moderate ankle sprain but copers resumed all pre-injury activity without limitation or recurrent injury while CAI patients suffered multiple “giving way” episodes and recurrent sprains. **Interventions:** Each subject was tested bilaterally during ten planned and ten unplanned GT trials. Each limb served as the lead and swing limb in five of the planned and unplanned GT trials. An auditory signal cued subjects to stop during randomly selected trials (unplanned GT) and catch trials ensured that anticipation of the auditory signal did not occur. The auditory signal was given consistently at the heel strike of the lead limb so that subjects were forced to stop within a single step. **Main Outcome Measures:** Ground reaction forces, collected at 1200Hz, from two adjacent force plates were used to calculate the maximum propulsion (lead limb) and braking forces (swing limb) measured in Newtons. A 3x2x3 mixed model (Group [control, coper, CAI], Limb [involved/uninvolved], and Task [planned GT, unplanned GT, catch]) MANOVA examined differences among force variables. **Results:** Both control (-88.6±33.6N) and coper

(-90.0±34.5N) subjects produced significantly less propulsive force [$F(2,280)=5.5$, $p<.01$] than the CAI group (-99.8±40.8N). Subsequently, braking forces were higher [$F(2,280)=13.7$, $p<.01$] for CAI (207.1 ±80.9N) patients than controls (180.3±64.1) and copers (180.1±64.1N). **Conclusion:** CAI subjects did not reduce their propulsive forces during GT trials (planned or unplanned) to the same extent as controls or copers. This required CAI subjects to generate greater braking forces to stop their forward momentum. This indicates an altered motor program and slower neuromuscular response in CAI patients during GT. Further, both feed-forward and feedback neuromuscular control alterations appear to exist in CAI subjects possibly signifying a decreased ability to cope with changing task demands. Copers, however, produced similar movement patterns as controls suggesting a return to normal neuromuscular control or the development of a successful compensation pattern which may represent the coping mechanism absent in those with CAI.

Ankle And Rearfoot Mechanics During A Running Gait In Subjects With Chronic Ankle Instability

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Context: Lateral ankle sprains are one of the most common joint injuries and although most resolve with conservative treatment, others develop chronic ankle instability (CAI). It has been suggested that dynamic ankle and foot mechanics predispose individuals with CAI to repetitive episodes of the ankle “giving way.” **Objective:** To evaluate movement and neuromuscular strategies at the ankle and rearfoot in individuals with CAI, individuals who suffered a lateral ankle sprain, but did not develop CAI (AS), and subjects with no history of a lateral ankle sprain (CON). **Design:** Case-control study. **Setting:** Controlled laboratory. **Patients or Other Participants:** Forty-five subjects were distributed into three groups [CAI (N = 15, height: 166±8 cm, mass: 86±20 kg) vs. AS (N = 15, height: 170±7 cm, mass: 75±19 kg) vs. CON (N = 15, height: 168±8 cm, mass: 65±14 kg)]. **Interventions:** A kinematic, kinetic, and electromyographic (EMG) analysis of a running gait was performed on each participant. **Main Outcomes Measures:**

The dependent variables of interest were rearfoot inversion angle (RFINV) at foot strike (FS), ankle dorsiflexion angle (DF) at FS, average rearfoot frontal plane internal moment (RFMOM) during loading, and onset of peroneus longus muscle activation (PLA) relative to FS. Separate one-way ANOVA with Tukey's *post-hoc* analysis were used to test for group differences ($\alpha = 0.05$). **Results:** There was a significant main effect for RFINV ($F_{2,44} = 13.37$, $P < 0.001$; CAI = $12.4 \pm 6.6^\circ$, AS = $7.3 \pm 2.5^\circ$, CON = $3.0 \pm 4.3^\circ$), DF ($F_{2,44} = 3.44$, $P = 0.04$; CAI = $6.0 \pm 4.7^\circ$, AS = $8.9 \pm 3.1^\circ$, CON = $9.4 \pm 4.3^\circ$), RFMOM ($F_{2,44} = 17.30$, $P < 0.001$; CAI = -0.03 ± 0.06 Nm, AS = -0.07 ± 0.05 Nm, CON = -0.24 ± 0.15 Nm) and PLA ($F_{2,40} = 10.72$, $P < 0.001$; CAI = -0.02 ± 0.06 ms, AS = 0.09 ± 0.07 ms, CON = 0.12 ± 0.09 ms). Post-hoc analysis revealed significantly greater RFINV and decreased DF, RFMOM, and PLA in CAI as compared to AS and CON. No significant differences existed between LAS and CON. **Conclusions:** Individuals with CAI have distinctive mechanics during a running gait. Specifically, those with CAI are more inverted and plantar flexed at FS. This increased supination may be due to the delay in PLA and results in a more vulnerable RFMOM during loading. Identifying the differences between the CAI and AS groups suggests that these mechanics contribute to the development of repetitive, not isolated lateral ankle sprain events. Clinicians treating patients with CAI should provide interventions to decrease RFINV during loading and increase peroneal neuromuscular control.

Increased Plantar Pressures On The Lateral Aspect Of The Foot With Chronic Ankle Instability

Schmidt H, Drewes LK, Lee SY, Fujiwara LM, Saliba SA, Hertel J: University of Virginia, Charlottesville, VA

Context: Injuries to the lateral ligaments of the ankle following an inversion ankle sprain are among the most common athletic injury. Repeated episodes of lateral instability resulting in frequent ankle sprains have been defined as chronic ankle instability (CAI). Previous plantar pressure research of CAI subjects has reported increased pressure and time spent on the lateral aspect of the foot during barefoot walking over a pressure mat; however, this has not been evaluated with an in-shoe plantar pressure system. **Objective:** To determine if individuals with CAI

demonstrated different in-shoe plantar pressures and forces during jogging compared to controls. **Design:** Case control. **Setting:** Athletic training laboratory. **Patients or Other Participants:** Twenty-five controls without history of previous ankle sprains volunteered (10 males, 15 females; 23 ± 6.9 years, 168 ± 9.0 cm, 77 ± 4.6 kg). Twenty-four subjects with CAI also volunteered (12 males, 12 females; 22.7 ± 6.4 years, 173.0 ± 11.5 cm, 73.6 ± 17.0 kg). CAI subjects reported an average of $82.6\% \pm 10.0$ on the FAAM-ADL and $66.0\% \pm 10.0$ on the FAAM-Sport. **Intervention(s):** All subjects jogged continuously on a treadmill at 2.68 m/s (6.0 mph) while three trials of 10 consecutive steps were recorded. The independent variable was group (CAI, controls). Independent t-tests were used to compare groups and a Bonferroni correction was applied for multiple comparisons. The corrected alpha level was $p < 0.008$. **Main Outcome Measures:** Measures of peak pressure, time to peak pressure (% stance), pressure-time integral (PTI), maximum force, time to maximum force (% stance), and force-time integral (FTI) were collected in the lateral rearfoot, lateral midfoot, and lateral forefoot with the PEDAR-x plantar pressure system (Novel Inc., Munich). **Results:** The CAI group demonstrated a slower loading response in the lateral rearfoot indicated by a longer time to peak pressure ($16.5\% \pm 10.1$, $P = .001$) and time to maximum force ($16.8\% \pm 11.3$, $P = .001$) compared to the time to peak pressure ($6.5\% \pm 3.7$) and time to maximum force ($6.6\% \pm 5.5$) for controls. In the lateral midfoot, CAI subjects demonstrated a significantly greater maximum force ($318.8 \text{ N} \pm 174.5$, $P = .008$) and peak pressure ($211.4 \text{ kPa} \pm 57.7$, $P = .008$) compared to the maximum force ($191.6 \text{ N} \pm 74.5$) and peak pressure ($161.3 \text{ kPa} \pm 54.7$) of controls. Additionally, CAI subjects demonstrated a significantly higher FTI ($44.1 \text{ N} \cdot \text{s} \pm 27.3$, $P = .005$) and PTI ($35.0 \text{ kPa} \cdot \text{s} \pm 12.0$, $P = .005$) compared to the FTI ($23.3 \text{ N} \cdot \text{s} \pm 10.9$) and PTI ($24.5 \text{ kPa} \cdot \text{s} \pm 9.5$)

for controls in the lateral midfoot. In the lateral forefoot, CAI subjects demonstrated a significantly greater maximum force ($239.9 \text{ N} \pm 81.2$, $P = .004$), FTI ($37.0 \text{ N} \cdot \text{s} \pm 14.9$, $P = .003$), and time to peak pressure ($51.1\% \pm 10.9$, $P = .007$) compared to maximum force ($170.6 \text{ N} \pm 49.3$), FTI ($24.3 \text{ N} \cdot \text{s} \pm 7.2$), and time to peak pressure ($43.8\% \pm 4.3$) for controls. For the lateral regions, no other variables were significantly different between groups (all $P > .008$). **Conclusions:** This is the first study to use an in-shoe plantar pressure analysis to study a population with CAI. The CAI group had significantly greater plantar pressures and forces in the lateral rearfoot, midfoot and forefoot compared to controls during jogging.

Effects Of Ankle Taping And Bracing On Plantar Pressure In Subjects With Chronic Ankle Instability

Germanowski LM, Drewes LK, Lee SY, Parente WR, Saliba SA, Hertel J:
University of Virginia, Charlottesville, VA

Context: Ankle taping and bracing are common interventions implemented to reduce the incidence of recurrent ankle sprains in physically active individuals with chronic ankle instability (CAI). There is no published research to date assessing the effects of these interventions on plantar pressure and force distribution in a population with CAI.

Objective: The purpose of this study was to assess the effects of taping and bracing on plantar pressure and force during walking and jogging in subjects with CAI. **Design:** Crossover. **Setting:** Athletic training laboratory. **Patients or Other Participants:** Twenty-four people (12 men, 12 women; 22.7 ± 6.4 years, 173.0 ± 11.5 cm, 73.6 ± 17.0 kg) with CAI volunteered for the study. CAI subjects reported an average score of $82.6\% \pm 10.0$ on the FAAM-ADL and $66.0\% \pm 10.0$ on the FAAM-Sport.

Intervention(s): The independent variable

was condition (taping, bracing, control). The order of the taping, bracing, and control conditions was counterbalanced and data was collected with the PEDAR-x plantar pressure system (Novel Inc, Munich) during both walking and jogging. All subjects walked and jogged on a treadmill at predetermined speeds of 1.3 m/s (3.0 mph) and 2.6 m/s (6.0 mph), respectively. Each measure was analyzed in walking and jogging with a 1x3 analysis of variance and a Bonferroni correction was applied for multiple comparisons. The corrected alpha level was $P < 0.008$. Tukey's post hoc tests were performed to identify specific differences. **Main Outcome Measures:** The dependent variables were peak pressure, time to peak pressure, pressure-time integral (PTI), maximum force, time to maximum force, and force-time integral (FTI) in the medial and lateral rearfoot; medial and lateral midfoot; and medial, middle, and lateral forefoot. **Results:** During walking, the peak pressure increased in the medial midfoot with ankle taping ($114.2 \text{ kPa} \pm 21.8$) and bracing ($110.2 \text{ kPa} \pm 34.7$) compared to the control condition ($96.1 \text{ kPa} \pm 22.4$) ($P = .001$). During jogging, the FTI in the medial forefoot was significantly greater in taping ($36.8 \text{ N} \cdot \text{s} \pm 12.4$) and bracing ($44.3 \text{ N} \cdot \text{s} \pm 16.4$) conditions compared to control condition ($32.7 \text{ N} \cdot \text{s} \pm 10.3$) and the bracing condition was significantly greater than the taping condition ($P = .001$). The PTI was significantly higher in the bracing condition ($58.2 \text{ kPa} \cdot \text{s} \pm 17.9$) in the medial forefoot compared to the control condition ($46.6 \text{ kPa} \cdot \text{s} \pm 11.7$) ($P = .007$). All other variables, in the respective regions of the foot, were not significantly different between conditions (all $P > .008$). **Conclusions:** Ankle taping and bracing did not diminish the increased pressures and forces on the lateral aspect of the foot previously reported in subjects with CAI. Instead, taping and bracing tended to increase peak pressures and forces on the medial aspect of the foot in jogging.

Evidence-Based Forum #3: Ankle & Foot

Thursday, June 18, 2009, 12:00PM-1:00PM, Room 214A; Discussants: Patrick McKeon, PhD, ATC, and Erik Wikstrom, PhD, ATC; Moderator: Cathleen Brown, PhD, ATC

Free Communications, Oral Presentations, Case Reports: Upper Extremity

Friday, June 19, 2009, 8:30AM-9:45AM, Room 214A; Moderators: Kevin M. Waninger, MD, and Michael J. Horan, ATC

Frontal Sinus Fracture In A Division I Men's Basketball Player

Manwaring PN, Pirog KB, McCarthy TJ, Waskowitz RS, Brown JR: Central Connecticut State University, New Britain, CT

Background: An 18-year-old, Division I men's basketball athlete sustained a frontal sinus fracture as a result of direct contact by an opponent's elbow during competition. The athlete presented with exquisite pain, a 2cm x 1cm gross depression deformity to the right forehead region above the supraorbital ridge with no overlying laceration. Initial evaluation showed vision, pupillary response, and tracking to be normal. Motor function was compromised with a demonstrated inability to elevate the eyebrow on the affected side. Within several minutes of the initial trauma, the athlete complained of nausea and had associated vomiting. Due to his continued distress and persistent vomiting he was transferred to the hospital for further evaluation and management.

Differential Diagnosis: Frontal sinus fracture, orbital fracture, subcutaneous hematoma, subdural hematoma, mild traumatic brain injury.

Treatment: Immediate evaluation by the team physicians confirmed the presence of a depression to the forehead contour, with point tenderness and localized swelling to the right frontal bone. Evaluation of the eye revealed extraocular movements to be intact. As noted, he was unable to elevate his right eyebrow. Periorbital sensations were intact, no bleeding in the anterior chamber, and zygomatic arch appeared to be intact. No oral or throat trauma was evident. No cerebral spinal fluid (CSF) rhinorrhea, or otorrhea. Concussion evaluation revealed slight memory and concentration deficits. The athlete was transported to the emergency department for a CT scan, which confirmed the diagnosis of a fracture to the anterior table of the frontal sinus and ruled out intracranial hemorrhage. After 24 hours of observation, he was released and referred to Oral Maxillofacial Surgery (OMFS) for management of the depressed frontal sinus fracture. The OMFS confirmed the original diagnosis, and recommended surgical stabilization of the fracture. During surgery, an incision was made which spanned between the zygomatic arches over the top of the head. The skin was incised to the subcutaneous tissue, and dissected to the level of the periosteum, and then dissected above the supraorbital rim. The fracture site was exposed by elevating the supraorbital flap. The

fractured bone was then elevated and the sinus was irrigated. The right nasolacrimal duct was intact. The fractured bone was replaced in its original position and secured using two titanium 1.2 mm plates with 3mm and 4mm screws. The supraorbital flap was repositioned, and the incision was closed with a multilayered closure approach. Post-surgically, the athlete received a course of peri-operative antibiotics and steroids to prevent infection and control edema. Follow up at thirteen days post operatively, normal tissue healing was noted and the headaches had resolved. At that time, the athlete was medically cleared to begin non-contact activities. A custom, acrylic face-mask was fabricated for the athlete to wear during contact activities which began at 7 weeks. Four months post-operatively, a follow-up CT scan revealed complete healing of the comminuted fracture site and healthy frontal sinus tissue. Annual sinus CT scans have been advised to monitor the status of the sinus tissue. **Uniqueness:** Frontal sinus fractures in the sport of basketball are uncommon, as the frontal sinus is extremely resilient to trauma. **Conclusion:** Diagnosis and treatment should occur in an urgent fashion in order to prevent short and long-term potential problems. Significant depressions warranting surgical reconstruction should occur within a 2-week window to avoid malunion of the fracture zone. Complications to surgery include post-op pain, swelling, infection, and the potential removal of plates and frontal sinus mucocele in later stages.

Degenerative Disk Disease With Subsequent Diskectomy In A 15-Year-Old Athlete

Waugh A, Cassidy C, Mulberry B: University of Kentucky, Lexington, KY

Background: Athlete is a 15-year-old soccer player/cheerleader with acute back pain. She sustained a contact injury (slid tackled) in a varsity high school soccer game. Initial complaint is of pain in her mid to lower back, worsening with extension. Athlete is tender to palpation in the L5-S1 region of her spine with paraspinal muscle pain. She has limited ROM due to pain. Neurovascular exam is normal, general left leg pain is present. Past medical history positive for mild low/mid back pain with cheerleading activities. Family history is significant for disk disease (father). **Differential Diagnosis:** Muscle strain, Ligamentous injury, Spondylolysis/lithesis,

disk herniation, Degenerative Disk Disease.

Treatment: X-rays obtained by the physician show no abnormalities. Physical exam findings show remaining tenderness to palpation in the L5-S1 region, increased muscle pain, and generalized left leg pain occasionally. Straight leg raise test is negative. The athlete is prescribed PT, NSAID's and limited to pain free activity until her next appointment. Physical therapy and anti-inflammatory medication prove effective at managing the athlete's pain and she is allowed to return to activity. The athlete is seen a few months later for continued back pain that worsens with activity. She reports several falls from cheerleading stunts and notes increased pain with tumbling. An MRI is ordered, finding show L5/S1 prominent disc herniation to the left of midline with impingement to the left aspect of the thecal sac and the left S1 nerve root sleeve. From this, the athlete was referred to an Orthopaedic spine specialist. Upon his exam symptoms had included pain in the upper back, lower back, radiculopathy about the left leg and occasional numbness in the left lateral thigh. **Diagnosis:** degenerative disk disease with an L5-S1 disk herniation and nerve root impingement. Continued physical therapy was recommended with discontinuation of activity for 6 weeks. This showed no improvement in symptoms and pain management was consulted. L3, L4, and L5 steroid injections were given with no relief. An epidural steroid injection was performed which provided no relief. Due to the failure of conservative treatment and injections it was recommended that the athlete undergo a diskectomy at the L5-S1 level. An L5-S1 diskectomy via laminotomy was performed and the athlete was hospitalized overnight for observation. She was allowed to be mobilized post operatively with restrictions to lifting, bending and stooping and placed on homebound education for her high school classes. Ten days post-op she was allowed to return to school with the allowance for her to alternate standing and sitting positions every 30minutes. She was instructed to limit flexion and extension of the spine and to restrict lifting greater than 5-8lbs. Six weeks post-op the athlete was allowed to begin straight ahead running and conditioning with a gradual progression to full activity. She tolerated this progression well and has been able to resume full soccer activities but has decided not to return to cheerleading. **Uniqueness:** Degenerative joint disease and disk herniation are rare in the adolescent athlete but usually present with atypical symptoms.

While children typically heal faster than adults, disk herniation in adolescents do not heal and usually require surgical intervention. It is uncommon for young athletes to have disk injuries that preclude athletic activity. **Conclusion:** Aggressive treatment of the athlete's disk disease and herniation proved to be the only treatment that allowed her to return pain free to not only ADL's but also to sport activity.

Spine Injury In A Competitive Cyclist

Hansen MS, Blair DF, Nelson SM, Farrar EL: Wenatchee High School/BioSports, Wenatchee, WA

Background: Our subject is a 49 y/o male competitive recreational cyclist who crashed on a time trial bike while competing in a multi-event relay on June 29, 2008. He failed to negotiate a curve and crashed into a rock going approximately 40 miles per hour. At the time of impact, the subject was knocked unconscious and did not regain consciousness for twenty minutes. The subject had difficulty breathing, chest pain, paresthesia/numbness and motor loss in the left hand/elbow, and neck pain. **Differential Diagnosis:** cervical/thoracic fractures, spinal cord injury, brachial plexus neuropraxia/neurotmesis, rib fractures, pneumothorax, closed head injury, spinal cord compression syndrome **Treatment:** Computerized tomography (CT) scan of his head, cervical, and thoracic spine revealed a C1 transverse process fracture, C5-7 spinous process, lamina, pedicle, and pars fractures, T1-3 burst fractures, and rib 1-3 fractures. The rib fractures also caused a pneumothorax. The first surgery was performed on July 2, 2008 (3 days post injury) for stabilization with a halo. Follow-up x-rays two days later revealed further instability of the T1-3 vertebral burst fractures. A second surgery was performed on July 7, 2008 for external fixation of vertebral levels T1 through T5. . The subject started treatment with electrical stimulation and ice along the spine following the surgery. He began weight bearing and walking with minimal assistance two days post surgery He was discharged from hospital six days after the second surgery and after total of two weeks in the hospital. During week three, thoracic, scapular, and shoulder range of motion/resistive exercises (non-painful and safe for healing tissues) were initiated. At four weeks post-operatively, when the dissolvable stitches were at their weakest, the subject reached forward and disrupted the surgical closure. The wound became infected with Methicillin-resistant staphylococcus aureus (MRSA) bacteria and a third surgery and hospitalization was required for a debridement

and resuturing of the thoracic spine incision. Early rehabilitation resumed four days post surgery with early mobilization of the shoulders and thoracic spine, gentle resistive upper extremity exercises, and daily walking of 30-90 minutes. Follow-up x-rays at four weeks showed early bone regeneration. The halo was removed after 9 weeks since significant bone regeneration was present. Cervical collar was removed after one week because of sufficient stabilization at the fracture sites. The subject still has C6 and C7 numbness and weakness four months post injury. However, EMG studies have demonstrated that the action potentials of the denervated nerves are regenerating. At 12 weeks, the subject returned to work 20 hours/week and cycling 6 hours/week. His daily rehabilitation regime consists active and passive range of motion, progressive resistance exercise with focusing on the upper extremities and cardiorespiratory conditioning. **Uniqueness:** The principles for spinal trauma surgery are well documented. Rehabilitation strategies and techniques are more controversial. Traditionally, patients are overmedicated and sedentary for the first two weeks post injury. Healing is slow and recovery of motion and strength difficult. The typical recovery for an extensive spinal injury may take several years with only 8% regaining full function. Since the subject demonstrated early bone regeneration, the halo was removed in 9 weeks instead of the typical 12-16 weeks. The patient's bone healed 30% faster than the typical cervical fracture patient. At ten weeks, the subject was able to resume bicycle riding. At twelve weeks, the subject was back to working three half days a week as a physical therapist and had regained enough motion to drive a car. **Conclusions:** Our subject's rapid recovery was facilitated by an early rehabilitation, effective inflammation control, pre-injury level of fitness, and determination to regain function.

Complex Comminuted Fracture Of The Proximal Phalanx After Crush Injury: A Case Report

Manspeaker SA, Welch CE, Hankemeier DA: Old Dominion University, Norfolk, VA

Background: A National Collegiate Athletic Association Division I female certified athletic trainer (23 y/o, 178 cm, 68 kg) presents to the athletic training room with extensive laceration and significant bleeding at the right index finger. The ATC was supervising isokinetic rehabilitation on an athlete when she suffered a complex open fracture to the index finger of the right hand. While un-strapping the athlete from the machine, her finger was crushed

between the knee attachment lever arm and the stop wedge of the dynamometer head as the athlete spontaneously enacted an extra repetition of the exercise. Upon realization of the injury, the athlete summoned other members of the staff to assist the injured ATC. As the ATC went into shock her wound was dressed, stabilized, and she was transported to the emergency room via ambulance. Radiographs were ordered to determine extent of the injury. **Differential Diagnosis:** Due to extensive tissue damage and positive radiographs, an initial diagnosis of complex open fracture of the right index finger was assigned. Other diagnoses to consider included nerve laceration, severing of flexor and extensor tendons of the index finger, rupture of the extensor hood, and volar plate disruption. **Treatment:** The ATC underwent open reduction internal fixation of the fractures with repair of the extensor tendon and complex skin repair. A specific diagnosis of comminuted fracture of the proximal phalanx of the right index finger with extensive injury and laceration to the dorsal and volar skin was applied. Due to the extensor tendon laceration, initial immobilization in PIP extension was recommended for four weeks while movement of the DIP and MP joints was encouraged. Rehabilitation four weeks post-splinting included: modalities for edema reduction, (rice massage, microcurrent edema reduction, manual edema mobilization) scar softening, (ultrasound, moist heat pack treatments) and initial range of motion (blocking exercises, self stretch PROM). Measures of AROM for the right PIP joint were 25-40 which is significantly lower than the left PIP (0-120). As the rehabilitation progressed dynamic splints and buddy straps were utilized outside of therapy to encourage flexion. Due to lack of ROM progression of both the right DIP (AROM 0-10) and PIP (AROM 25-35°), she underwent a second surgery 16 weeks post-injury for extensor tenolysis and capsulotomy to alleviate flexion limitations focalized at the PIP joint. The surgical plate and screws were also removed. No immobilization period was recommended and AROM exercises (blocking drills, tendon gliding exercises) along with PROM (Hand CPM unit) was initiated the next day. The same therapy procedures from before the surgery along with functional electrical stimulation and the graston technique were utilized to encourage ROM. At 18 weeks post injury, the patient underwent a closed capsulotomy manipulation to break adhesions that were limiting her PIP flexion. At 50 weeks post-injury a third surgery of flexor and extensor tenolysis was performed to release the flexion contracture at the finger. This surgery improved ROM, but the patient never regained full ROM. At 60 weeks post-

injury therapy was discontinued leaving the patient with a PIP AROM of 30-110°. **Uniqueness:** This case is unique in that the extensor tendon laceration was longitudinal in nature thus not requiring the full length of extension immobilization that occurred. The immobilization period complicated the rehabilitation process as it caused adhesions to develop. The ATC currently has a PIP flexion contracture of 55 degrees, demonstrating that the second and third surgeries were relatively ineffective. **Conclusions:** Immobilization periods should reflect current practices and consider patient goals and outcomes. Although full ROM was not achieved, the patient adapted to limited ROM and is able to carry on daily tasks without incident.

The Addition Of Forteo™ In The Treatment Of A Delayed Surgical Repair Of A Non-union Scaphoid Fracture In An NCAA Division-1 Football Player: A Case Study

Seagraves BL, Muchnick PW, Courson RW, Bolgla LA: University of Georgia, Athens, GA, and Medical College of Georgia, Augusta, GA

Background: This report describes the unique treatment of a scaphoid fracture in a 17-year-old African-American collegiate

football player. During summer training, the athlete had difficulty using the right wrist and hand during any upper extremity weight bearing activity. The athlete reported having sustained an injury to the right wrist during his senior year of high school. On physical examination, he presented with tenderness over the right anatomical snuff box, a lack of full right wrist extension, and inability to bear weight through the right wrist. Based on these findings, the athlete was referred for further radiographic testing. **Differential Diagnosis:** non-union scaphoid fracture, lunate fracture/dislocation, lunate instability, Bennett's fracture. **Treatment:** Results from both the X-rays and MRI to the right wrist confirmed an unstable, non-union scaphoid fracture. Furthermore, the MRI did not show a collapse at the proximal pole of the scaphoid, suggesting no evidence of avascular necrosis. The athlete was referred to a hand specialist who stabilized the athlete's right scaphoid via percutaneous pinning with a 22-mm screw. Following surgery, the athlete began a 28-day course of the drug Forteo™ (750 mcg/3 mL SOL) via percutaneous injection. He received cast immobilization for the initial 4-week period followed by the customary scaphoid fracture management consisting of bone stimulation and progressive range of motion and strengthening exercises. At post-op month 2, the athlete exhibited improved right wrist function, with no side effects from the

drug, and signs of bone consolidation. He continued with range of motion and strengthening exercise for the next 2 months. At post-op month 4, the athlete was pain-free and demonstrated improved signs of bone consolidation. At this time, the athlete was fit with a custom-made, protective fiberglass splint and returned to full contact practice.

Uniqueness: This case report highlights the unique application of Forteo™ for the post-surgical treatment of a scaphoid fracture in an otherwise healthy collegiate athlete. Forteo™ is a drug shown to stimulate osteoblast activity and thus strengthen bone. It typically is prescribed for the treatment of osteoporosis in older adults who are at risk for bone fractures. The player in this case study initially presented with a non-union scaphoid fracture that had occurred a year earlier. Based on this presentation, the hand surgeon recommended a 28-day course of Forteo™ to promote bone strength. Following surgical stabilization, Forteo™ administration, and rehabilitation, the player returned to unrestricted impact activities in a timely manner. **Conclusion:** A scaphoid fracture is a challenging condition to manage due to its high incidence of non-union. Findings from this case report inferred that the addition of Forteo™ resulted in the consolidation of a non-union scaphoid fracture that a collegiate football player sustained a year earlier.

Free Communications, Thematic Posters: Landing Assessment in the Ankle & Knee Friday, June 19, 2009, 10:00AM-11:30AM, Room 214A; Moderator: J. Troy Blackburn, PhD, ATC

Contribution Of Knee Flexor/Extensor Strength On Sex-Specific Energy Absorption And Torsional Joint Stiffness During Drop Jumping

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

Context: Lower extremity injury often occurs during abrupt deceleration when attempting to change the body's direction. Sex differences in strength and biomechanics have been documented and are thought to be risk factors of acute injury. However, it is unknown if differences in thigh strength can affect sex specific energy absorption and torsional joint stiffness patterns during dynamic tasks. **Objective:** To determine sex differences in sagittal plane lower extremity energetics and joint stiffness and then determine if thigh strength predicted observed sagittal plane lower extremity energetics and joint stiffness within each sex. **Design:** Descriptive cohort design. **Setting:**

Laboratory environment. **Participants:** Recreationally active, college aged students (41 females, 40 males; 22.2 ± 2.8 yr, 1.70 ± 0.11 m, 69.9 ± 15.7 kg). **Intervention:** All measures were performed on the dominant leg (stance leg when kicking a ball). Knee flexor and extensor maximal voluntary isometric contractions (MVICs) on an instrumented dynamometer assessed thigh strength. Lower-extremity landing mechanics during the initial landing phase of double leg drop jumps (0.45m) were assessed with 3D electromagnetic motion sensors and an instrumented force platform. **Main Outcome Measures:** MVIC flexion and extension torques were normalized to body mass (Nm/kg). Hip, knee, and ankle sagittal plane energy absorption ($J \times BW^{-1} \times Ht^{-1}$) and torsional joint stiffness ($Nm \times BW^{-1} \times Ht^{-1/2}$) were calculated during the initial landing phase of the drop jump. Sex by joint repeated measures ANOVAs compared males and females on energy absorption and torsional stiffness. Sex specific linear regressions determined if thigh muscle strength predicted sagittal plane

landing energetics and stiffness at each joint. **Results:** Females absorbed significantly greater energy about the knee joint (Females = $0.05 \pm 0.02 J \times BW^{-1} \times Ht^{-1}$, Males = $0.03 \pm 0.01 J \times BW^{-1} \times Ht^{-1}$; $P < 0.05$) and had significantly less hip torsional stiffness (Females = $0.006 \pm 0.004 Nm \times BW^{-1} \times Ht^{-1/2}$; Males = $0.010 \pm 0.009 Nm \times BW^{-1} \times Ht^{-1/2}$; $P < 0.05$). In females, increasing knee extensor MVIC predicted greater knee energy absorption ($R^2 = 0.11$, $P < 0.05$), and increasing knee flexor MVIC predicted greater hip torsional stiffness ($R^2 = 0.12$, $P < 0.05$). No regressions were statistically significant ($P > 0.05$) for males. **Conclusions:** Sex-specific biomechanics during counter-movement activity revealed females used a strategy that attempted to decrease system stiffness through increased energy absorption about the knee and decreased stiffness at the hip. Additionally, female, but not male, strength patterns were predictive of knee energetics and hip stiffness during landing. These findings collectively suggest that the task may have been more difficult for females,

which resulted in a different movement strategy among those with different levels of thigh strength to safely complete the task. Future work is needed to better understand how differences in thigh strength may contribute to often-observed sex differences in landing mechanics. Supported by NIH-NIAMS Grant R01- AR53172

Sagittal Plane Kinematics In Individuals with Chronic Ankle Instability During Single Leg Jump Landing

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Context: Chronic ankle instability (CAI) commonly develops following lateral ankle sprain. Trunk position has been linked as a risk factor in lower extremity joint injury and has the ability to influence distal joint kinematics. Little is known about trunk motion in individuals with CAI. **Objective:** To determine if individuals with mechanical (MAI) or functional (FAI) ankle instability exhibit different sagittal plane kinematics of the ankle, knee, hip, and trunk compared to a control group during a single leg landing. We hypothesized MAI and FAI groups would demonstrate greater lower extremity and trunk extension during landing. **Design:** Cross-sectional. **Setting:** Biomechanics Laboratory. **Patients or Other Participants:** Thirty volunteer recreational athletes (3 groups; n=10 per group; 5 males, 5 females each). MAI: age 20.20±1.14 years, height 174.39±6.90 cm, mass 70.40±10.81 kg; FAI: age 20.20±1.55 years, height 177.57±9.80 cm, mass 74.32±10.32 kg; Control: age 20.00±1.54 years, height 172.79±8.77 cm, mass 66.94±10.17 kg. MAI and FAI groups had ≥2 episodes of ankle instability in the last year. MAI subjects had clinically lax lateral ankle ligaments while FAI and control subjects did not. **Interventions:** Maximum vertical jump in an anterior direction was measured. Retroreflective markers were attached to the body using a modified Helen-Hayes marker set. Participants were positioned 70cm from an in-ground force plate and asked to perform a vertical jump to 50% of their maximum. Participants landed on the involved leg and balanced for 3s. A 7-camera Vicon system (240Hz), synchronized with a forceplate (1200Hz), collected kinematics and kinetics. One-way ANOVAs tested for group differences and Tukey post-hoc testing was utilized with $\alpha=0.05$. **Main Outcome Measures:** Ankle, knee, hip, and trunk sagittal plane angles were identified 250ms pre-initial contact, at initial contact, and 1s after landing. Vertical ground reaction force was used to identify initial contact. Variables

were averaged over 10 trials. Participants also completed the Cumberland Ankle Instability Tool (CAIT). **Results:** Groups were not different in age, height, or weight ($P \geq 0.302$). The MAI (16.2±0.68) and FAI (17.7±1.01) groups had significantly lower CAIT scores ($P < 0.001$) than the control (29.6±0.27) indicating decreased function. The MAI group (5.71°±5.60) demonstrated greater knee flexion 250ms before initial contact than the FAI group (-0.63°±2.57) ($P=0.02$). The MAI group demonstrated greater trunk extension before (-12.45°±5.68), at (-13.22°±6.85), and 1s after initial contact (-13.56°±7.12) compared to the FAI group (-5.30°±4.08; -5.57°±3.99; -5.92°±3.88) ($P=0.023$; 0.022 and 0.029, respectively). No other group differences were noted. **Conclusions:** The MAI group demonstrated greater knee flexion and more trunk extension during a single leg landing than the FAI group. Despite reported functional differences at the ankle, only proximal joint kinematics were different between groups. Trunk position, including increased extension, may play a role in center of mass position and influence ankle injury mechanisms and stability after landing. Funded by a grant from the University of Georgia Research Foundation.

The Comparison Of Lower Extremity Energy Absorption Between Healthy And Chronic Ankle Instability Subjects During A Single Leg Drop Landing

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Brigham Young University, Provo, UT

Context: Chronic ankle instability (CAI) may alter how lower extremity joints and muscles absorb energy. The demands placed on proximal joints and muscles may increase with altered lower extremity energy absorption. **Objective:** To determine if the lower extremity joints in CAI subjects absorb energy different than healthy subjects during a single leg drop landing. **Design:** Two group cross-sectional study. **Setting:** Controlled laboratory setting at the BYU Human Performance Research Center. **Participants:** Thirty (11 males, 19 females) physically active college aged subjects volunteered. Fifteen subjects were assigned to the healthy group (age = 21.2±2.0 yrs, height = 174.7±9.2 cm, mass = 65.1±11.4 kg) and 15 to the CAI (age = 22.5±4.3 yrs, height = 173.3±8.1 cm, mass = 75.4±13.9 kg) group. The self-reported answers subjects provided to the Ankle Instability Index determined if subjects qualified for the CAI group. Subjects with no history of lower extremity injury (last year) or surgery (last two years) were included in the healthy group. Healthy subjects were

matched by leg dominance (stance leg when kicking a ball) with a CAI subject. **Interventions:** The independent variable was group assignment. Subjects performed five practice single leg drop landings on their dominant leg from a height of 35 cm. Data were collected from the next three drop landings. Energy absorption was analyzed from initial contact until the mechanical power (torque x angular velocity) curve became positive. The integral of mechanical power (negative work) indicated the net energy absorbed by muscles surrounding each joint. **Main Outcome Measures:** The dependent variable was energy absorption of the ankle, knee, and hip joints. Each joint's energy absorption was calculated for the three data collection drop landing trials. The mean of those three trials was used for statistical analysis. A one-way ANOVA determined if energy absorption of the lower extremity joints differed between groups. **Results:** Mean energy absorption values were calculated for the ankle (healthy: 38.1%±13.4, CAI -42.6%±21.8%), knee (healthy: 45.7%±14.8%, CAI - 50.0%±24.8%), and 8.3%±13.7%). Energy absorption at the ankle ($F_{1,28} = .198, P = .660$), knee ($F_{1,28} = .406, P = .529$), and hip ($F_{1,28} = 3.371, P = .077$) joints were not different between groups. **Conclusions:** No lower extremity energy absorption difference was observed between healthy and CAI subjects. Although the hip energy absorption data of CAI subjects suggested a trend towards decreased energy absorption during a single leg drop landing compared to healthy subjects. The observed trend suggests further research is needed to understand how CAI may affect proximal joint and muscle energy absorption. Future research is needed to assess this trend and to determine if CAI subjects can learn to increase hip joint energy absorption through an intervention.

Effect Of Instructions On Lower Extremity Muscle Activation During Landing

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Context: We have previously reported that changing landing strategies modifies lower extremity biomechanical parameters, possibly influencing non-contact Anterior Cruciate Ligament (ACL) injury risk. Further, landing with higher quadriceps and lower hamstring contractions has been

suggested to increase ACL injury risk. However, little research exists examining the effect of instructions on lower extremity muscle activation during landing. **Objective:** To examine the influence of a single instructional session on lower extremity muscle activation when landing in different styles. **Design:** Within-subject **Setting:** Controlled laboratory **Participants:** Twenty healthy volunteers (10M, 10F; 23.4±3.6yrs, 171.0±9.4cm, 3.3±12.7kg) **Interventions:** Participants were instructed to perform 5 single-leg landings each from a box (M = 45cm; F = 30cm) in 3 styles; 1) self-selected (SS); 2) leaning slightly forward (LF), and 3) with the upper body as upright as possible (UR). Sufficient practice was allowed for familiarization with the landing styles. Surface electromyography (sEMG) data were obtained from the medial and lateral gastrocnemius (MG, LG), medial and lateral quadriceps (MQ, LQ) and, medial and lateral hamstring muscles (MH, LH). Separate one-way repeated measures ANOVAs ($p=.05$) examined differences in muscle activity between landing styles, with Bonferroni pairwise comparisons with corrections when needed. **Main Outcome Measurements:** Peak muscle amplitudes (μV) were recorded over a 100 ms period post touchdown. sEMG signals were filtered using a centered RMS algorithm (25 ms time constant). The ensemble average of 5 trials for each RMS window was used for analyses. **Results:** Significant differences across landing conditions were observed for the MG ($p = .004$; SS=.49±.21, LF=.57±.21, UR=.46±.25), MQ ($p = .004$; SS=1.26±.62, LF=1.02±.52, UR=1.42±.92), and LH ($p = .03$; SS=.71±.63, LF=.51±.55, UR=.70±.58), but not for the LG ($F_{2,38}=.73$, $p = .49$; $\eta^2=.06$, 1-b=.17; SS=.59±.31, LF=.56±.27, UR=.53±.23), LQ ($F_{2,38}=3.14$, $p = .06$; $\eta^2=.14$, 1-b=.60; SS=1.22±.69, LF=1.08±.47, UR=1.31±.71), and MH ($F_{2,38}=1.77$, $p = .19$; $\eta^2=.09$, 1-b=.35; SS=.71±.63, LF=.51±.55, UR=.70±.58). Bonferroni pairwise comparisons indicated significantly lower activations of the MQ in LF landings as compared to SS and UR landings, and in SS landings as compared to UR landings. Lower activation levels of the LH were noted in LF landings as compared to SS landings. **Conclusions:** Although leaning forward landings resulted in changes in activations in some muscles (medial quadriceps and lateral hamstring), no clear changes were observed in other muscles. Our results suggest that a single session instructing individuals to land in a specific style may not be enough to alter their muscle activation patterns during landing. What specific neuromuscular training methods should be used and how long the training should be performed to alter lower extremity muscle

activation patterns is still unknown and should be further investigated.

Differences In Knee Stiffness Regulation During Drop Jumps From Unknown Heights

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Context: Functional knee stability can be described by stiffness measures, which quantify the resistance of a joint to changes in position. Muscle recruitment increases joint stiffness, protecting ligamentous structures from excessive loads. However, previous studies have demonstrated that muscle activation is attenuated when visual feedback is impaired and that visual-spatial skills are associated with the unanticipated errors in coordination leading to non-contact knee injuries. No direct evidence exists linking visual feedback with altered stiffness regulation strategies during functional activities. **Objective:** The purpose of this study was to determine if stiffness regulation strategies are altered during unanticipated drop-jumps from unknown heights. **Design:** One-group repeated measures design. **Setting:** Controlled laboratory setting. **Patients or Other Participant:** Twenty-one healthy collegiate football players participated (age=19.4±1.1yrs, mass=101.1±21.8kg, height=186.8±7.5cm). **Interventions:** The independent variables were knowledge of the drop jump height (full vision, no vision) and 2 drop heights (50 cm control height, 35 cm early landing height). Subjects stood on a hydraulic lift platform (Central Hydraulics, Inc.), self initiated a drop on an AMTI force plate (Watertown, MA), landing on both legs with a toe heel sequence and then jumped vertically as quickly and high as possible. Subjects performed 12 jumps with height and vision condition randomized. Reflective markers defined the trunk, thigh, lower leg, and foot segments and were recorded (240Hz) with an 8 camera (Eagle Cameras; Motion Analysis Corp., Santa Rosa, CA) system. Kinematic and kinetic data was imported into Visual3d software (C-motion, Inc., Rockville, MD) using Euler angles and net joint moments (internal) for data reduction and calculation of knee stiffness. A 2-way ANOVA was performed on knee stiffness. **Main Outcome Measures:** The dependent variable was knee stiffness (Nm/kg/degree) determined as the change in knee moment (normalized to body mass) divided by the flexion angle from ground contact to maximum knee flexion. **Results:** Knee stiffness was significantly decreased during the no vision conditions (vision mean = 0.043±0.022 Nm/kg/deg, no vision mean =

(0.030±0.017 Nm/kg/deg $P=0.0001$). No significant differences were observed between drop jump heights (50cm height mean = 0.035±0.019 Nm/kg/deg, 35cm height mean = 0.038±0.018 Nm/kg/deg, $P = 0.14$) and no interactions were observed. **Conclusion:** This data suggests that the lack of sufficient visual-spatial awareness impairs the normal anticipatory knee stiffening strategy necessary for performing coordinated functional activities. A decrease in knee joint stiffness during a drop jumps from unknown heights suggests this methodology may simulate the biomechanical aberrations describing non-contact knee injuries where sudden “buckling” or “giving way” into rapid knee flexion occurs shortly after ground contact.

Differences In Lateral Drop-Jumps From Unknown Heights Among Individuals With Ankle Instability

Rosen AB, Swanik CB, Kaminski TW, Thomas SJ, Knight CA: University of Delaware, Newark, DE

Context: Ankle instability (AI) is a debilitating condition that occurs after 20-50% of all sprains. Landing from a jump is one of the main causes of ankle injury, yet literature is lacking on lateral jumping maneuvers that explore the role of visual cues and anticipatory muscle contractions, which may influence functional stability. **Objective:** The purpose of this study was to examine electromyographic (EMG) activity of the tibialis anterior (TA), peroneus longus (PL) and lateral gastrocnemius (LG) muscles in unstable and stable ankles during lateral drop-jumps from unknown heights. **Design:** Posttest only control group. **Setting:** Controlled, laboratory setting. **Patients or Other Participants:** Forty subjects participated. Twenty subjects with unstable ankles qualified for the unstable group with a Cumberland Ankle Instability Tool (CAIT) score of 24.5 or below (age=20.9±2.3 yrs, mass=76.2±16.2 kg, height=173.1±8.1cm, CAIT=20.4±4.15). Twenty matched (age, gender, ankle) subjects without ankle sprains (CAIT score of 29 or 30) were controls (age=20.6±2.4 yrs, mass=75.6±18.5 kg, height=173.9±9.9 cm, CAIT=29.8±.52). **Interventions:** Independent variables were instability, vision, and jump height. MANOVAs were used to establish mean differences between EMG activity of the TA, PL, and LG muscles. An 8-channel Konigsberg EMG transmitter was used for collection. Subjects performed lateral jumps off a platform, set to heights of either 35cm or 50cm, onto a force plate, followed by an immediate jump for maximum height. stable ankles (4.79±4.76%ms, $p<.050$) and reactive

TTP (unstable TTP 161±41ms, stable 141±47ms, $p<.047$). Significantly decreased or latent EMG was observed across all eyes closed conditions in the TA (preparatory area: open 1.30±1.67%ms, closed 82±.955%ms, $p<.028$; preparatory peak: open 18.54±14.28%, closed 14.77±15.85% $P<.019$), PL (reactive area: open 6.09±10.48%ms, closed 4.45±9.2%ms, $p<.007$; reactive peak: open 64.61±101.61%, closed 41.71±61.67% $p<.021$; reactive TTP: open 128±44ms, closed 141±49ms, $p<.024$) and LG (reactive area: open 5.65±10.44%ms, closed 3.23±5.74%ms, $p<.050$). No significant differences were observed between heights. **Conclusions:** By removing visual cues, unanticipated lateral joint loads occur simultaneously with decreases or delayed muscle activity, which reduces ankle stiffness and dynamic restraint capabilities. Patients with unstable ankles exhibit even greater TA inhibition, which may limit talonavicular stability and intensify lateral joint surface compression and pain. Patients with AI may also present with a confounding overreliance on visual information during functional activities.

The Relationship Between Lower Extremity Kinematics And The Landing Error Scoring System

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Context: The Landing Error Scoring System (LESS) is a valid and reliable lower extremity movement screening tool used to identify faulty movement patterns that are theorized to lead to anterior cruciate ligament (ACL) injury. However, it is unclear which faulty movement patterns most influence LESS scores. It is important to understand which kinematic variables are most predictive of total LESS score to better guide injury prevention programs. **Objective:** To identify the hip and knee kinematic variables that influence total LESS score. **Design:** Correlational. **Setting:** Field Laboratory. **Participants:** Forty-five (27 male, 18 female, age=15.5±1.3 years; height=175.0±11.9cm; mass=68.5±10.8kg) high school basketball players volunteered for the study. **Interventions:** Three-dimensional hip and knee kinematics during a jump-landing task were collected using an electromagnetic tracking system synched with a non-conductive force plate. The task consisted of jumping from a 30-cm high box set at a horizontal distance of 50% of the participant's height away from the force plate, and upon

landing, jump vertically for maximum height. Sagittal and frontal plane views of the task were captured using two mini-DV cameras. Each participant performed three trials of the jump-landing task. The LESS is scored using a binary system (0=no error, 1=error) based on several jump-landing characteristics including knee flexion angle, knee valgus angle, trunk flexion angle, foot position, and stance width. A higher LESS score indicates a greater number of errors committed, and thus poor jump-landing technique. **Main Outcome Measures:** Peak three-dimensional hip and knee kinematics were determined during the stance phase (initial contact to toe off) of the jump-landing task. The average of the three trials of total LESS score and peak hip and knee kinematics were used for the data analysis. Pearson product-moment correlations were performed to determine the relationship between hip and knee kinematics and total LESS score during the jump-landing task ($\alpha\leq 0.05$). A forward stepwise multiple regression analysis was performed to determine the combination of hip and knee kinematics that were most predictive of total LESS score ($\alpha\leq 0.05$). **Results:** Decreased knee flexion angle ($r=-0.378$, $P=0.005$), increased knee valgus angle ($r=0.418$, $P=0.002$), and decreased hip flexion angle ($r=-0.429$, $P=0.002$) were significantly correlated with increased total LESS score. The regression analysis revealed that a combination of knee valgus and hip flexion angles was most predictive of total LESS score ($R^2=0.398$, $P<0.001$). **Conclusions:** These results show that 40% of the variance in total LESS score is explained by knee valgus and hip flexion angles during the stance phase of the jump-landing task. Clinicians should consider using the LESS to identify athletes with faulty movement patterns, which may predispose them to lower extremity injury such as ACL rupture.

Knee Proprioception And Strength Correlate To Knee Flexion Angle During A Landing Task

Nagai T, House TJ, Deluzio JB, Lawrence DM, Lovalekar MT, Sell TC, Abt JP, McGrail M, Lephart SM: University of Pittsburgh, Pittsburgh, PA

Context: Tactical performance and prevention of knee injuries during dynamic landing tasks requires afferent information from joint mechanoreceptors about joint position, kinesthesia, and sense of heaviness, as well as adequate muscular strength to attenuate large impact forces. In order to design better physical fitness training for the Soldiers and to minimize unintentional musculoskeletal injuries, understanding the

relationship between those variables would be beneficial. **Objective:** To investigate the relationship between knee proprioception, strength, and knee flexion angle during a landing task. **Design:** Descriptive Laboratory Study. **Settings:** Human Performance Research Laboratory. **Patients or Other Participants:** Convenient sample of 50 healthy male Soldiers of the 101st Airborne Division (Age: 26.4±5.8 yrs; Height: 176.5±8.0 cm; Mass: 79.8±16.6 kg). **Interventions:** Knee flexion and extension conscious proprioception measured as threshold to detect passive motion (TTDPM) was performed on an isokinetic dynamometer at 45° flexion and 0.25°/s. Subjects wore a compression boot, were blindfold, and listened to static noise in order to eliminate extraneous cues. Subjects were instructed to press a stop-button when they first felt limb movement and were then able to detect the direction of movement. The arc between the initial and final positions was reported as TTDPM. Subjects performed a total of five trials for each direction (order of direction was randomized). Isometric knee extension and flexion strength was evaluated at 45° flexion with the isokinetic dynamometer. Landing kinematics were evaluated using a 3D motion analysis system while subjects performed three single-leg stop-jumps at a distance 40% of their height from the force plate. Knee flexion angles at initial contact and maximum knee flexion angle were calculated. **Main Outcome Measurements:** TTDPM toward flexion and extension direction, isometric knee extension and flexion strength, knee flexion angles at initial contact and maximum knee flexion angles during a single-leg stop-jump task. Due to the nature of TTDPM data (positively skewed), a nonparametric correlation, Spearman's rho, was used to evaluate the relationship. P-value was set at 0.05. **Results:** The following pairs were significant: TTDPM and initial knee flexion (TTDPM Flexion: rho = -0.318, $p=0.024$; TTDPM Extension: rho = -0.349, $p=0.013$), knee strength and knee flexion angle at initial contact (Flexion Strength: rho=0.392, $p=0.005$; Extension Strength: rho=0.335, $p=0.018$), and knee strength and peak knee flexion angle (Flexion Strength: rho=0.447, $p=0.001$; Extension Strength: rho=0.465, $p=0.001$). **Conclusions:** Enhanced knee proprioception and increased knee strength was associated with greater knee flexion angle at initial contact. Greater knee extensor strength was also associated with peak knee greater knee strength, and greater initial and peak knee flexion are inter-related and may play a vital role in unintentional musculoskeletal injury prevention for the Army Soldiers.

Lower Extremity Muscle Activation Influences Knee Flexion Angle During A Jump-Landing Task

Walsh MC, Padua DA, Blackburn JT, McGrath ML, Boling MC: University of North Carolina, Chapel Hill, NC, and University of North Florida, Jacksonville, FL

Context: Non-contact anterior cruciate ligament (ACL) injuries are common in athletics. Decreased knee flexion angle and high quadriceps muscle activity are known to increase ACL loading, and may increase ACL injury risk. However, the relationship between knee flexion angle and activation of multiple lower extremity muscles has not been defined. **Objective:** To determine the relationship between lower extremity muscle activity and knee flexion angle during a jump-landing task. **Design:** Single-group correlational design. **Setting:** Research laboratory. **Patients or Other Participants:** Volunteer sample of thirty recreationally active participants (15 males, 15 females, age=21.63±2.01 years, height = 173.95±11.88cm, mass=72.57±14.25kg). **Interventions:** Surface electromyography (EMG)

of the gluteus maximus (GM), vastus medialis oblique (VMO), vastus lateralis (VL), biceps femoris (BF), and lateral gastrocnemius (LG), and sagittal plane knee motion were collected as participants performed 10-trials of a jump-landing task. **Main Outcome Measures:** GM, VMO, VL, BF, and LG activation were normalized to a 3-second MVIC. Knee flexion angle at initial contact (IC), peak knee flexion angle, and knee flexion displacement were determined during the stance phase of the jump-landing task (IC to toe off). Mean EMG activity was calculated during the preactivation (200ms prior to IC) and deceleration (IC to peak knee flexion) phases. Quadriceps:hamstring ratio (Q:H ratio) was calculated as the mean VMO and VL EMG amplitude divided by the corresponding value for the BF. Separate bivariate correlations and multiple regression analyses were performed to determine the association between knee flexion angle and lower extremity muscle activity ($p \leq 0.05$). **Results:** VMO and GM activity, and Q:H ratio during the preactivation phase were negatively correlated with knee flexion angle at IC (VMO: $r = -0.385$, $P = 0.045$, GM: $r = -0.385$, $P = 0.043$, Q:H ratio: $r = -0.442$, $P = 0.018$). VMO, VL, and GM activity

during the deceleration phase were negatively correlated with peak knee flexion angle (VMO: $r = 0.687$, $P = 0.01$, VL: $r = -0.467$, $P = 0.011$, GM: $r = -0.386$, $P = 0.043$). VMO and VL activity during deceleration were negatively correlated with knee flexion displacement (VMO: $r = -0.631$, $P = 0.001$, VL: $r = -0.453$, $P = 0.014$). Regression analyses revealed that Q:H ratio and GM activity predicted 34.7% of variance in knee flexion angle at IC ($P = 0.006$), VMO activity predicted 47.1% of variance in peak knee flexion angle ($P = 0.001$), and VMO and VL activity predicted 49.5% of variance in knee flexion displacement ($P = 0.001$). **Conclusions:** Based on these results, decreased sagittal plane knee motion is related to increased activation of the quadriceps and GM musculature. Increased activation of the hip and knee extensors may facilitate a more erect body posture, possibly predisposing individuals to ACL injury. Interventions which increase sagittal plane knee motion may be effective for ACL injury prevention by influencing both knee kinematics and muscle activation patterns.

Free Communications, Oral Presentations, Case Reports: Lower Extremity

Friday, June 19, 2009, 4:30PM-6:00PM, Room 214A; Moderator: Beth Hubbard, MS, ATC

Treatment Of Chronic Patellar Tendinopathy Using Platelet-Rich Plasma In A Male Division I Athlete

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Background: This report presents a case of chronic patellar tendinopathy treated with platelet-rich plasma (PRP). A division I male basketball player (height=203.2 cm, weight=93.2 kg) had chronic anterior knee pain for 3 years, with tenderness at the inferior pole of the patella. The athlete's pain was severe enough to limit performance and was reported at 8/10. **Differential Diagnosis:** Patellar tendinopathy, Larsen-Johansson disease, and infrapatellar bursitis can all cause pain at the inferior pole of the patella. **Treatment:** An MRI revealed thickening of the patellar tendon with extensive increased intrasubstance signal consistent with hypertrophic patellar tendinitis. He was treated conservatively with rehabilitation, McConnell taping, patellar tendon strapping, anti-inflammatories, and modification of his activities. After 3 months of treatment and no progress, the athlete was re-examined. A diagnostic ultrasound showed increased thickness consistent with tendinopathy. At

this time, the decision was made to do a needle-guided ultrasound PRP injection of the patellar tendon. Prior to the procedure, a blood sample was taken from the athlete and processed to extract only the part of the plasma that contains a high concentration of platelets. Using ultrasound needle guidance, the autologous plasma coagulate was infused into the patellar tendon. Following the procedure, the athlete was full weight-bearing, took pain medication as needed and applied ice to his knee every three hours. Five days after the injection, the athlete had no pain with ambulation and had only mild edema over the tendon. The athlete described his pain level at 5/10 with complaints of tightness of the patellar tendon. The athlete began a daily rehabilitation program with the athletic training staff that included light biking, hamstring and hip flexibility, and straight leg raises. Eleven days after the procedure, the athlete was allowed to participate in a light practice. The athlete was able to run, cut, plant, and shoot without problems. His pain level however remained at 5/10. Three days later, the athlete complained of being very sore after 20 minutes of practice. This necessitated a decrease in on-court activity for several days. The athlete continued with

the daily rehabilitation program in the athletic training room. Approximately 3 weeks after the procedure, the athlete had progressed to the point that he was allowed to start limited practicing with the team. Although the athlete reported a marked reduction in pain following the PRP procedure, his current level of pain was limiting his performance. The athlete declined anything other than conservative treatment until the end of the basketball season. Four months after the initial PRP injection, a diagnostic ultrasound revealed an osteophyte at the inferior pole of the patella. Tendon width was measured to be 1.17cm in the affected knee and .48cm in the unaffected knee. The increased thickness was due to fibrotic scar tissue. A second PRP injection was completed using the same technique described above. Three weeks after the treatment, the affected and unaffected patellar tendons were similar in size. The athlete rated his pain at 2/10 at the most and was able to play basketball and lift weights with no issues other than some residual soreness. **Uniqueness:** This case study presents a unique treatment protocol for chronic patellar tendinopathy using PRP. There is little published research examining the use of PRP as a treatment for patellar tendinopathy.

Conclusions: The use of PRP is a promising option for treatment of chronic patellar tendinopathy. Platelets contain powerful growth factors, which promote tissue repair and regeneration. Clinicians should be aware of this option when conservative management has failed.

Bilateral Popliteal Artery Entrapment Syndrome

Buselli ML, Vesci BJ: Boston University, Boston, MA

Background: This case presents a twenty-year-old female Division I field hockey player with a mass of 68 kg and a height of 165 cm. The patient, currently a junior, has been suffering from lower leg pain since the fall of her freshman year, concurrent with the onset of her collegiate career. Upon initial evaluation, relevant medical history included extensive diagnostic testing, rehabilitation and three surgical interventions leading to the release of all lower leg compartments bilaterally. Patient denies symptoms prior to her collegiate career, is a non smoker, and possesses no other cardiovascular risk factors. **Differential Diagnosis:** Medial tibial stress syndrome, tarsal tunnel syndrome, stress reaction, nerve entrapment, acute or chronic exertional compartment syndrome, popliteal artery entrapment syndrome (PAES). **Treatment:** The patient initially presented freshman year with bilateral non-descript lower leg pain. Chief complaint consisted of “tightening” in lower leg musculature during exertion with distal sensation deficits. An EMG ruled out tarsal tunnel syndrome with potential damage to the posterior tibialis nerve. Pressure readings confirmed exertional compartment syndrome leading to the first surgical intervention performed on the left lateral compartment. Six weeks following the surgery the anterior compartment of the right lower leg was released. However, increased exertion resulted in the return of symptoms. New complaints of numbness and tingling arose identifying the need for further testing. After completing non invasive vascular studies, the patient underwent a subsequent procedure releasing the remaining compartments bilaterally. Two months following this procedure the patient returned to running with success in short intervals. Consequently, with increased durations of running, similar symptoms manifested within the distal musculature. The patient was then fitted with custom orthotics for correction of foot biomechanics. This intervention offered some symptomatic relief allowing her to participate in the fall season her sophomore year. Persistent pain again raised questions of vascular compromise. The patient had non-

invasive vascular studies pre and post exercises in conjunction with bilateral knee MRI to rule out popliteal artery entrapment. Studies continued into fall of junior year when an angiogram with and without maneuvers revealed the diagnosis. The patient was diagnosed with a possible type 6 functional popliteal entrapment, a mixture of muscle hypertrophy and small anatomical abnormalities. In addition, it was inferred she had suffered thrombosis of arteries in the ankle region, affecting collateral circulation. Numbness and tingling symptoms were explained by acute loss of blood supply. Two years following initial onset of symptoms the patient underwent explorative/curative surgery that revealed a tight retinacular band on both limbs. The band spanned two by four centimeters bridging the popliteal fossa. This accessory slip was divided along with a tendinous sling of the soleus muscle. The medial head of the gastrocnemius was released. Furthermore, the popliteal artery, vein, and tibial nerve were dissected free from the soleus tendon. Following rehabilitation the patient returned to full activity. **Uniqueness:** This case fails to assume one identity within the standard classification of PAES. Rather, this patient portrays a combination of medial gastrocnemius entrapment syndrome in conjunction with an accessory slip. Furthermore, PAES has previously been diagnosed more frequently in males in their late twenties to late thirties. However, it appears PAES has now become a differential diagnosis in the collegiate population. **Conclusion:** Due to the complex nature of this pathology it initially went undiagnosed. When evaluating chronic lower leg pain, this case illustrates the importance of ruling out devascularization due to popliteal artery entrapment. This diagnosis may be rare in the general population of females in this age group; however, perhaps due to functional physiological changes, it may become more prevalent in the athletic population.

Anteromedial Thigh Pain In A Collegiate Cross Country Runner

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Background: An 18 y/o male freshman cross country athlete at the University of Kentucky presented to training room with a complaint of anteriomedial pain over the middle 1/3 of his left thigh. The athlete was running approximately 70 miles per week when he presented, and his previous high for mileage per week was approximately 50. The athlete kept a daily log of his running, whereby a graph of the athlete's average seven day

mileage was created. The graph shows that the athlete maintained his seven day average mileage at around 70 miles per week for approximately 2 months. Prior to the athlete coming to see the ATC, he had his highest seven day average mileage to date. The athlete stated that the pain began approximately one week prior and had progressively worsened. During physical exam he presented with no edema or point tenderness of the thigh. His strength was 5/5 for all muscle groups although he did note some pain with adduction and internal hip rotation. The athlete was instructed to alternate cross training and running days for one week. A stretching/strengthening protocol was initiated and the athlete was given over the counter non-steroidal anti-inflammatory medication. After one week of initial treatment, the athlete underwent orthopaedic evaluation due to failure to progress. **Differential Diagnosis:** Adductor longus/brevis/magnus strain; vastus medialis strain; sartorius strain; femoral stress fracture. **Treatment:** A pelvic and femur X-ray did not show any signs of fracture. Non-operative treatment with NSAIDS and alternated cross training and running were continued for another week, at which time, symptoms continued to worsen. At this time an MRI of the left thigh was obtained. The MRI revealed extensive marrow edema of the femoral shaft and periostitis along the insertion of the adductor tendons (Primarily the adductor longus, with adductor magnus also potentially involved.) The athlete was diagnosed with “thigh splints” or adductor insertion avulsion syndrome. **Uniqueness:** A review of the literature indicated that there have been few reported cases of thigh splints. One report of interest described seven female military recruits with thigh splints, and in five of those seven cases, the condition occurred bilaterally. **Conclusion:** The findings in this athlete explain the continuum between thigh splints and femoral stress fracture. The radiographic and MRI findings as well as clinical presentation are very similar if not identical. A sudden increase in training volume and intensity such as in this case, has been reported to be a factor for the development of femoral stress fracture. In this case it caused the onset of thigh splints and was detected before the development of a femoral stress fracture. After allowing adequate rest and gradually returning to running, the athlete was able to have a successful outdoor track season. By monitoring the athlete's mileage closely as he returned to running, he is now capable of handling weekly mileages that are comparable to his mileage at the onset of injury. The use of the athlete's mileage chart was a very useful tool to make sure the athlete was not progressing back too quickly to full activity.

Similar charts would be useful to athletic trainers who are returning injured athletes to full participation. Had early diagnostic tests not been done, it is possible that the athlete could have developed a femoral stress fracture and would have resulted in a much longer recovery time.

Pre-Injury, Post-Injury, And Post-Surgery Hip And Knee Kinematics Of A Place Kicker Suffering An ACL Tear
Tritsch AJ, Milligan MD, Rubley MD, Holcomb WR: University of Nevada at Las Vegas, Las Vegas, NV

Background: This case report details the findings in a 21 YO male Division I left footed place kicker who suffered a traumatic ACL rupture with concomitant meniscal and MCL injury in his kicking leg during kickoff coverage. On the field assessment by the athletic trainer revealed a positive Lachman's, anterior drawer, and valgus stress test. Athlete reported no history of previous knee injury. After three weeks of rehab the athlete was able to return to place kicking in an ACL derotational brace without surgical intervention. Postseason the athlete underwent ACL reconstruction with meniscal debridement. The athlete participated in a study prior to the injury allowing the unique opportunity to analyze kinematic data pre-injury, post-injury and following recovery from reconstructive surgery. Three-dimensional kinematic data were collected using a 12-camera Vicon™ Motion Analysis system (v. 4.6, Oxford Metrics, Oxford, UK) at a sampling rate of 120 Hz. The subject performed 10 trials at each collection. In this report we compared motion analysis data collected pre-injury, to similar data obtained upon return to kicking but prior to ACL reconstruction and data obtained after rehabilitation following ACL reconstruction.

Differential Diagnosis: Sprained ACL, PCL, MCL, meniscal tear, osteochondral defect, patellar dislocation, tibial plateau fracture. **Treatment:** MRI revealed full thickness tear of the ACL, MCL, a mild sprain of the PCL, and torn posterior horn of the lateral meniscus. Post-injury the athlete's case was addressed with him in detail by university team physicians and athletic training staff. The athlete was adamant to attempt a return to kicking in the same season. Thus after consideration the athlete was allowed to undertake an aggressive rehabilitation program for the injured knee with the athletic training staff. The athlete was able to return to place kicking three weeks post-injury. Post-season arthroscopy confirmed MRI findings and the athlete underwent bone-patella tendon-bone allograft reconstruction

of the ACL and debridement of the meniscal injuries. Post-surgical rehabilitation under the direction of the athletic training staff was completed and athlete returned to full activity the following season. **Uniqueness:** To our knowledge this is the only study of kicking mechanics of a place kicker pre-injury, pre-surgery and post-surgery with an acute ACL injury. This data provides interesting information regarding the compensatory mechanisms of a high level kicker. Results revealed kicking leg hip flexion angles decreased by nearly 35° from pre-injury to pre-surgery, while hip extension angles increased by 11°. Pre to post surgery values showed an increase in hip flexion of 8° while hip extension increased by an additional 7°. Knee flexion and extension angles stayed within 6° across the three collection times. Plant leg hip flexion values decreased nearly 15° from pre-injury to pre-surgery, while hip extension angles increased almost 52° from 43.3° to -8.6°. Pre and post surgery values stayed more consistent, a 5° decrease in hip flexion and 7° increase in hip extension. Knee flexion angles from pre-injury to pre-surgery decreased by 30° while knee extension angles over the same period decreased by 13°. From pre-surgery to post-surgery there was a 17° increase in knee flexion and a 3° decrease in knee extension. **Conclusions:** This athlete seemed to adopt a compensatory adjustment of both his kicking and plant leg kinematics after tearing his ACL and after surgery. Post injury the athlete's plant leg hip extension angle greatly increased while knee values remained relatively similar. The injured kicking leg showed increased max hip extension and knee flexion, while there was a decrease in hip flexion and knee extension. Authors postulate this was an attempt to overcome quadriceps weakness associated with ACL injury by increasing ROM, possibly increasing limb velocity and force at ball contact.

Bilateral Deep Posterior Exertional Compartment Syndrome In A Collegiate Volleyball Athlete: A Clinical Case Study

Peterson TD, Hartsell HL: Barton College, Wilson, NC

Background: An 18-year-old female volleyball player first reported to ATC after having severe pain in both calves. Initially, pain was located at the musculotendinous junction of each calf moving superiorly toward the mid-calf region. Athlete reported pain to be worse during exertional activity and soreness could last into the next day. Athlete stated that in the evening she would experience leg cramps at rest. Athlete continued

with her season, however, pain began to be evident during activities such as lower body lifting, calf raises, and jumping; progressing to the point she could not complete a full workout. **Differential Diagnosis:** Muscle Cramps, Muscle Strain, Superficial Posterior Compartment Syndrome, Deep Posterior Compartment Syndrome, Stress Fracture and/or Shin Splints. **Treatment:** In her first season, athlete was treated with ice and stretching before, during, and after practices and games as needed. Thermal modalities were not used prior to activity because athlete reported it would make her symptoms worse and occur more rapidly. It was recommended by a physician for her to start consuming multivitamins, mustard before activity, quinine water, and then possible lab work. In the spring, symptoms continued so she was referred to a physician to test for compartment syndrome. Signs and symptoms were not present during clinical exam so athlete was not tested. She continued with sub-maximal workouts throughout spring and summer as tolerated. In the fall of her second season, symptoms worsened, limiting her playing time. Thermal modalities were introduced after two weeks because athlete reported feeling better with this treatment. However, she still had similar episodes so cryotherapy and stretching were used when symptoms arose. Athlete was referred back to the physician at the beginning of September where he performed an intracompartmental pressure test in the posterior compartment. Results were negative; however, swelling and hardness were witnessed in her lower legs after the exertional test. She was then referred to a Lower Leg Specialist who initially ordered a bone scan to rule out injuries such as stress fractures and shin splints. Results were negative. Athlete returned to the physician in mid-October where an intracompartmental pressure test was performed specific to the deep posterior compartment. Results were positive for increased pressure after exertion. In December, athlete had bi-lateral fasciotomy of the deep posterior compartment. Athlete completed rehabilitation in August and successfully completed her third season. **Uniqueness:** While deep posterior compartment syndrome is second in occurrence to anterior compartment syndrome, it is most often seen in aerobic athletes, including runners and soccer players. As a collegiate volleyball player, the athlete mainly participated in anaerobic activity, causing all the symptoms of chronic compartment syndrome, which is not typical. This case is also unique in that the athlete's response to treatments changed over time. Initially, as in most cases of compartment syndrome, heating the area caused more pain

and more problems. After a year of treating the symptoms without heat, thermal effects began to make the area feel better, even though symptoms were still present. In addition, the athlete's symptoms would begin to resolve shortly after cessation of activity, however they would often return later after no additional exertion. **Conclusion:** Chronic Compartment Syndrome can present in any of the four compartments in anaerobic athletes as well as aerobic athletes. As athletic trainers, we need to be able to recognize all the signs and symptoms of compartment syndrome, even atypical ones. If any signs and symptoms continue over time and treatments are not working, persistence in testing is necessary to rule out any and all injuries.

A Maisonneuve Fracture In A Collegiate Football Player

Zema MS, Siple BJ, Deachilla PC, Pippin RM, Winkelspecht AN, Jones CM, Litsinger KR, Seiler BD: Slippery Rock University of Pennsylvania, Slippery Rock, PA

Background: The objective of this case study is to present an athlete who sustained the rare occurrence of a Weber C and

Maisonneuve Fracture of his ankle during a collegiate football game. A Weber C Fracture consists of a fibular fracture above the syndesmosis. This case study focused on a Weber C Fracture with associated medial joint space widening and soft tissue injury in a collegiate athlete. The athlete was a 22 year old, African American male who was a linebacker of a Division II varsity collegiate football team. The athlete had no previous medical history to the involved lower leg and ankle. The injury occurred in-season during a game. During play on an artificial turf field, an opponent rolled onto the athlete's left leg while foot was in a fixed position. The initial on-field evaluation revealed gross deformity with obvious ankle dislocation. The athlete's chief complaint was pain and an inability to move the left ankle. During further evaluation, he presented with skin intact, normal neurovascular tests, and crepitus of the fibula. **Differential Diagnosis:** In this particular case, possible injuries included tibial fracture, grade 3 eversion ankle sprain with rupture of deltoid ligament and lateral ligaments, syndesmotom sprain, tibial plafond fracture, and avulsion fracture. **Treatment:** Directly following the injury, the ankle was reduced on field by the team's orthopedic surgeon, and immobilized with a walking boot. The

athlete was provided crutches and strictly instructed to avoid any weight bearing. He was then transported for x-rays which confirmed a Weber C fibula fracture with associated soft tissue injury and medial joint space widening. Three days post-injury, the athlete underwent surgery to repair the fracture, at which time was surgically diagnosed as a Maisonneuve fracture with a posterior malleolar fracture. Also repaired were the syndesmosis sprain, and rupture of the deltoid ligament. **Uniqueness:** This particular injury is unique in that a Maisonneuve fracture is found to occur in only 1 to 11% of all literature concerning ankle fractures. A Maisonneuve fracture is a fracture of the proximal fibula with associated injury to the deltoid and tibiofibular ligaments. Also noted in the physician's notes was a severely comminuted fibular fracture. **Conclusions:** On-field care and treatment of this type of injury is of utmost importance for proper treatment and remediation of the injury. Surgical intervention and proper rehabilitation are important in the return of the athlete to activities of daily living and continuing an active lifestyle.

Free Communications, Oral Presentations: Injury Epidemiology

Saturday, June 20, 2009, 10:15AM-11:45AM, Room 214A; Moderator: Thomas P. Dompier, PhD, ATC

A Comparison Of Hamstring Strain Incidence Between Sexes, Sports, And Divisions In NCAA Athletics

Cross KM, Gurka K, Conaway M, Ingersoll CD: University of Virginia, Charlottesville, VA

Context: Hamstring strains are prevalent injuries that are associated with an extensive period of time lost from sport. Consequently, athletic trainers invest much time in developing prevention and rehabilitation programs, but they are based more on anecdotal conjecture, rather than evidence-based research. In order to develop prevention and rehabilitation programs, the population who is most at risk of hamstring strains must first be accurately identified and effectively described to give direction for assessing risk factors. **Objective:** The purpose was to calculate the incidence of hamstring strain by sex, sport, and level of play in the National Collegiate Athletic Association (NCAA) for the 2004-2007 athletic seasons. These rates were then compared between sexes, between sports and between divisions. **Design:** Epidemiological study. **Setting:** Data were collected at select colleges and universities at all levels through

the NCAA Injury Surveillance System (ISS). **Patients or Other Participants:** The participants were student-athletes who had incurred a hamstring strain at NCAA institutions for which data were recorded in the ISS in the following sports: Male: baseball, basketball, cross country, football, lacrosse, soccer, tennis, wrestling; Female: basketball, cross country, field hockey, lacrosse, softball, soccer, tennis, volleyball. **Main Outcome Measures:** We calculated the incidence rate and incidence rate ratios for hamstring strain. **Results:** Males (0.480 injuries/1000 athlete-exposures (AEs)) had a higher rate of hamstring strain compared to females (0.216 injuries/1000 AEs; Adjusted IRR=1.62, 95% CI, 1.28, 2.05; females are referent group). In summary, males who participated in soccer (0.691 injuries/1000 AEs) and football (0.604 injuries/1000 AEs) experienced the highest rates of hamstring strain among the sports under study. Males who participated in cross-country (0.026 injuries/1000 AEs) experienced the lowest rates of hamstring strains. Females who participated in soccer (0.381 injuries/1000 AEs) and field hockey (0.379 injuries/1000 AEs) had the highest rates of hamstring strain. Females who participated

in volleyball (0.102 injuries/1000 AEs) experienced the lowest rates of hamstring strain. No differences in the incidence of hamstring strain existed between the NCAA divisions. **Conclusions:** Student-athletes participating in sports that emphasize sprinting for relatively long distances and provide minimal opportunities for rest were more likely to sustain a hamstring strain. Preventive hamstring strain programs should be emphasized in these sports, particularly for male athletes. Conclusions drawn from or recommendations based on the data provided by the National Collegiate Athletic Association are those of the author(s) based on analyses/evaluations of the author(s) and do not represent the views of officers, staff or membership of the NCAA.

Incidence Of Meniscus Injuries In The U.S. Military: Demographic And Occupational Risk Factors In A High Risk Population

Jones JC, Burks R, DeBerardino TM, Sturdivant RX, Cameron KL: United States Military Academy, West Point, NY

Context: The menisci are often reported as the most frequently injured structures about the knee and injuries to the menisci generally lead to progressive degenerative joint changes. Surprisingly, few population-based studies have examined the incidence of meniscal injuries and there is limited data on the influence of demographic and occupational risk factors associated with meniscal injuries. The U.S. Military population is a large and physically active cohort that is at increased risk to meniscal injuries. **Objective:** To examine the incidence of meniscal injuries and the influence of demographic and occupational risk factors among active duty U.S. Service Members between 1998 and 2006. **Design and Setting:** The Defense Medical Epidemiological Database (DMED) was queried for all meniscal injuries among active duty U.S. Service Members during the study period using ICD-9-CM codes 836.0 (medial meniscus), 836.1 (lateral meniscus), and 836.2 (meniscus unspecified). Injury data were stratified by age, gender, race, rank and service. Multivariate Poisson regression models were used to estimate incidence rates (IR) and 95% confidence intervals (CI). Adjusted IR and incidence rate ratios (IRR) were also calculated for each variable while controlling for the influence of the other variables within the model. **Participants:** All active duty military personnel serving in the Army, Marine Corps, Navy and Air Force during the study period were included. Over the 9-year period examined, 12,115,606 persons-years at risk to injury were documented in DMED with an average of 1,346,178 U.S. Service Members at risk for injury annually. **Main Outcome Measure:** The primary outcome measures in this study were the IR per 1000 person-years at risk to injury. Rates were calculated by age, gender, race, rank, and service. **Results:** During the study period 100,201 acute meniscal injuries and 12,115,606 persons-years at risk to injury were documented in DMED. Overall, the IR for meniscal injuries among active duty U.S. Service Members was 8.27 per 1000 persons-years at risk. The majority of injuries affected the medial meniscus (50%) with the remaining injuries distributed between the lateral meniscus (22%) and unspecified meniscal injuries (27%). Significant main effects were noted for all five of the

demographic and occupational variables ($p<.001$) indicating that age, gender, race, rank, and service are important risk factors associated with meniscal injuries. Males were almost 20% more likely to experience an acute meniscal injury when compared to females (IRR 1.18, 95% CI=1.15-1.20). The rate of meniscal injury progressively increased with age, with those over 40 years of age experiencing injuries more than 4 times as often when compared to those under 20 (IRR 4.25, 95% CI=4.08-4.42). **Conclusions:** Gender, race, age, service, and rank are important risk factors for meniscal injuries within this population and these results may have implications for other physically active populations.

Estimated Survival Probabilities For Return To Play Outcomes From Ankle Sprains, Knee Sprains, And Concussion In High School Athletes

Reed A, Medina McKeon JM, Uhl TL, Bush HM: University of Kentucky, Lexington, KY

Context: In the U.S., there are more than 7.3 million athletes participating in interscholastic athletics. Although this represents 18 times more athletes than at the collegiate level, there is a surprising lack of epidemiological information for the high school athletic population. **Objective:** To examine sex differences for time to return-to-play (T-RTP) outcomes and to estimate T-RTP probabilities for ankle sprains, knee sprains, and concussions in interscholastic athletes. **Design:** Descriptive retrospective epidemiological study. **Setting:** Interscholastic injury data for the 2007-08 survival analyses were used to examine T-RTP curves for ankle sprains, knee sprains, and concussions. Statistical comparison of sex differences in these survival curves were evaluated by separate log-rank analyses. Estimated survival probability for T-RTP was determined by Kaplan-Meier Estimator (censored data). Statistical significance for log-rank analyses was set at $P<.05$. **Main Outcome Measures:** For the survival analyses, variables included T-RTP (return, no return) at specified time points (same day return, 1-day return, 3-days, 7-days, 10-days, 22-days, no return by season's end[censored]). Separate survival analyses were performed for ankle sprains, knee sprains, and concussions. Statistical comparison of the sexes (male, female) was performed for each survival curves (T-RTP). **Results:** 105 ankle sprains, 40 knee sprains, and 38 concussions were reported for the 2007-2008 academic year. There were no

statistical significant sex differences of T-RTP (Average Days $\pm$ Standard Deviations) for ankle sprains (males=3.89 $\pm$ 8.8 vs. females=6.28 $\pm$ 2.9, $P=.30$), knee sprains (males=20.52 $\pm$ 28.7 vs. females=31.82 $\pm$ 53.8, $P=.31$), or concussions (males=13.10 $\pm$ 21.2 vs. females=14.67 $\pm$ 38.5, $P=.52$). Since no sex differences were identified, injuries were entered into survival probability estimators separated by injury type only (ankle sprain, knee sprain, concussion). T-RTP survival estimates indicate that there is a 90% chance that an athlete will return from an ankle sprain in 7 days, and a concussion in 10 days. For knee sprains, there was only a 75% calculated probability that an athlete will return to participation at 22 days. For a 1-day return, there was a 45% chance for those with ankle sprains, a 30% chance for knee sprains, and only 6% probability of return from a concussion. **Conclusions:** Time lost from ankle, knee, or concussion injuries was similar between males and females. Survival analyses can be applied to estimate return-to-play timelines for injuries. Estimated survival probabilities can be useful information for the ATC to provide to the athlete or coach. Future research might evaluate differences in return-to-play survival curves between new and recurrent injuries, and in response to therapeutic intervention.

Postural Alignment Risk Factors For Patellofemoral Pain In A Military Population: The JUMP-ACL Study

Boling MC, Padua DA, Marshall S, Guskiewicz K, Pyne S, Beutler AI: University of North Florida, Jacksonville, FL; University of North Carolina, Chapel Hill, NC; United States Naval Academy, Annapolis, MD; Uniformed Services University of the Health Sciences, Bethesda, MD

Context: The etiology of patellofemoral pain (PFP) is not well understood, most likely due to the lack of large-scale prospective investigations assessing risk factors for this condition. Increased quadriceps angle (Q-angle) and excessive pronation are theorized risk factors for the development of PFP due to their influence on the alignment of the patella within the femoral trochlea; however, these factors have yet to be determined as true risk factors for the development of PFP. **Objective:** To determine the association between Q-angle and navicular drop, and incident PFP. **Design:** Prospective cohort. **Setting:** US Military Academy. **Patients or Other Participants:** The cohort consisted of 1,319 cadets (females=513, males=806) who were

freshmen at the time of enrollment in the current investigation. This cohort is part of a larger scale investigation of risk factors for ACL injury (JUMP-ACL). **Interventions:** Q-angle and navicular drop were assessed on the dominant lower extremity. Q-angle (°) was measured in a weight-bearing stance as the angle formed between a line from the ASIS through the center of the patella and a line from the tibial tuberosity through the center of the patella. Navicular drop (mm) was measured as the difference between the navicular tuberosity height in a non weight-bearing subtalar joint neutral position and a weight-bearing position. Each measurement was taken three times and participants were asked to march in place between each measurement. Participants were followed for a maximum of 2.5 years to determine those who developed PFP. Incident PFP was determined by a manual review of medical records by the principal investigator over the 2.5 years in which the following criteria needed to be met for inclusion in the injured group: retropatellar knee pain with physical activity, pain on palpation of either the patellar facets or femoral condyles, and negative findings on examination of the knee ligaments, menisci, bursae, and synovial plica. **Main Outcome Measures:** The average of the three Q-angle and navicular drop measurements were used for data analysis. Separate Poisson regression analyses were performed to determine the association between Q-angle and navicular drop and incident PFP ($P \leq 0.05$). **Results:** Forty midshipmen were diagnosed with PFP during the follow-up period (females=24, males=16). Quadriceps angle was not a significant predictor for incident PFP (Rate ratio (RR)=0.99, 95% Confidence interval (CI)=0.47, 2.09, $P=0.98$). Increased navicular drop was a significant predictor for incident PFP (RR=2.52, 95% CI=1.25, 5.08, $P=0.01$). **Conclusions:** The rate of development of PFP was 2.52 times greater for individuals with increased navicular drop (navicular drop³10.67mm); however, increased Q-angle was not associated with an increased risk of PFP. Multiple theorized risk factors for PFP have yet to be investigated, therefore, more large-scale prospective cohort investigations are needed to truly understand the risk factors for PFP. (Funded by the NIAMS Division of the National Institutes of Health, #R01-AR050461001, National Academy of Sports Medicine, and the National Basketball Athletic Trainers' Association)

A Comparison Of High School Sports Injury Surveillance Data Reporting By Certified Athletic Trainers, Coaches, And Athletes

Comstock RD, Yard EE, Collins CL: The Research Institute at Nationwide Children's Hospital, Columbus, OH, and Ohio State University, Columbus, OH

Context: High school athletes sustain 1.5 million injuries annually. Sports injury rates can be reduced by applying targeted, evidence-based, preventive interventions. To date, the most successful sports injury surveillance studies utilized certified athletic trainers (ATs) as reporters. However, there is a need to investigate other reporter options for high schools that lack the services of an AT. **Objective:** To examine the feasibility of using high school coaches or athletes as reporters in a national, internet-based sports injury surveillance study, using the same methodology that has proven successful in the National High School Sports-Related Injury Surveillance Study, which utilizes ATs as reporters. **Design:** Prospective injury surveillance study. **Setting:** Eighteen US high schools with an NATA-affiliated AT during the 2006-07 school year. **Patients or Other Participants:** ATs, varsity coaches, and varsity athletes from football, boys' and girls' soccer, and boys' and girls' basketball. **Interventions:** At each participating school, an online data collection tool, High School RIO™ (Reporting Information Online), was used concurrently but separately by the AT, a varsity coach from each of the 5 sports of interest, and the varsity athletes from each of the 5 sports of interest to report athlete-exposure and injury information. Enrolled ATs and coaches received weekly emails throughout the study period reminding them to report and asking them to remind their athletes to report. Reporters were able to view all data submitted throughout the study and update reports as needed. **Main Outcome Measures:** Quantity and quality of exposure and injury reports. **Results:** All enrolled ATs participated. Only 43% of enrolled coaches participated and <1% of enrolled student-athletes participated. Participating ATs submitted 96.7% of expected exposure reports while participating coaches submitted only 36.5%. All ATs reported athlete-exposures correctly, compared to only 2 in 3 coaches. Participating ATs submitted 338 injury reports while participating coaches submitted only 55 (16.3% of the 338 submitted by ATs). Injury patterns derived from AT-submitted reports differed from patterns derived from coach-submitted reports. Only 38 coach-submitted injury reports could be matched with an AT-

submitted injury report. Within matched report pairs, answer discrepancies frequently existed for important injury-related variables such as time loss (44.7% of matched reports disagreed), diagnosis (36.8% disagreed), and need for surgery (16.2% disagreed). ATs had higher non-response for demographic questions, while coaches had higher non-response for need for surgery. **Conclusions:** Because coaches and athletes demonstrated poor participation and compliance, we recommend that ATs be the primary data reporters in large, national studies. Injury surveillance conducted in high schools lacking ATs will require devotion of large monetary and time resources to ensure adequate participation and compliance by coaches or athletes. (Funded by a General Research Program Grant from the NATA Research and Education Foundation.)

Population Based Estimates Of Medial Ulnar Collateral Ligament Injury

Sweet SL, Dompier TP, Ragan BG, Mack MG, Lund RJ: University of Northern Iowa, Cedar Falls, IA

Context: Recently, there has been widespread speculation that elbow injuries, specifically medial ulnar collateral ligament (MUCL) injuries have been increasing over the past fifteen years. To date, however, no population-based estimates of MUCL injuries currently exist. **Objective:** To determine population-based incidence rates of MUCL injury over a three-year period. **Design and Setting:** Epidemiological, cross-sectional analysis of existing national health care databases. **Data Sources:** Non-identifiable, aggregate data provided by the National Center for Health Statistics (NCHS) for 2003-2005. The two comprehensive databases of ambulatory services chosen were the National Ambulatory Medical Care Survey and the National Hospital Ambulatory Medical Care Survey. **Data Management:** For each database, complex sampling designs and estimation procedures with weighting were used by the NCHS to ensure the samples were scientifically sound and nationally representative. International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes for sprain or strain of the MUCL (841.1) and ulnohumeral joint (841.3) were used to identify the data required for this study. Surprisingly, there were too few cases in the data bases to provide reliable estimates. The NCHS considers estimates based on fewer than 30 records to be unreliable. In order to obtain a

sufficient sample size of at least 30, a general ICD-9-CM code of 841 had to be used which includes all sprains/strains, both to the medial and lateral aspects of the elbow. Therefore, the focus of the analysis changed from MUCL injuries to elbow injuries. **Main Outcome Measures:** Frequency distributions of elbow injuries and incidence rates with 95% confidence intervals were calculated for the following variables: age, gender, and year. **Results:** The total overall incidence rate of elbow

injuries was 88.84 per 100,000 people (95% CI = 88.64, 89.04). Females had a higher overall total incidence rate of 121.45 per 100,000 people (95% CI = 121.15, 121.80) compared to males, 54.72 per 100,000 people (95% CI = 54.50, 54.94). The 15-24 year old age division showed the highest injury risk at 242.81 per 100,000 people (95% CI = 241.94, 243.69), followed by the 65 and older group at 164.51 per 100,000 people (95% CI = 163.43, 165.58). The 45-64 year old age group had the lowest incidence (33.75

per 100,000 people; 95% CI = 33.50, 34.00) of elbow injuries. **Conclusions:** Based on the results, injuries to the MUCL and the elbow are rare. It is important to note that MUCL injuries are unique and maybe underrepresented in the database because those injuries usually seek out specific centers for care. One surprising result was females had a 2.5 times higher incidence rate of elbow injury when compared to males. *Funded by a Master's Research Program Grant from the NATA Research and Education Foundation.*

Free Communications, Thematic Posters: Classification & Intervention Strategies In Those With Ankle Instability

Saturday, June 20, 2009, 12:00PM-1:30PM, Room 214A; Moderator: Thomas W. Kaminski, PhD, ATC, FACSM

Kinesio® Tape At The Ankle Increases Hip Adduction During Dynamic Balance In Subjects With Functional Ankle Instability

de la Motte SJ, Arnold BL, Ross SE, Pidcoe PE: Uniformed Services University of the Health Sciences, Bethesda, MD, and Virginia Commonwealth University, Richmond, VA

Context: The effects of Kinesio® tape use in subjects with functional ankle instability (FAI) during functional tasks is uninvestigated. Specifically, 3-D kinematics of the lower extremity have not been examined in FAI subjects using Kinesio® tape. Theoretically, Kinesio® tape may enhance sensorimotor function by improving proprioception feedback leading to altered movement strategies. **Objective:** To determine if lower extremity kinematics differed in FAI subjects using Kinesio® tape during maximal reach on the Star Excursion Balance Test (SEBT). **Design:** Case-control study with all subjects receiving all treatments. **Setting:** Sports Medicine Research Laboratory **Patients or Other Participants:** Twenty subjects with FAI (Age=24.2±3.8yrs; Ht=169±11.6cm; Wt=69±12.4kg) and twenty uninjured subjects (Age= 25.7±5.6yrs; Ht= 170.1.4 ±8.8cm; Wt= 69.9±10.5kg) with no history of ankle sprain. FAI was operationally defined as repeated episodes of ankle “giving way” and/or ankle “rolling over”, regardless of neuromuscular deficits or pathologic laxity. All FAI subjects scored ≤ 26 on the Cumberland Ankle Instability Tool. All subjects were recreationally active. **Interventions:** SEBT reaches included the anteromedial, medial, and posteromedial directions. FAI subjects used their unstable side as the stance leg, while control subjects were side-matched to the FAI group. The stance leg ankle was taped using 1) Kinesio® tape and the Kinesio taping method (Kinesio

method); 2) white linen tape with the Kinesio method; 3) Kinesio® tape along the distal peroneal tendons (lateral method); 4) white tape with the lateral method. Three-dimensional kinematic data were collected during SEBT performance. A repeated measures ANOVA analyzed the effects of group, tape, tape method, and reach direction on lower extremity kinematics ($\alpha=0.05$). Tukey HSD post-hoc analyses were performed for all significant interactions. **Main Outcome Measures:** Hip abduction/adduction angles (degrees) at maximum reach of the SEBT. Positive angles were indicative of hip abduction, while negative angles signified hip adduction. **Results:** A significant four-way interaction for tape, method, direction, and group ($F_{2,72}=3.874$, $P=.03$) was found. Tukey HSD post-hoc testing showed a significant difference between FAI and control subjects with every taping condition for posteromedial reach. FAI subjects exhibited more hip abduction while control subjects used more hip adduction (Condition 1: .65±8.23° vs. -2.14±8.51°; Condition 2: 1.29±7.71° vs. -1.75±8.29°; Condition 3: 1.08±8.39° vs. -1.88±18.33°; Condition 4: 2.13±7.62° vs. -1.54±6.61°). Additionally, a significant difference in FAI subjects' hip abduction angles between the white tape/Kinesio method (.65±8.23°) and Kinesio tape/Kinesio method (1.08±8.39°) was found. **Conclusions:** FAI subjects used hip abduction while control subjects used hip adduction at maximal posteromedial reach. FAI subjects' hip abduction was significantly less with the Kinesio® tape/Kinesio condition, and closer to the hip adduction angles of control subjects. These results indicate that the use of Kinesio® tape at a distal joint can alter proximal joint movement in subjects with FAI.

Stochastic Resonance Stimulation Administered At A Customized Optimal Intensity Improves Balance In Stable And Unstable Ankles.

Ross SE, Arnold BL, Linens SW, Wright CJ: Virginia Commonwealth University, Richmond, VA

Context: Stochastic resonance (SR) stimulation administered on the skin over ankle muscles at low subsensory intensities has improved balance in subjects with or without functional ankle instability (FAI). However, treatment effects associated with SR stimulation could be maximized at a particular level of intensity emitted from stimulators. SR stimulation administered at an optimal intensity has implications for allowing individuals to perform balance exercises more effectively, potentially facilitating and enhancing rehabilitation. **Objective:** Our objective was to determine balance improvements associated with SR stimulation administered at a customized optimal intensity. **Design:** A two-group (FAI, no FAI), two-treatment (SR_{on}, SR_{off}) cross-over design. **Setting:** Research laboratory. **Patients or Other Participants:** Fifteen uninjured subjects (169.6±7.7 cm, 63.8±11.1 kg, 23.1±3.8 yrs) and 15 subjects with FAI (171.7±8.2 cm, 66.5±10.5 kg, 22.7±2.6 yrs) who reported “giving-way” sensations at their ankle and recurrent ankle sprains with physical activity (sprains =3.2±2.5, “give-ways”/week= 0.57±0.54). **Interventions:** Vibrating tactors were placed over peroneal, anterior tibialis, gastrocnemius, and posterior tibialis muscles on the leg with FAI or a matched test leg of uninjured subjects. Sensory threshold for each subject was determined by sending a random noise signal to a stimulation unit that caused the tactors to vibrate. The intensity was increased until the vibration was just barely felt. This level signified the sensory threshold, which was used to individualize 4 SR stimulation

intensity interventions. Quiet double leg balance trials without vision or shoes were performed on a force plate under a control condition and 4 SR stimulation intensity interventions administered at 25%, 50%, 75%, and 90% of each subject's sensory threshold. Testing order was counterbalanced. Resultant center-of-pressure velocity (COPV) values were calculated over 3 trials for each condition. The intensity that produced the slowest velocity for each subject for all SR stimulation conditions was identified as the customized optimal intensity. The resultant COPV associated with this customized optimal intensity was used for data analysis. A two-factor mixed-model repeated measures ANOVA with 1 within factor (SR_{on} , SR_{off}) and 1 between factor (FAI, no FAI) compared the resultant COPV at the customized optimal intensity to the control condition ($\alpha=.05$). **Main Outcome Measures:** Resultant COPV was calculated as the resultant vector of the anterior/posterior COPV and medial/lateral COPV. Slower velocity indicated improved balance. **Results:** A significant main effect for treatment ($F_{(1,28)}=16.92$; $P<0.001$) indicated that SR stimulation improved balance over the control condition ($SR_{on}=0.65\pm0.21$ cm/s; $SR_{off}=0.74\pm0.27$ cm/s). No significant main effect for group ($F_{(1,28)}=0.21$; $P=0.65$) or treatment by group interaction ($F_{(1,28)}=1.14$; $P=0.30$) were found. **Discussion:** No balance differences were evident between groups. SR stimulation administered at a customized optimal intensity improved balance by 12% over our control condition. This improvement exceeds previous reports by researchers who did not customize SR stimulation intensities to an optimal level for each subject.

Intrinsic Foot Muscle Test Deficits In A Population With Chronic Ankle Instability

Drewes LK, Hertel J: University of Virginia, Charlottesville, VA

Context: Individuals with chronic ankle instability (CAI) have demonstrated neuromuscular deficits in the lower leg musculature. The intrinsic foot musculature (IFM) makes a significant contribution for maintaining a stable base of support for the lower extremity during dynamic tasks. Function of the IFM is not routinely evaluated in patients with lower extremity injuries. The intrinsic foot muscle test (IFMT) is a functional performance test used to evaluate the strength and activation of the IFM as the patient maintains a neutral foot position during a 30-second, single-limb stance task. The IFMT has no published research to support its ability to detect differences in a population with neuromuscular deficits.

Objective: To compare CAI subjects to healthy controls on IFMT performance. **Design:** Case control. **Setting:** Athletic training laboratory. **Patients or Other Participants:** Eighteen subjects with CAI (23 ± 6.4 years, 173 ± 10.8 cm, 73 ± 18.2 kg) and eighteen healthy, matched controls (26 ± 4.6 years, 169 ± 7.1 cm, 68 ± 10.7 kg) volunteered. CAI subjects reported an average of 82.9 ± 12.4 on the FAAM-ADL and 66.4 ± 10.2 on the FAAM-Sport and controls reported an average of 100 ± 0.0 on the FAAM-ADL and 99.7 ± 1.4 on the FAAM-Sport. **Interventions:** Subjects were asked to perform the IFMT. For the test, subjects were instructed to lift their toes toward the ceiling as the heel and ball of the foot were flat on the floor. Subjects then maintained the elevated arch height and foot position as they lowered their toes back to the floor. While maintaining this foot position, subjects stood on the single limb for the 30-second test. During the test, the investigator evaluated the strength and activation of the IFM according to the subjects' ability to maintain the arch height and foot position. Subjects' performance was classified (poor, fair, satisfactory) based on their ability to consistently maintain navicular height without over-activity of the extrinsic foot muscles, indicated by toe flexion. Due to the low number of 'satisfactory' performances ($n=2$), the 'fair' and 'satisfactory' classifications were grouped together and a 2x2 Chi-square analysis determined the association between performance on the IFMT and CAI status. The alpha-level was set at $P<0.05$. **Main Outcome Measures:** The dependent variable was performance classification on the IFMT (poor, fair/satisfactory). **Results:** The Chi-square analysis indicated a 'poor' classification on the IFMT was associated with the CAI group (Poor: 61%, Fair/Satisfactory: 39%) and a 'fair' classification was associated with the healthy controls (Poor: 28%, Fair/Satisfactory: 72%, $P=.044$). **Conclusions:** CAI subjects performed worse compared to controls on the IFMT. Poor control of the IFM may affect balance and stability of CAI individuals during dynamic tasks. The IFMT may be a useful functional test in detecting neuromuscular deficits of the IFM following a lower extremity injury.

The Effect Of Attentional Focus On The Acquisition And Transfer Of Postural Stability In Individuals With Chronic Ankle Instability

Sulewski AL, Tripp BL, Wikstrom EA: University of Florida, Gainesville, FL, and University of North Carolina at Charlotte, Charlotte, NC

Context: Research indicates balance training may restore normal ankle neuromuscular control in patients with chronic ankle instability (CAI). Empirical evidence also

suggests employing an external attentional focus (EAF) during balance training leads to better acquisition, retention, and transfer of automated skills compared to an internal attentional focus (IAF). **Objective:** To compare the effects of balance training that employs an EAF to an IAF in the acquisition and transfer of postural stability in subjects with CAI. **Design:** Quasi-randomized controlled trial. **Setting:** Controlled laboratory setting. **Patients:** Sixteen healthy college-aged volunteers with a history of CAI were randomly assigned to an IAF group ($n=8$, 21.4 ± 2.2 yrs, 173.6 ± 8.3 cm, 87.1 ± 16.0 kg) and EAF group ($n=8$, 22.3 ± 3.9 yrs, 166.1 ± 7.6 cm, 74.8 ± 21.0 kg). All subjects had a history of a moderate to severe lateral ankle sprain that required at least three days of immobilization and at least one recurrent injury within the past twelve months. Groups did not differ ($p>0.05$) in number of days immobilized after their initial injury (EAF: 8.6 ± 6.9 , IAF: 13.3 ± 18.2), or number of recurrent injuries (EAF: 5.6 ± 8.0 , IAF: 2.38 ± 0.7). **Interventions:** Subjects completed balance training sessions on three consecutive days which included 20, 20 second trials on a Biodex Stability System (BSS-level 6). Prior to the first practice trial and after every second trial subjects were prompted, based on group assignment, where to focus their attention. The IAF group was instructed to "keep your balance by stabilizing your body" and the EAF group was instructed to "keep your balance by stabilizing the platform." Training and testing trials were conducted in a unilateral stance on the involved limb. **Main Outcome Measures:** Prior to and immediately after balance training, 2 test trials recorded the overall stability index (OSI), anterior/posterior stability index (APSI), and medial/lateral stability index (MLSI) using the BSS-level 6 and average reach (cm) of all eight Star Excursion Balance Test (SEBT) directions normalized to leg length. Independent sample T-tests compared pre to post training change scores between the IAF and EAF groups. **Results:** Pretest scores were not different ($p>0.05$) between IAF and EAF groups for SEBT (0.78 ± 0.11 , 0.75 ± 0.08), OSI (2.69 ± 1.76 , 2.38 ± 1.29), APSI (2.13 ± 1.45 , 1.85 ± 0.90), or MLSI (1.78 ± 1.23 , 1.66 ± 1.02). Balance training failed to improve BSS measures ($p>.05$) but improved SEBT (Pre: $.77\pm.10$, Post: $.81\pm.09$) reach distance ($p<.01$). Change scores for the OSI [$T_{14}=-1.04$, $p=0.32$], APSI [$T_{14}=-1.39$, $p=0.19$], and MLSI [$T_{14}=0.05$, $p=0.961$] did not differ between EAF (OSI: 0.42 ± 0.81 , APSI: 0.31 ± 0.47 , MLSI: 0.37 ± 0.96) and IAF groups (OSI: 0.04 ± 0.65 , APSI: -0.12 ± 0.75 , MLSI: 0.39 ± 0.87). Additionally, change scores for the normalized SEBT did not differ [$T_{14}=1.30$, $p=0.22$] between the EAF

(0.35±0.03) and IAF (0.06±0.04) groups. **Conclusions:** Balance training improved postural stability skill transfer but neither an IAF or EAF resulted in better skill acquisition or transfer in CAI subjects after three training sessions.

Perception Of Strength Deficits Differentiate Functional Ankle Instability From Stable Ankles.

Linens SW, Ross SE, Arnold BL: Virginia Commonwealth University, Richmond, VA

Context: Functional Ankle Instability (FAI) is often quantified through the use of questionnaires. The Ankle Joint Functional Assessment Tool (AJFAT) is a questionnaire that quantifies functional limitations associated with FAI. Determining which functional limitation or symptom on the AJFAT that distinguishes FAI from stable ankles may provide insight into the primary deficit perceived by FAI patients. **Objective:** Our purpose was to determine which functional limitation or symptom on the AJFAT distinguishes FAI from a stable ankle.

Design: Case control study. **Setting:** Sports medicine research laboratory. **Patients or Other Participants:** Fifteen subjects with no history of ankle injury (23.1±5.4 yrs, 167.2±9 cm, 66.6±14.6 kg) and fifteen subjects with a history of unilateral FAI (22.7±3 yrs, 171.8±10 cm, 74.5±10 kg) who reported “giving-way” sensations at their ankle and recurrent ankle sprains with physical activity participated in this study. **Interventions:** Subjects with FAI answered questions on the AJFAT by comparing their unstable ankle with their stable ankle, while subjects with stable ankles answered these questions by comparing their matched test ankle with their non-test ankle. Subjects chose the answers that described their ankle using the following scale: much less than the other ankle, slightly less than the other ankle, equal in amount to the other ankle, slightly more than the other ankle, or much more than the other ankle. The AJFAT has 12 questions that rate 1) ankle pain, 2) ankle swelling, 3) ability to walk on uneven surfaces, 4) overall feeling of stability, 5) overall ankle strength, 6) ability to descend stairs, 7) ability to jog, 8) ability to change direction when running, 9) overall activity level, 10) ability to sense a “rollover” event, 11) ability to respond to a “rollover” event, and 12) ability to return to activity after a “rollover” event. A stepwise linear regression analysis determined functional limitations or symptoms on the AJFAT that predicted ankle group membership ($\alpha=0.05$). **Main Outcome Measures:** Each answer on the AJFAT was assigned a point value between 0 and 4 (point

values were unknown to subjects). Higher point values represented greater levels of symptoms or greater instability associated with functional limitations. **Results:** Overall feelings of strength deficits predicted ankle group membership, indicating that the FAI group had greater ratings of perceived strength deficits than subjects with stable ankles (FAI=2.73±0.80, stable=1.80±0.56; $R=0.573$, $R^2=0.329$; $F=13.72$, $P=0.001$). No other functional limitation or symptom on the AJFAT significantly predicted ankle group membership ($P>0.05$). **Conclusions:** The traditional definition of FAI is described by recurrent ankle sprains and “giving-way” sensations without any mention of strength deficits. However, our analysis indicates that perception of strength deficits explains 33% of the variance in ankle group membership. Therefore, quantifying perception of strength deficits may be an important component for assessing FAI.

Effects Of Ankle Taping On Mechanical Stability In Those With Chronic Ankle Instability

Hubbard TJ, Cordova ML: University of North Carolina at Charlotte, Charlotte, NC

Context: A high percentage of patients suffer from chronic ankle instability (CAI) after an initial ankle sprain. This high percentage of re-injury necessitates examination of preventative methods. **Objective:** The purpose of this study is measure the effect ankle tape has on laxity in those with and without chronic ankle instability. **Design:** Case-Control **Setting:** Research Laboratory. **Patients or Other Participants:** Twenty subjects with unilateral CAI (7 males and 13 females, age=20.6±1.8yr., mass=69.9±13.7kg, ht=172.3±9.3cm) and twenty healthy subjects (7 males and 13 females, age=21.9±4.3yr., mass=72.0±14.6kg, ht=171.1±6.7cm) participated in the study. **Interventions:** Both the right and left ankle of each subject was tested under two conditions: 1) before the application of tape and 2) immediately after 15 minutes of exercise with the tape still present on the ankle. Mechanical joint stability was measured with an instrumented ankle arthrometer. The arthrometer measured ankle joint motion for anterior/posterior translation and inversion/eversion angular displacement. For each dependent variable a two (group) x two (time) repeated measures ANOVA analysis was performed. **Main Outcome Measures:** Anterior displacement (mm), posterior displacement (mm), inversion rotation (°), eversion rotation (°). **Results:** There were significant group by time interactions ($F(1,38)=6.580$, $p=.014$) for anterior displacement. Post hoc testing indicated significantly more anterior displacement in the involved ankle of

the CAI group relative to the matched control limb both before (16.6 ± 1.4mm vs. 11.1 ± .96mm) and after tape (14.6 ± 1.4mm vs. 9.9 ± 1.2mm) application. Similarly, significant time main effects for posterior displacement ($F(1,38)=9.650$, $p=.004$), inversion ($F(1,38)=48.813$, $p=.001$) and eversion ($F(1,38)=4.368$, $p=.043$) rotation were also revealed. Specifically, tape application decreased posterior displacement, inversion and eversion rotation only in the CAI group. Additionally, a significant group main effect for inversion rotation ($F(1,38)=36.558$, $p=.001$) was also illustrated. Follow up testing indicated significantly greater inversion rotation for the CAI ankle (35.4±2.2°) compared to the matched healthy ankle (31.4±3.0°) before tape application. **Conclusions:** The study reported mechanical laxity to significantly decrease in those with CAI after tape application. Although there was still a significant difference in mechanical laxity between the involved ankle vs. the uninvolved ankle of the CAI group, and the matched healthy group, laxity did decrease in the CAI ankle after the application of tape. This suggests part of the benefit of ankle taping with regard to prevention of re-injury, may be due to decreased mechanical laxity at the ankle joint.

Dynamic Stability Improvements With Rehabilitation In Subjects With Chronic Ankle Instability

Gribble PA, Shinohara J: University of Toledo, Toledo, OH

Context: Time to Stabilization (TTS), a measure of dynamic stability, is diminished in subjects with chronic ankle instability (CAI). It is not known if TTS is influenced through rehabilitation. **Objective:** To compare the influence of two rehabilitation protocols on Resultant Vector TTS (RVTTs). **Design:** Within-subject, between-groups repeated measures design. **Setting:** Athletic Training Research Laboratory. **Patients or Other Participants:** Thirty-three subjects with unilateral CAI (13 males, 20 females; 19.9±2.2yrs; 173.5±8.1cm; 73.3±10.5kg) volunteered for the study. **Interventions:** Subjects reported to the laboratory for two testing sessions 6 weeks apart during which TTS was assessed with a jump-landing task. During the pre and post-test sessions, five trials of a jump-landing task consisting of a single-leg landing from height equivalent to 50% of the subject's maximum jump height were performed. Subjects jumped off of both feet from a distance 70cm away from the center of the forceplate, reached up and touched the indicated marker, and landed on the forceplate on a single test limb. The task was repeated for both limbs in a randomized order. Ground reaction forces were used to

calculate TTS in the medial/lateral and anterior/posterior directions. The combination of those two values yields the RVTTS value (sec). After the pre-testing session, subjects were randomly assigned to one of 3 rehabilitation groups: Ankle (AR), Knee (KR), or Control/None (NR). Subjects in the AR and KR reported 3 times/week for 6 weeks for supervised rehabilitation according to group assignment. The pre-post change in RVTTS was calculated for each limb and served as the dependant variable. For the RVTTS delta score, a Group (AR, KR, NR) by Side (injured, non-injured) repeated measures ANOVA was performed. Significance was set a priori at $p < .05$. **Main Outcome Measure(s):** Pre-post change in RVTTS. **Results:** For the change in RVTT, a significant Group-by-Time interaction existed ($F_{2,33} = 3.353$; $p = 0.049$). Post-hoc analysis revealed that RVTTS reduced significantly on the injured side of the KR group ($\Delta = -0.347 \pm 0.392$ sec) compared to the non-injured side ($\Delta = 0.098 \pm 0.325$ sec) following rehabilitation; with an effect size of 1.24. Additionally, the RVTTS reduced significantly on the injured side of the KR group ($\Delta = -0.347 \pm 0.392$ sec) compared to the injured side of the NR group ($\Delta = 0.215 \pm 0.521$ sec) following rehabilitation; with an effect size of 1.23. Finally, the RVTTS reduced significantly on the injured side of the AR group ($\Delta = -0.161 \pm 0.429$ sec) compared to the injured side of the NR group ($\Delta = 0.215 \pm 0.521$ sec) following rehabilitation; with an effect size of 0.79. **Conclusions:** Both rehabilitation protocols were associated with an improvement in dynamic stability. The magnitude of the change in RVTTS was greater in the KR group, suggesting that proximal rehabilitation may be more effective in improving dynamic stability in patients with CAI.

Effect Of Two Rehabilitation Protocols On Static Postural Control Among Subjects With Chronic Ankle Instability

Shinohara J, Gribble PA: University of Toledo, Toledo, OH

Context: Static postural control has been shown to be altered in those with chronic ankle instability (CAI). It is not known if implementing various forms of rehabilitation may help to improve these documented deficits. **Objective:** To compare the effect of traditional therapeutic ankle rehabilitation with a rehabilitation protocol focused on proximal joint function in influencing static postural control in CAI subjects. **Design:** Within-subject, between-groups repeated measures design. **Setting:** Research Laboratory. **Patients or Other Participants:**

Twenty-six subjects with unilateral CAI (14 males, 12 females; 19.9 ± 2.3 yrs; 174.8 ± 7.7 cm; 71.9 ± 10.2 kg) volunteered for the study. **Interventions:** Subjects reported to the laboratory for two testing sessions, six weeks apart, during which static postural control was assessed on a force plate with eyes-open (EO) and eyes-closed (EC). Center-of-Pressure (COP) data were sampled at 50Hz and averaged for three 15-second test trials, both for EO and EC. The Motion Monitor software collected COP data during the testing. MATLAB software was utilized to calculate the Time-to-Boundary (TTB) in both the sagittal (TTBAP) and frontal (TTBML) planes for EO and EC conditions. After the pre-testing session, subjects were randomly assigned to one of three rehabilitation groups: Ankle (AR; $n = 7$), Proximal Joint (PR; $n = 8$), or Control/None (NR; $n = 11$). Subjects in the AR and PR reported three times/week for six weeks for supervised rehabilitation. All subjects returned for post-testing identical to the pre-testing. The TTB dependant variables, calculated for TTBAP and TTBML in both eyes open and eyes closed conditions, were the absolute minimum, mean of the minima, and standard deviation of TTB minima. For each dependent variable, a Group (AR, PR, NR) by Time (pre, post) by Side (injured, non-injured) repeated measures ANOVA was performed. **Main Outcome Measures:** TTB absolute minimums, TTB mean of minima, and standard deviation of TTB minima for TTBAP and TTBML in EO and EC. **Results:** For the TTBML absolute minimum in the EO condition, a significant 3-way interaction ($F_{1,23} = 3.65$; $p = .042$) indicated that for PR group, the injured side improved from the pre-test (1.01 ± 0.52 sec) to the post-test (1.55 ± 0.51 sec). For the TTBAP absolute minimum in the EC condition, a significant 3-way interaction ($F_{1,23} = 5.49$; $p = .011$) indicated that for AR group, the injured side improved from the pre-test (1.93 ± 0.93 sec) to the post-test (2.56 ± 1.15 sec). For the TTBAP mean minima in the EC condition, a significant 3-way interaction ($F_{1,23} = 4.68$; $p = .020$) indicated that for PR group, significant improvements were observed for the injured (Pre: 10.34 ± 4.24 sec; Post: 12.74 ± 6.72 sec) and non-injured sides (Pre: 9.37 ± 2.16 sec; Post: 13.54 ± 8.14 sec); and during the post-test, both sides of the PR group were significantly better than the both sides of the AR (Inj: 11.03 ± 5.90 sec; Post: 10.72 ± 5.54 sec) and NR (Inj: 9.74 ± 4.06 sec; Post: 8.86 ± 2.94 sec). **Conclusions:** Rehabilitation for CAI can improve static postural control. However, it appears that rehabilitation focused on proximal joint function may be more beneficial than a traditional ankle rehabilitation protocol at improving static postural control.

The Ability Of Four Single-Limb Hopping Tests To Detect Functional Performance Deficits In Individuals With Functional Ankle Instability

Caffrey E, Docherty CL, Schrader J, Klossner J: Indiana University, Bloomington, IN

Context: Conflicting results exist regarding the presence of functional deficits in individuals with functional ankle instability (FAI). Functional performance differences may exist in those with FAI if measured with the proper test. **Objective:** To examine if functional performance deficits exist in subjects with FAI during four single limb hopping tests. **Design:** Repeated measures design. **Setting:** A controlled laboratory environment. **Participants:** Sixty physically active college students volunteered for this study. Thirty participants (15 males, 15 females, 20.5 ± 1.6 yrs; 172.3 ± 9.9 cm; 70.9 ± 12.2 kg) were placed in the FAI group and thirty participants (15 males, 15 females, 20.0 ± 1.0 yrs; 169.7 ± 8.8 cm; 65.7 ± 10.8 kg) were placed in the control group. All subjects in the FAI group had a history of unilateral ankle sprain and residual symptoms of giving way. All subjects in the control group had no history of ankle injury to either ankle. **Interventions:** The independent variables in this study were group at two levels (FAI and control) and limb at two levels (FAI limb or matched control limb and contralateral limb). All subjects completed four single-limb hopping tests on both limbs. The tests included: figure-of-8 hop, side hop, 6-meter crossover hop, and square hop tests. All functional performance tests were timed using an electric timer (Speedtrap 2, Brower Timing Systems, Draper, Utah). A repeated measures analysis of variance with one between subjects factor (group at 2 levels) and one within subjects factor (limb at 2 levels) was completed for each functional test. Tukey post hoc analysis was completed on any significant differences. **Main Outcome Measures:** Performance of each functional performance test was measured in time (seconds). **Results:** We found a significant limb by group interaction in the figure-of-8 hop ($F_{1,58} = 6.23$, $p = .02$), side hop ($F_{1,58} = 6.10$, $p = .02$), and the 6-meter crossover hop ($F_{1,58} = 4.07$, $p = .05$). For the figure-of-8 hop we identified performance deficits between the FAI limb of the FAI group (11.26 ± 2.59 sec.) and both the uninjured limb of the FAI group (11.02 ± 2.28 sec.) and the matched limb of the control subjects (10.95 ± 1.63 sec.). Similarly, for the side hop we identified performance deficits between the FAI limb of the FAI group (9.53 ± 2.43 sec.) and both the uninjured limb

of the FAI group (9.17 ± 1.81 sec.) and the matched limb of the control subjects (8.86 ± 1.16 sec.). For the 6-meter crossover hop we identified a performance deficit between the FAI limb of the FAI subjects (2.90 ± 0.99 sec.) and the matched limb in the control subjects (2.68 ± 0.62 sec.). For the square hop we revealed no significant differences in performance ($F_{1,58} = 2.62$, $p = .11$). **Conclusions:** Performance deficits were present in individuals with FAI on three of the four tests: figure-of-8 hop, side hop, and 6-meter crossover hop. Clinically, these tests have the potential to be used as a screening battery for FAI especially if used during pre-participation physical examinations.

Free Communications, Oral Presentations: Knee Injury Outcome Studies

Thursday, June 18, 2009, 8:15AM-9:30AM, Room 214B; Moderator: Luzita Vela, PhD, ATC

Changes In Health Related Quality Of Life In Young Female Athletes With Knee Injuries

McGuine TA, Winterstein AP, Carr KE, Hetzel SJ: University of Wisconsin, Madison, WI

Context: The SF12 v2.0 is a widely accepted tool used by health care providers to measure Health Related Quality of Life (HRQOL). The Physical Composite Score (PCS) and Mental Composite Scores (MCS) from the SF12 v2.0 are well recognized as valid measures of patient outcomes after treatment of orthopedic injury. However, there are limited data that illustrate how HRQOL changes over the course of one year following injury in young female athletes. Understanding HRQOL changes after injury will enable sports medicine professionals to better affect health outcomes of their athletes.

Objective: Identify HRQOL changes at regular intervals over the course of one year in young female athletes who have a knee injury. **Design:** Prospective cohort.

Settings: Data were collected at a sports medicine clinic and university student health service. **Participants:** A convenience sample of 139 high school and college female athletes (age = 16.9 ± 1.6 years) who sustained a knee injury while participating in a sport or regular fitness activity. Injuries were categorized as anterior cruciate ligament tears ($n=51$), anterior knee pain ($n=38$), patellar instability ($n=20$), IT band syndrome ($n=9$), meniscal tear ($n=8$), collateral ligament sprain ($n=6$), and other knee pain, (loose body, OCD, contusion; $n=7$).

Interventions: Each subject completed the SF12v2.0 five times over one year. The survey intervals included pre-injury, at diagnosis, and 3, 6 and 12 months post injury. 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 PCS and MCS from pre-injury to the diagnosis, 3-month, 6-month and 12-month intervals. Paired differences were assessed with the Wilcoxon Signed-Rank Test ($p \leq 0.05$) reported as the median (interquartile ranges [IQR]: 25th and 75th). **Results:** The median PCS score for all subjects pre-injury was 56.6 [54.8,58.0]. The paired PCS scores were significantly lower at diagnosis (-10.6; [-19.4,-5.2]; $p < 0.001$), at 3 months (-5.01; [-11.8,0.0]; $p < 0.001$) and at 6 months (-1.73; [-5.4,1.1]; $p < 0.001$). There were no differences in the paired PCS scores at 12 months (0; [-4.4,2.7]; $p = 0.370$). The median

MCS score for all subjects pre-injury was 55.9 [51.2,58.9]. The paired MCS scores were significantly lower at diagnosis (-1.95; [-9.5,3.0]; $p < 0.001$). There were no differences in the paired MCS scores at 3 months (-0.24; [-6.3,4.2]; $p = 0.314$), at 6 months (-0.16; [-4.5, 4.7]; $p = 0.847$) and at 12 months (-2.1; [-5.7,4.7]; $p = 0.106$).

Conclusions: Young female athletes who sustained a knee injury had lower HRQOL for up to 6 months after sustaining a knee injury. Understanding HRQOL changes after injury will enable sports medicine providers to better affect the physical, psychological and social health outcomes of their athletes.

Validation Of Accelerometers As A Measure Of Knee Dysfunction And Recovery

Scott CB, Mack MG, Ragan BG: University of Northern Iowa, Cedar Falls, IA

Context: Physical activity (PA) measures under free-living conditions, specifically step counts, are used as a valid functional measure in disability research. **Objective:** The purpose of the research was to examine step counts, as a valid functional measure using accelerometers following knee surgery.

Design: We used a non-experimental, observational, matched-pair design. **Setting:** Data were collected in outpatient rehabilitation clinics. **Participants:** Sixteen participants (age range 18 – 60 years, $36.3 \text{ yrs} \pm 17.4$; weight = $74.84 \text{ kg} \pm 1.63$; height = $179.20 \text{ cm} \pm 8.38$) volunteered for the study in accordance with IRB protocol. Eight surgical subjects were recruited (6 female, 2 male) and were matched with healthy pairs based upon gender, age, and perceived PA level. The surgical cases included: one ACL reconstruction with microfracture, two ACL with meniscal repair, one chondromalacia patella, and four meniscectomies. Two of the patients dropped out, resulting in 12 participants. **Interventions:** Subjects were asked to complete an injury history form, Knee and Osteoarthritis Outcome Score (KOOS), and wear a GT1M ActiGraph accelerometer (ActiGraph, Pensacola, FL) on the hip for three consecutive days at one week, three weeks, and eight weeks after surgery. The dependent variable was PA step counts and the independent variable was surgical status and time. The reliability and validity of accelerometers have been well established for a variety of populations outside of orthopedic medicine. Sample size of 14 was determined with power analysis based on

previous disability research which indicated a large effect size. **Main Outcome Measure:** The main outcome measure was physical activity measured in step counts. **Results:** Repeated measures ANOVA found significant differences for the patient group ($F(1,10) = 83.4$, $p < .001$). The patient group step count increased from time one ($M = 3379 \text{ SD} \pm 1522$) to time three ($M = 5445 \text{ SD} \pm 2433$). There was no significant increase from time one to time two ($M = 4085 \text{ SD} \pm 3639$) or time two to time three. Steps counts for the control group did not change over time ($T1:M = 11343 \text{ SD} \pm 2032$; $T2:M = 9813 \text{ SD} \pm 4622$; $T3:M = 10678 \text{ SD} \pm 4066$). **Conclusion:** Mean step counts for the control group remained constant over time, while the patients step counts increased. However, at eight weeks post-surgery the patient group still had a mean step count of only half that of the control group. These results support the use of physical activity as a valid indicator of knee dysfunction and recovery.

Functional Knee Outcomes One Year After Injury In Young Female Athletes

Carr KE, McGuine TA, Winterstein AP, Hetzel SJ: University of Wisconsin at Madison, Madison, WI

Context: The assessment of knee function is a useful measure of how injuries influence daily living, fitness, and sports activities. Self-report instruments such as the 2000 International Knee Documentation Committee (IKDC) Functional Knee Scale are widely used by orthopedic providers and researchers to assess the affect of treatment regimens on knee function. While the impact of knee injury on a female athlete's ability to participate in sport is well known, less well known is how knee injuries affect overall knee function. **Objective:** Describe the long-term (one year) changes in knee function in young female athletes who have sustained four types of knee injuries. **Design:** Prospective cohort. **Settings:** Data were collected at a sports medicine clinic and university student health service. **Participants:** A convenience sample of 127 high school and college female athletes (age 17.3 ± 1.3 yrs.) who sustained a knee injury while participating in a sport or fitness activity. Injuries were classified as: anterior cruciate ligament tear (ACL, $n=51$), anterior knee pain (AKP, $n=48$), patellar instability (PAT, $n=20$) and meniscal tear (MT, $n=8$). All subjects returned to their sport within one year following injury. **Interventions:** Each subject completed the 2000 IKDC five

times over one year. The intervals included pre-injury, at diagnosis, and 3, 6 and 12 months post injury. Internal consistency and test-retest reliability of the 2000 IKDC were reported as 0.92 and 0.95, respectively. A difference of 12 points in an individual subject's IKDC score indicates a significant change. **Main Outcome Measures:** Dependent variables included the paired differences in the IKDC scores from pre-injury to 12 months post injury for subjects in each injury classification. Paired differences were assessed with the Wilcoxon Signed-Rank Test ($p \leq 0.05$) reported as the median (interquartile ranges [IQR]: 25th and 75th). Fisher's Exact Test ($p \leq 0.05$) was used to determine if there were differences between the groups in the percentage of athletes who returned to their pre-injury IKDC scores. **Results:** The IKDC scores at 12 months were significantly lower than pre-injury scores for ACL (-5.75 [-45.9,25.2]; $p=0.001$), AKP (-6.9 [-44.8,22.9]; $p<0.001$), and PAT (-9.77 [-42.5,2.3]; $p=0.001$) but not MT (-3.44 [-14.9,12.6]; $p=0.205$). 42 (30.2%) had significantly lower IKDC scores at 12 months compared to pre-injury. There were no differences ($p=0.445$) between groups in the percentages of subjects whose knee function returned to their pre-injury score: ACL (69%; 35/51), AKP (65%; 32/48), MT (88%; 7/8) and PAT (55%; 11/20). **Conclusions:** As a group, female athletes with ACL, PAT, and AKP injuries demonstrated lower knee function scores one year following injury. Individually, 30% had lower knee function scores than they did before injury. Sports medicine providers need to be aware that knee injuries can affect knee function for up to one year following injury.

Anterior Cruciate Ligament Reconstruction Return To Play Criteria Commonly Utilized By Certified Athletic Trainers

Hetzler TM, Luke AL, Bushman BA, Hetzler BS: Missouri State University, Springfield, MO, and St. John's Sports Medicine-HealthTracks, Springfield, MO

Context: Currently there are no universally utilized and accepted return-to-play (RTP) criteria for individuals returning from an anterior cruciate ligament reconstruction (ACLR). **Objective:** To determine the most common RTP criteria following ACLR as utilized by Certified Athletic Trainers (ATC). **Design:** Descriptive survey via an online questionnaire. **Setting:** On-line. **Patients or Other Participants:** Clinically practicing ATCs within the USA who were current certified members of the NATA, as identified from the national directory, were contacted

via email with a request to participate in the on-line survey (InQsit) ($n= 21,166$). A response rate of 9% was attained ($n=1,836$).

Interventions: The survey was developed specifically for this study and included 21 questions (e.g. selection from a list, comment boxes for narrative responses, simple yes/no questions). The focus of the survey was to determine what clinical assessments are most commonly used by certified athletic trainers as part of RTP criteria following an ACLR. All responses were anonymously submitted directly into a secure database. Test-retest reliability was determined with a separate group of ATC ($n=10$), $r= 0.97$. **Main Outcome Measures:** Commonly used assessments, criteria related to those assessments, clinician satisfaction with criteria, method for establishing criteria, and person responsibility for selecting criteria were reported as frequencies and percentages.

Results: The most commonly reported baseline measurements included normal range of motion (94%), freedom of pain (87%), normal strength (manual muscle test) (81%) and normal strength (weight room) (77%). The most commonly reported utilized RTP assessments were sport-specific drills (92%), straight-line sprinting (84%), and back-pedaling (80%). Other moderately reported assessment activities included figure-eight jogging (73%), straight-line jogging (70%), single-leg squat (68%), shuffle-slide (64%), figure-eight sprinting (64%), one-leg hop (64%), step-up/step-down (62%), carioca (62%), and jogging an S-curve (61%). When considering if an individual has passed or failed the assessment activities, 90% of respondents examine quality of movement (4% use video analysis), 62% compare performance to norms, and 61% use percentage of strength. In terms of method for establishing and person responsible for selecting criteria, 71% reported a collaborative effort between the physician and themselves (the ATC). Satisfaction with criteria utilized was 86%. **Conclusions:** A wide range of activities and methods of evaluating these activities are being employed by individual physicians and athletic trainers to determine RTP following an ACLR. Many of these activities and methods for evaluating the activities rely on the ATC's subjective opinion rather than being based on universally tested and accepted activities and norms for those activities.

Free Communications, Oral Presentations: Knee Interventions

Thursday, June 18, 2009, 9:45AM-10:30AM, Room 214B; Moderator: Cynthia Trowbridge, PhD, ATC

Effects Of A Pre-Practice Injury Prevention Program On The Landing Error Scoring System

Buckley BD, Thigpen CA, Joyce CJ, Boling MC, Padua DA: University of North Florida, Jacksonville, FL, and University of North Carolina, Chapel Hill, NC

Context: The Landing Error Scoring System (LESS) is a reliable and valid clinical assessment tool that is used to evaluate lower extremity (LE) movement patterns that are theorized to predispose individuals to injuries such as anterior cruciate ligament ruptures. Exercise intervention programs have been developed to modify these faulty movement patterns; however, the effect of these prevention programs on LESS scores is not known in high school basketball athletes.

Objective: To determine the effects of a pre-practice injury prevention program on LESS scores in high school basketball athletes.

Design: Cross-sectional. **Setting:** Field Laboratory. **Participants:** Forty-five (27 male, 18 female, age=15.5±1.3 years; height=175.0±11.9cm; mass=68.5±10.8kg) high school basketball players volunteered for the study.

Interventions: Camcorders recorded frontal and sagittal plane views of participants as they performed three trials of the jump-landing task prior to the basketball season (pre-season). The jump-landing task consisted of participants jumping from a 30-cm high box and following initial landing, immediately jumping upward for maximal vertical height. The LESS was scored using a binary system (0=no error, 1=error) based on several jump-landing characteristics such as knee flexion angle, knee valgus angle, trunk flexion angle, and foot position. A higher LESS score indicates a greater number of movement errors committed, and thus poor jump-landing technique. Participants performed a series of exercises for 10-15 minutes at the start of practice over the 12-week basketball season. At the end of the season, participants repeated the three trials of the jump-landing task (post-season). The pre-practice injury prevention program emphasized strengthening of the hip abductors, control of sagittal, frontal and transverse plane motions of the hip and knee, and muscle imbalances at the hip, knee, and ankle. **Main Outcome Measures:** The pre and post-season LESS scores across the 3 trials were averaged and used for data analysis. Based on their pre-season LESS score, participants were divided into quartiles, representing "Excellent" (LESS<3.3), "Good"

(3.3≤LESS<4.3), "Moderate" (4.3≤LESS<5.3), and "Poor" (LESS≥5.3) jump-landing biomechanics. Separate repeated measures analyses of variance were performed to compare the pre and post-season scores for each quartile. **Results:** A significant main effect was found for time ($F_{1,41}=4.8$, $P=.03$) and group ($F_{3,41}=44.6$, $P<.001$). Further analyses indicated a significant decrease in LESS scores for the "Poor" group (pre-season=5.8±0.13, post-season=5.0±0.26, $P=.02$). There were no significant changes in LESS score among the excellent (pre-season=2.6±0.57, post-season=2.6±1.24, $P=1.0$), good (pre-season=3.6±0.25, post-season=3.6±0.70, $P=1.0$), and moderate (pre-season=4.7±0.10, post-season=4.2±0.31, $P=0.18$) groups. **Conclusions:** Our results suggest individuals with faulty movement patterns respond to a pre-practice injury prevention program by decreasing the number of errors on the LESS. The LESS is a useful tool that can be used to identify individuals with faulty movement patterns and determine the effect of a pre-practice intervention program.

Improvements In Landing Technique From An Injury Prevention Program Are Retained In Youth Soccer Athletes

DiStefano LJ, Padua DA, DiStefano MJ, Marshall SW: University of North Carolina, Chapel Hill, NC

Context: Previous research indicates that anterior cruciate ligament injury prevention programs can reduce injury rates and modify potential neuromuscular risk factors for injury. However, it is unknown how long changes are retained after the completion of an injury prevention program. **Objective:** To evaluate whether improvements in landing technique are retained 4-9 months after an injury prevention program is completed and to determine if the response is similar between sexes. **Design:** Repeated measures design. **Setting:** Soccer field. **Participants:** 114 youth soccer athletes (Males: n=33, age=12±2 years, height=165±13cm, mass=53±11kg; Females: n=77, age=12±2 years, height=159±7cm, mass=49±10kg) who improved their landing technique following an injury prevention program. **Intervention:** Sex and three assessment times (pre-intervention, immediately post-intervention, and 4-9 months post-intervention) were the independent variables for this study. Participants' landing technique during three trials of a jump-landing task was

videotaped from the frontal and sagittal planes. The videos were graded by one rater using the Landing Error Scoring System (LESS). Assessment of landing technique occurred before and after the completion of an injury prevention program, as well as four to nine months following the post-test (retention test). The participants did not perform the program between the post-test and the retention test. The twelve-week injury prevention program consisted of flexibility, strengthening, agility, balance, and plyometric exercises and was performed as a ten-minute warm-up prior to practice three days per week. **Main Outcome Measures:** The LESS evaluates multiple landing characteristics including frontal and sagittal plane motion of the foot, knee, hip, and trunk. A low LESS score indicates fewer landing errors and better landing technique. The average LESS score across three trials was used for analysis. A mixed model analysis of variance was conducted to evaluate changes in LESS score between the three time points and sexes after controlling for the differences in length of time between the post-test and the retention test ($\alpha\leq0.05$). A Bonferroni test was performed for post hoc analyses. **Results:** A significant main effect for time was observed ($F_{(2,193)}=10.89$, $P<.001$). LESS scores were significantly lower during the post-test (3.28±1.40) and the retention test (3.72±1.27) compared to the pre-test (5.02±1.73, $P<.001$), but LESS scores were significantly higher during the retention test compared to the post-test ($P=.02$). No other significant differences were observed ($P>.05$). **Conclusions:** Improvements from an injury prevention program are retained months after discontinuing the program. However, there appears to be some decay over time in the intervention effect as participants demonstrated deteriorating landing technique during the retention test compared to the post-test. These results indicate injury prevention programs may need to be performed more than once in order for improvements in landing technique to continue for an extended period of time. *Funded by the National Academy of Sports Medicine*

Influence Of Intermittent Visual Deprivation On Knee Movement Trajectories Following ACL Reconstruction In Females.

Bjornaraa J, DiFabio RP: College of St. Catherine at Minneapolis, and University of Minnesota, Minneapolis, MN

Context: Females participating in sports with pivoting and jumping suffer 4-6 times greater rates of ACL injury than males. Specific movement patterns have been identified as influential in ACL injury; however more global knee trajectory variables have not been investigated. **Objective:** The purpose of this research was to: 1) determine if ACL reconstructed subjects display different knee movement patterns during cutting activities than healthy subjects, 2) observe if subjects with visual disruption display different knee movement trajectories than with vision available, and 3) determine if visual deprivation alters knee movement patterns in ACL reconstructed subjects more significantly than in healthy subjects. **Design:** Randomized controlled trial. **Participants:** Volunteer sample of seventeen healthy female subjects (age = 25.3 ± 6 years) and 17 female subjects

with an isolated ACL injury followed by reconstruction (age = 26.5 ± 6.3 years) were studied. **Setting:** This study was performed in a controlled laboratory setting. **Interventions:** A 3D electromagnetic system measured knee position during a cutting motion. Anatomic landmarks on the pelvis, thigh, and shank were digitized for data capture. Subjects stood on a force platform and were instructed to catch a ball and cut immediately to the direction indicated by a specific tone (40 trials). Visual conditions were randomized so that shutter glasses either disrupted vision for 1 second as the subject began the cutting movement, or remained open for movement duration. Independent variables were group (ACL reconstructed or healthy), Vision (disrupted or full), and Lead/Push off leg (ACL/non or Dominant/Non). **Main Outcome Measures:** A 2-way ANOVA determined differences between knee trajectories using dependent variables of absolute velocity, amount of gross knee oscillation, and time to reach peak GRF (% of cut). **Results:** Eleven of 16 velocity comparisons demonstrated significantly slower knee velocities for ACL reconstructed subjects (i.e. 2.21 ± 0.37 m/sec and 2.63 ± 0.40

m/sec, respectively; $p=0.002$). ACL reconstructed subjects displayed reduced knee vertical axis oscillations in 3 of 4 comparisons with healthy subjects (i.e. $1.95/\text{sec} \pm 0.57$ and $2.91/\text{sec} \pm 1.15$, respectively; $p=0.04$). ACL reconstructed subjects displayed increased time to reach peak GRF over healthy subjects in all 4 comparisons (i.e. $79 \pm 3\%$ of cut and $76 \pm 4\%$ of cut, respectively; $p=0.03$). With visual disruption, more oscillatory knee motion occurred along the vertical axis in 2 of 4 comparisons (i.e. $1.93 \pm 0.57/\text{sec}$ no vision and $1.76 \pm 0.47/\text{sec}$ with vision; $p=0.04$). No differences existed between the reconstructed and non-surgical knees within the ACL group. **Conclusions:** ACL reconstructed subjects displayed movement patterns that differed from healthy subjects and may be indicative of a new motor program that allows for successful task completion while reducing the forces and load on the knee, yet may result in increased risk of re-injury or reduced athletic performance. Overall visual disruption appeared to have minimal affects on movement.

Free Communications, Oral Presentations: Heat & Hydration in Equipment Sports

Thursday, June 18, 2009, 10:45AM-12:00PM, Room 214B; Moderator: Susan Yeargin, PhD, ATC

Sweat Rate And Sweat Sodium Concentration In Professional Ice Hockey Players Compared With Professional And Collegiate Football Players Matched By Race, Height, Mass And BSA

Godek JJ, Fowkes Godek S, Bertini T, Kopec J, McCrossin J, Dorshimer G: DevTay Enterprises, Kennett Square, PA; West Chester University, West Chester, PA; Philadelphia Flyers, Philadelphia, PA; Delancey Medical Associates, Philadelphia, PA

Context: By previously measuring sodium losses in professional ice hockey players (AHL) and professional/collegiate football players (FB) during practices we believed that sodium replacement should be individualized for both groups. However, we noticed higher sweat sodium concentration [SwtNa⁺] in AHL. We also found racial differences in SwtR in matched football players. We hypothesized that AHL players would have higher [SwtNa⁺] than FB. **Objective:** To measure sweat rate (SwtR) and [SwtNa⁺] and make comparisons between AHL and FB players matched by race, height, mass and body surface area

(BSA). **Design:** Observational cohort. **Setting:** Data were collected during a preseason practice in August for FB and in early October for AHL. **Patients or Other Participants:** Fourteen, white AHL players (age = 24 ± 4 y, height = 186.4 ± 5.1 cm, mass = 95 ± 9.4 kg, BSA = 2.20 ± 0.1 m²) and fourteen, white professional/collegiate football players (age = 23 ± 4 y, height = 184.2 ± 5.6 cm, mass = 96.5 ± 10.3 kg, BSA = 2.20 ± 0.1 m²) volunteered. **Interventions:** Before practices the skin of the upper right forearm of each subject was appropriately prepped and a sterile sweat patch was secured to the skin. During or following practice, the patches were removed, placed in sterile, low retention tubes, immediately centrifuged, frozen and later analyzed by flame photometry. Mass was recorded before and after practice while dressed in shorts. Subjects consumed water during practice from pre-measured individual containers. Following practice bladders were emptied completely for volumetric measurements. SwtR was calculated by change in mass adjusted for fluids consumed and urine excreted divided by practice time in hours. Comparisons were made using independent t-tests. **Main**

Outcome Measures: SwtR, [SwtNa⁺] and Na⁺ losses. **Results:** WBGT was different in AHL (8.7 ± 1.9 °C) compared to FB (26.1 ± 2.5 °C). There were no differences in SwtR (AHL = $1.76 \pm .5$ L•hr⁻¹ and FB = $1.67 \pm .5$ L•hr⁻¹; $P = .65$) but [SwtNa⁺] was higher in AHL (62 ± 17 mmol•L⁻¹, ranging from 31 to 87 mmol•L⁻¹) compared to FB (34 ± 15 mmol•L⁻¹, ranging from 13 to 65 mmol•L⁻¹; $P = .0001$). SwtNa⁺ losses were higher in AHL (109 ± 45 mmol/h versus 59 ± 39 mmol/h), $P = .004$. **Conclusions:** Lower [SwtNa⁺] in FB compared to racially and physically matched AHL players might be explained by heat acclimatization in FB, but could be due to dietary differences. Regardless, Na⁺ losses ranging from 353 to 3595 mg/h in FB and 1312 to 3987 mg/h in AHL suggests that these athletes need individualized sodium replacement, and it may be more important in the hockey population given the number of games and length of season.

Professional Football Players' First Morning Urine Samples Do Not Reflect Hydration Status Just Prior To Morning Preseason Practices

Condon S, Fowkes Godek S, Bartolozzi AR, Burkholder R, Borgmann A, Peduzzi C: Philadelphia Eagles, Philadelphia, PA; West Chester University, West Chester, PA; Pennsylvania Hospital, Philadelphia, PA

Context: Several researchers routinely use first morning urine samples (1stAM Urine) to indicate hydration status prior to morning practices or camps, which could be hours later. However, it is unknown as to whether urine samples provided immediately after an overnight fast are valid measurements of pre-exercise hydration status. **Objective:** To measure urine specific gravity (USG) and osmolality (Uosm) of 1stAM Urine samples and compare them to samples taken just prior to morning practice (Pre-ex Urine) in professional football players. A second purpose was to determine if there is a relationship between body size, measured by body mass index (BMI) and morning state of hydration. We hypothesized that differences would exist in the urine samples and that body size would be related to 1stAM Urine. **Design:** Observational study. **Setting:** The 6th, 7th and 8th days of one professional football team's pre-season training camp. **Patients or Other Participants:** Thirteen players from a variety of positions (age=27.8 ± 4.6y, mass=106 ±22kg, height = 186.6 ±8cm, BMI = 30.1 ±4.1 and 6.1 ±4.5 years in the league) agreed to participate. **Interventions:** Sterile urine cups were labeled and placed in the players' rooms the night prior to data collection. The players were instructed to provide a urine sample upon awaking in the morning and bring it with them to the on-site laboratory. A second labeled sterile urine cup was given to them when they arrived at the laboratory after they consumed a morning meal with fluids. Players provided the second urine sample approximately 90 min after the first sample just prior to going out to the field. On-site determination of USG was done by refractometry and Uosm by freezing point depression. Correlated t-tests were used. **Main Outcome Measures:** USG and Uosm. **Results:** Uosm and USG were significantly different in the 1stAM Urine (850 ± 206 mOsm/kg and 1.0239 ± .0056) compared to Pre-ex Urine (664 ± 280 mOsm/kg and 1.0177 ± .0077), $P = .03$ and $P = .016$ respectively. There was a strong correlation between Uosm and USG ($r = .978$, $P < .0001$) but no correlation between BMI and Uosm or BMI and USG. **Conclusions:** The data suggests that using first morning urine samples is not

appropriate for determining pre-practice hydration state in professional football players. The results are clinically relevant in that first morning urine indicates hypohydration but pre-exercise urine indicates euhydration. Although we previously reported that post practice USG, because of myoglobin, may not be a good measure of hydration, pre-exercise USG as measured by refractometry is highly correlated with Uosm and is therefore an appropriate measure of hydration state in this population. It appears that body size is unrelated to morning hydration state in professional football players.

Fluid And Electrolyte Balance In NFL Players Individually Supplemented With 50% Of Their Known Daily Sweat Sodium Losses Using NaCl Enhanced Fruit Juice During Preseason

Fowkes Godek S, Bartolozzi AR, Burkholder R, Condon S, Peduzzi C: West Chester University, West Chester, PA; Pennsylvania Hospital, Philadelphia, PA; Philadelphia Eagles, Philadelphia, PA

Context: Sweat sodium ranged from 15 to 99 mmol/l in NFL players (n=45) with total sodium losses during two-a-days of 2.3 to 22g. Therefore, individualized electrolyte replacement may be important for this cohort. **Objective:** To individually replace known sodium losses in NFL players during the first week of two-a-days and measure blood electrolytes and changes in plasma volume (% Δ PV) and body mass (% Δ mass). We hypothesized that no differences would be found across days. **Design:** Observational cohort. **Setting:** 2007 preseason training camp of one NFL team. **Patients or Other Participants:** Eleven NFL veterans volunteered, 2 had EAMC on day 8 and requested continued supplementation, therefore 9 players (age=26.9 ±2.6y, ht=187.7 ±7cm, mass=111±21kg and BSA=2.4±0.23m²) participated. **Interventions:** Blood samples were taken for baseline measures upon players' arrival to camp and prior to the morning practice on Days 3, 5 and 10. Blood sodium, potassium and chloride were determined by ion-selective electrode and % Δ PV was calculated using Hct and Hb. Urine samples were provided for baseline measures of euhydration and mass was recorded to the nearest ½ lb. % Δ mass in the mornings of Days 3, 5 and 10 was calculated from baseline. On Days 1-4 players practiced 2x/d and then alternated 1 or 2 practices/d on Days 5 through 10. For the first week of camp at 4 meals/d players

consumed NaCl in juice containing minimal potassium in amounts equal to 50% of their daily sweat sodium losses known from a prior study. One-way ANOVA with repeated measures were used. **Results:** Mean WBGT for days 1-10 were 25.6±2°C for morning and 28±1.7°C for afternoon practices. Urine specific gravity and osmolality when baseline mass was recorded were 1.014 ± .006 and 466±242mOsm/kg indicating euhydration. Blood sodium was not different on Day 3 (140 ±1.2mmol·l⁻¹), Day 5 (139 ± 1.8mmol·l⁻¹) or Day 10 (139 ± 2.2mmol·l⁻¹) compared to baseline (140 ±1.6mmol·l⁻¹). No differences were found for blood potassium or chloride between days and all were within normal clinical range. % Δ mass on the morning of Days 3 (+.6%), Day 5 (+.04%) and Day 10 (+.36%) also did not differ. PV increased significantly on Day 5 (13% above baseline), $P = .049$. **Conclusions:** This was the first study to individualize sodium replacement in NFL players. Blood sodium remained unchanged during the first 10 days of preseason in players who individually replaced 50% of their daily sweat sodium losses. Mass was maintained through day 10 and importantly, PV expanded significantly by day 5. We previously reported low blood sodium on Day 3 in unsupplemented NFL players and high blood potassium by Day 9. Individualized replacement with NaCl and minimal potassium assisted in maintaining fluid and electrolyte balance in NFL players without promoting hyperkalemia.

Effect Of Various Cooling Methods In Reducing Core Body Temperature During Recovery From Exercise In The Heat

DeMartini JK, Ranalli GF, Casa DJ, Lopez RM, Ganio MS, McDermott BP, Stearns RL, Armstrong LE, Maresh CM: University of Connecticut, Storrs, CT

Context: Hyperthermia, which can become dangerous and/or influence performance, is common in the athletic population and in a variety of environments. This study will provide some direction for certified athletic trainers and other medical personnel as to what cooling methods have the best efficacy to cool hyperthermic athletes during a brief recovery period. **Objective:** The purpose of this study was to evaluate and compare the effectiveness of different cooling methods in lowering the core body temperature of individuals following exercise in the heat. **Design:** Randomized crossover design. **Setting:** Outdoor sports complex in warm environment (mean ± SD: WBGT:26.64 ± 4.71°C). **Patients or Other Participants:**

Sixteen males (n=9) and females (n=7) (24 ± 6 yr, 182 ± 7 cm, 74.03 ± 9.17 kg, $17.08 \pm 6.23\%$ body fat). **Interventions:** Subjects exercised for two to three one hour sessions over four days. After each exercise bout subjects were cooled for 10 minutes in a shaded pavilion (WBGT: $22.37 \pm 4.55^\circ\text{C}$) by one of 9 cooling modalities including cold water immersion (CWI), shade, Port-a-Cool® (fan), Emergency Cold Containment System® (ECCS), Rehab Hood® (hood), Nike Ice Vest® (NIV), Game Ready Active Cooling Vest® (GRV), ice buckets, and ice towels. These cooling rates were compared to sun (control). **Main Outcome Measures:** Rectal temperature (T_{RE}), heart rate (HR), thirst sensation, thermal sensation, and a modified Environmental Symptoms Questionnaire (ESQ). **Results:** The average T_{RE} following exercise (pre-cooling) across all trials was $38.73^\circ\text{C} \pm .12$. After 10 minutes of cooling CWI ($-.65 \pm .29^\circ\text{C}$), ice buckets ($-.74 \pm .34^\circ\text{C}$), and ECCS ($-.68 \pm .24^\circ\text{C}$) had significantly ($p < 0.006$) greater decrease in T_{RE} compared to sun ($-.42 \pm .15^\circ\text{C}$). HR at the ten minute mark was significantly ($p < 0.006$) lower for CWI (82 ± 15 bpm), fan (88 ± 12 bpm), ECCS (87 ± 14 bpm), and ice towels (84 ± 15 bpm) as compared to sun (101 ± 15 bpm). Thermal sensation scores between modalities were all significantly ($p < 0.006$) lower (CWI: $1.7 \pm .6$; fan: $3.2 \pm .8$; ECCS: $4.6 \pm .7$; hood: $4.6 \pm .6$; NIV: 4.5 ± 1 ; GRV: $4.0 \pm .5$; ice buckets: 4.0 ± 1 ; ice towels: 3.0 ± 1) when compared to sun ($5.5 \pm .5$) except for shade (5.0 ± 0.8). There were no significant differences ($p > 0.006$) in thirst scores between all modalities when compared to sun. ESQ scores were significantly ($p < 0.006$) lower for CWI (1 ± 6), fan (4 ± 5), and ice towels (3 ± 8) when compared to sun (13 ± 12). **Conclusions:** Our findings indicate when athletes are experiencing mild hyperthermia following intense exercise in the heat that CWI, ice buckets, and ECCS offer superior cooling rates (as compared to rest in the sun) during a brief break period.

Exertional Heat Illness: Illness Rates For College Football Participants During Pre-Season Practice – A Predictor For Heat Acclimatization
Cooper ER, Ferrara MS, Resch J, Broglio SP, Casa DJ, Powell JW: University of Georgia, Athens, GA; University of Illinois, Urbana-Champaign, IL; University of Connecticut, Storrs, CT; Michigan State University, East Lansing, MI

Context: Collegiate football programs follow a mandatory 5-day acclimatization period (day 1&2 helmets, day 3&4 shells, day 5 full equipment; after day 5 alternation between double/single sessions may begin) at the beginning of pre-season football practice in an attempt to allow athletes adjustment to environmental conditions. Acclimatization periods for active adult populations have been reported to require anywhere from 5–14 days. **Objective:** To observe the overall illness rate (IR) of Exertional Heat Illnesses (EHI's) as they correspond to heat acclimatization periods during practice sessions of pre-season football practice as equipment is added and double session commence. **Design:** A four-year cross-sectional study. **Setting:** NCAA collegiate institutions from 6 geographical regions – northeast, southeast, southwest, southwest, northwest, upper-midwest, and lower-midwest. **Patients or Other Participants:** A convenience sample of intercollegiate football programs representing 114 team-seasons. **Interventions:** A certified athletic trainer (ATC) was identified at each institution and recorded all EHI's. Data included the total number of participants per day (athlete-exposures, AE) and practice day. 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:** ATC's recorded each EHI occurrence and exposure data during the study period. The data collection period spanned the first 14 practice days in August for each athletic season (2004 – 2007). EHI

rates were calculated by dividing the total number of illnesses by the total number of AE. The injury rate was calculated for practice days 1 and 2, practice days 3 and 4, practice day 5, practice day 7 and practice day 14. The Incidence Density Ratio (IDR) was calculated using days 1 and 2 as the control and the following days as experimental (days 3 and 4, 5, 7, and 14) and the 95% confidence interval (CI). Statistical significance was set at $p < .05$. **Results:** The overall IR was calculated during practice days 1 and 2 (IR = $6.94/1000\text{AE}$), days 3 and 4 ($3.86/1000\text{AE}$), day 5 ($2.35/1000\text{AE}$), day 7 ($3.71/1000\text{AE}$) and day 14 ($0.9/1000\text{AE}$). The IDR using days 1&2 as the control found that the experimental practice days had a reduced illness risk for days 3&4 (RR = .50, 95% CI = .27-.92, $p < .05$), day 5 (RR = .47, 95% CI = .21, 1.04, $p > .05$), day 7 (RR = .89, 95% CI = .46, 1.7, $p > .05$) and day 14 (RR = .33, 95% CI = .13, .82, $p < .05$). **Conclusions:** Days 1–5 represent single session practices with a gradual addition of equipment/uniform worn. The EHI risk was greatest on practice days 1&2, with a steady decrease through day 5 with a slight increase on day 7 followed by a steady decline to day 14. We found that complete acclimatization and reduction of EHI risk can take up to 14 days. This project was funded by the NCAA and the NATA College and University Athletic Trainers Committee.

Evidence-Based Forum #1: Heat & Hydration

Thursday, June 18, 2009, 12:15PM-1:15PM; Room 214B; Discussants: Doug Casa, PhD, ATC, FACSM and Susan Yeargin, PhD, ATC; Moderator: Robert Howard, MA, ATC

Free Communications, Oral Presentations: Clinical Intervention Outcomes

Friday, June 19, 2009, 8:15AM-9:00AM, Room 214B; Moderator: Marjorie King, PhD, ATC, PT

Four Weeks Of Daily Dynamic And Static Stretching Increased Flexibility

Jutte LS, Short JA, Harrison MC: Ball State University, Muncie, IN

Context: Research suggests that static stretching increases flexibility but may decrease muscle power. Thus, some individuals suggest using dynamic stretching prior to physical activity to increase flexibility without decreasing muscle power. We could find no research to support that dynamic stretching increases flexibility. Previously, we demonstrated a single bout of dynamic stretching did not affect flexibility or power.

Objective: The purpose of this study was to assess the effects of 4 weeks of daily dynamic and static stretching on flexibility and muscle power.

Design: Two-factor between subjects repeated measures design.

Settings: Athletic Training Research Laboratory

Patients or Other Participants:

Thirty-six, recreationally active, healthy, college students, (M:22 F:14, age:21.8±2.8 yrs, ht:1.7±0.09 m, wt:72.7±13.6 kg) participated in our study. Subject criteria included: no orthopedic injuries in the last 6 months, no cardiovascular or neurological disorders and limited hamstring flexibility (inability to fully extend knee with 90° of hip flexion). **Intervention:** Subjects were randomly assigned to 1 of 3 groups [dynamic stretching (D), static stretching (S), & control (C)]. Groups D and S performed 2 minutes of daily bilateral hamstring stretching for 4 weeks while group C did not stretch. For 4 weeks, hamstring flexibility and lower limb power were measured weekly before and after a stretching bout. We calculated group means and standard deviations for each time. The data was analyzed using a repeated measures ANOVA followed by Tukey-Kramer multiple comparison tests. The *p*-value was set at .05.

Main Outcome Measures: Hamstring flexibility was measured with a bubble inclinometer. The subject's range of motion (ROM) was measured by assessing the deficit in knee extension with the hip flexed at 90°. Lower limb power was measured by vertical jump (VJ) using a Vertec. **Results:** There was a group by time interaction for ROM ($F_{18,296}=4.10$ $p<.001$). ROM increased for group D by 9.8° (pre-wk0=33.8±12.3° & post-wk4= 24±13.9°), and group S by 11.4° (pre-wk0=38.5±8.3° & post-wk4=27.1±8.6°) while group C did not change (pre-wk0=30±8.4° & post-wk4= 31±8.6°). VJ increased over time [pre-wk0=46.0±14.0 cm, pre-wk4=48.0±13.5 cm, & post-wk4=48.5±14.0cm ($F_{9,296}=2.74$, $p=.004$)]. There

were no significant differences between weekly pre- and post-stretching VJ measures for either stretching technique. **Conclusions:** Four weeks of either daily dynamic or static stretching increased hamstring flexibility in individuals with limited hamstring flexibility. Our data does not support the idea that static stretching decreases acute muscle power, as measured by vertical jump. Dynamic stretching may be as effective as static stretching prior to regular activity.

Deep Abdominal Muscle Training Provides Minimal Important Changes In Perceived Disability, But Not In Pressure Biofeedback Values In Asymptomatic People With A

Significant History Of Low Back Pain

Hammill RR, Hart JM, Saliba S, Konold T, Hertel J, Ingersoll CD: University of Virginia, Charlottesville, VA, and Bridgewater College, Bridgewater, VA

Context: People with a history of low back pain (LBP) are persistently unable to adequately contract their deep abdominal muscles. Training these muscles to efficiently stabilize the lumbar segments and pelvis is necessary to control pain and prevent recurrence. The Oswestry Disability Index (ODI) v.2.0 can assess a patient's perceived disability. A minimal important change (MIC) of 30% has been presented for ODI scores. The Pressure Biofeedback Test (PBT) has been presented as a tool that can estimate abdominal muscle function.

Objective: To compare the mean pressure changes of PBTs and mean ODI scores, and to assess the number of participants who achieved a MIC with a two week abdominal muscle training intervention. **Design:** Randomized controlled trial. **Setting:** Sports medicine laboratory or athletic training clinic. **Patients or Other Participants:** 26 volunteers (age=28.9±10.4 years, height=169.4±9.8 cm, mass=73.1±10.1 kg) with a significant history of recurrent low back pain (minimum of 3 episodes in the past year) were randomly divided into control (CON) and training (AB) groups. **Interventions:** Participants randomly assigned to the AB group were asked to perform exercises commonly used to treat LBP. These patients met with a certified athletic trainer 6 times over two weeks and were given a home exercise program that was modified after each session. AB subjects were asked to record their activity in a log book. All subjects were pretested (PRE), tested later the same day (PST1), and then again after

two weeks (PST2).

Main Outcome Measures: The PBT was used to estimate changes in subjects' ability to activate their deep abdominal muscles. Subjects filled out ODIs (v.2.0) at each time interval. We ran separate 2x3 ANOVAs using group and time as our factors. **Results:** The AB group had PBT changes of 3.84±7.16, 2.89±5.99, and 4.28±6.54 mmHg at PRE, PST1, and PST2, respectively, compared to 2.75±4.39, 2.63±5.01, and 4.43±5.74 mmHg for the CON group. There was no significant interaction ($F_{1,4,25.8}=0.217$, $P=0.719$, $1-\beta=0.076$) or main effect (Time: $F_{1,4,25.8}=1.456$, $P=0.247$, $1-\beta=0.240$; Group: $F_{1,19}=0.300$, $P=0.865$, $1-\beta=0.053$). Mean ODIAB group scores were 12.00±9.64, 9.14±7.05, and 6.71±5.00 at PRE, PST1, and PST2, respectively, compared to 11.67±5.03, 10.17±5.75, and 9.00±4.94 for the CON group. There was no significant interaction ($F_{2,46}=0.036$, $P=0.965$, $1-\beta=0.055$) or main effect for group ($F_{1,23}=0.981$, $P=0.332$, $1-\beta=0.158$). There was a significant main effect for time ($F_{2,46}=5.740$, $P=0.006$). Pairwise comparisons for time indicated a significant difference between the PBT between PRE and PST1, and between PRE and PST2. 77% of AB participants had a MIC, compared with 50% of CON participants. **Conclusions:** A two-week deep abdominal muscle training program in asymptomatic people with a significant history of recurrent LBP does not affect PBT estimates. ODI scores may fluctuate over time regardless of training, although abdominal training therapy is more likely to induce a MIC.

The Effects Of A Six-Week Core Stabilization Training Program On Dynamic Balance And Core

Endurance In Track And Field Athletes

Sandrey MA, Mitzel JG: West Virginia University, Morgantown, WV, and Western Carolina University, Cullowhee, NC

Context: Core training is vague and it is not known how core training for healthy track and field athletes affects dynamic balance and core endurance. **Objectives:** To examine the effects of a six-week core stabilization training program on dynamic balance and core endurance. **Design:** Pre-test/post-test, repeated measures design. **Setting:** AA High School. **Patients or Other Participants:** The experimental group (EG) consisted of 13 healthy track and field athletes (15.38±1.12 yrs, 172.31±10.42 cm, 62.43±9.01 kg) using a sample of

convenience. The control group (CG) of 15 (15.87±1.06 yrs, 173.19±7.26 cm, 77.11±22.14 kg) consisted of healthy baseball and softball athletes from the same high school that were matched to the age and activity levels of the EG. **Interventions:** The EG performed the six-week supervised program three times a week for an average of 30 minutes/session. The core stabilization exercises increased in difficulty each week by adding movements, equipment or decreasing stability. Subjects began at exercise level one and progressed with time, sets/reps weekly. The control group performed no exercises. Pre/post testing included the Star Excursion Balance Test (SEBT) with a randomized starting point for both limbs, Back Extensor Test (BET), 45° Abdominal Fatigue Test (AFT), and Right and Left Side Bridging Test (SBT). Analyses consisted of group, limb and test (SEBT normalized reach distances), group and test

(BET, AFT), and group, side and test (SBT) repeated measures ANOVA with a Bonferroni Correction factor ($P=0.007$). **Main Outcomes Measures:** Four reach distances of the SEBT (anteromedial, lateral, medial, posteromedial), the AFT, BET, and SBT for both sides. **Results:** Percent improvement ranged from 12.54% to 250.88% with AFT demonstrating the greatest increase. For SEBT there was a significant limb by group interaction for medial ($P=0.003$, left limb CG>EG), and lateral ($P=0.003$, left limb EG>CG) directions. There was a significant main effect for group in the medial direction with CG>EG ($P=0.004$, 74.02±1.45/67.26±1.56). There was a significant main effect for the medial ($P<.001$), anteromedial ($P=0.002$), and lateral ($P=0.003$) directions for the left limb. Significant test by group interactions were observed for the AFT ($P<.001$), and BET ($P<.001$) with EG>CG

times at post-test. There was a significant main effect of test for the AFT ($P<.001$, 42.69±21.33/149.79±84.62) and BET ($P<.001$, 46.73±23.86/103.08±32.63). There was a significant side by group interaction ($P<.001$) for SBT with EG>CG for the right side. There was a significant main effect for test ($P<.001$) for right (28.77±14.36/77.20±34.28) and left (26.77±13.40/69.61±27.12) SBT with post test > pre-test. No significant difference was evident between groups. **Conclusion:** Although there was a significant difference between groups for the medial direction, no other group results were significant. Despite this the EG did show substantial improvements between pre/post AFT, BET and SBT times after the six-week training.

Free Communications, Oral Presentations: Shoulder Injury: Incidence, Treatment & Outcomes

Friday, June 19, 2009, 9:15AM-10:15AM, Room 214B; Moderator: Sheri Walters, ATC, PT

A Randomized, Controlled Study Of The Acute Effects Of Muscle Energy Techniques On Posterior Shoulder Tightness

Moore SD, Laudner KG, Somers AK, McLoda TA, Shaffer M: Illinois State University, Normal, IL, and University of Iowa, Iowa City, IA

Context: Overhead athletes often exhibit posterior shoulder tightness, which has been associated with lost shoulder range of motion (ROM) and increased risk of shoulder pathology. Stretching protocols aimed at improving posterior shoulder motion have revealed inconsistent results. Although utilization of muscle energy techniques (MET) has been hypothesized to lengthen muscle and fascia, limited empirical data exist describing the effectiveness of such stretches for treating posterior shoulder tightness. **Objective:** To determine if MET provides acute improvements in glenohumeral horizontal adduction and internal rotation ROM. **Design:** Randomized, single-blinded, pre-test post-test design. **Setting:** Collegiate athletic training room. **Participants:** Sixty-one NCAA Division I baseball players were randomly assigned to one of three groups. Nineteen participants (age=19.5±1.0 years, height=184.4±6.2 cm, mass=86.9±7.0 kg) received a MET to increase the flexibility of the horizontal abductors (MET for HAbd), 22 participants (age=20.4±1.1 years, height=183.7±6.5 cm, mass=88.2±11.2 kg) received a MET to increase the flexibility of

the external rotators (MET for ER), and 20 participants (age=19.8±1.1 years, height=186.2±6.5 cm, mass=89.4±7.8 kg) received no treatment (control). Participants had no recent upper extremity injury or surgical history. **Interventions:** We measured pre and post-test glenohumeral horizontal adduction ROM (ICC=0.93, SEM=1.6°) and internal rotation ROM (ICC=0.98, SEM=2.0°) using the Pro Digital Inclinometer (SPI-Tronic, Garden Grove, CA). Participants were supine with the scapula stabilized for ROM measurements and MET application. Muscle energy technique application consisted of a 5 second isometric contraction against the examiner in the direction of either glenohumeral horizontal abduction (MET for HAbd) or external rotation (MET for ER) at 25% of maximum force followed by a 30 second active-assisted stretch. The active assisted stretch involved moving the glenohumeral joint into end range horizontal adduction (MET for HAbd) or internal rotation (MET for ER). This procedure was performed a total of 3 times. We conducted a mixed model ANOVA, followed by a one-way ANOVA and Tukey post hoc analysis for significant group-by-time interactions ($P<.05$). **Main Outcome Measures:** Dependent variables included glenohumeral horizontal adduction and internal rotation ROM. **Results:** A significant group-by-time interaction was found for glenohumeral horizontal adduction ROM ($P=.02$) (MET for HAbd group: pre-test=-10.0±9.6°, post-test=-3.4±9.9°; MET for

ER group: pre-test=-13.5±7.7°, post-test=-8.5±8.9°; control group: pre-test=-7.8±6.0°, post-test=-8.9±7.2°). A significant group-by-time interaction was also found for glenohumeral internal rotation ROM ($P=.02$) (MET for HAbd group: pre-test=43.5±10.1°, post-test=47.7±11.7°; MET for ER group: pre-test=44.5±8.6°, post-test=44.7±8.6°; control group: pre-test=50.7±11.3°, post-test=50.5±12.1°). The MET for the HAbd group had a significantly greater improvement in glenohumeral horizontal adduction ($P=.02$) and internal rotation ROM ($P=.03$) compared to the control group. No significant differences were found for any other variables ($P>.05$). **Conclusions:** Our results indicate that an application of a MET for the horizontal abductors provides acute improvements in both glenohumeral horizontal adduction and internal rotation ROM among baseball players.

The Effect Of Shoulder Plyometric Training On Selective Muscle Recruitment And Glenohumeral Force Couple Co-Activation Strategies
Swanik KA, Swanik CB, Thomas SJ, Huxel KC, Kelly JD: Neumann College, Aston, PA; University of Delaware, Newark, DE; Indiana State University, Terre Haute, IN; Temple University Hospital, Philadelphia, PA

Context: Limited prospective data exists quantifying neuromuscular adaptations to the

shoulder following plyometric training. Although performance improvements are often attributed to the repetitive stretch-shortening contractions, it is unclear whether changes in selective muscle recruitment or force couple coactivation provides distinct advantages over traditional strengthening exercises used in a rehabilitative setting.

Objective: To measure electromyographic (EMG) amplitude and co-activation of five glenohumeral muscles before and after 8 weeks of upper extremity strength and plyometric training. **Design:** A randomized pre-test post-test comparison group study. **Setting:** This study was performed in a controlled laboratory setting. **Participants:** Forty recreationally active male volunteers participated with no history of upper extremity orthopedic pathology. Subjects were randomly assigned to either a Plyometric (age 20.43 $\pm$ 1.4yrs; height 180.0 $\pm$ 8.80cm; weight 73.07 $\pm$ 7.21kg) or Strength training (Control) group (age 21.95 $\pm$ 3.4yrs; height 173.98 $\pm$ 11.91cm; weight 74.79 $\pm$ 13.55kg).

Interventions: The independent variables were group (plyometric vs. strength training) and time (pre and post test). Bipolar Intramuscular fine wire and surface electrodes were used to collect (Noraxon USA Inc.) muscle activity of the anterior deltoid(D), supraspinatus(SP), infraspinatus(I), teres minor(TM), and subscapularis(SB) during a weighted ball toss exercise, which time and amplitude was normalized. Kinematic data was collected simultaneously (Polhemus, Inc., Colchester, VT) to identify each phase of the plyometric exercise (eccentric, amortization and concentric). Data was analyzed using 2 (group) X 2 (time) ANOVA's with repeated measures on time. **Main Outcome Measures:** The dependent variables were EMG area (%1%), and the glenohumeral agonist/antagonist force couples co-activation ratios (D/I + TM and SB/I + TM) during the three phases (eccentric, amortization, and concentric). **Results:** Several main effects and interactions were observed with the most notable occurring in the TM. Both groups increased TM EMG area after training during the amortization (pre = 1.56 $\pm$ 1.04, post = 2.02 $\pm$ 1.17, p = 0.01) and concentric phase (pre = 6.29 $\pm$ 2.96, post = 9.01 $\pm$ 3.68, p = 0.0001). Both groups also had decreased force couple co-activation ratios during the concentric phase (D/I + TM = pre = 0.582 $\pm$ 0.142, post = 0.464 $\pm$ 0.108, p = 0.0001 and SB/I + TM = pre = 0.528 $\pm$ 0.200, post = 0.435 $\pm$ 0.153, p = 0.016). No significant differences by group or time were observed in the individual muscle SB or I for any phase. **Conclusion:** These results suggest that both plyometric and weight training facilitate increased recruitment of the TM during the concentric phase of a weighted ball toss

exercise. Neuromuscular TM changes may be largely responsible for the decreased force factors" for subacromial impingement in overhead athletes. *Funded by a General Research Program Grant from the NATA Research and Education Foundation.*

Outcomes Of Standardized Treatment Program Of Exercise And Manual Therapy For Patients With Subacromial Impingement Syndrome: A Case Series

McClure PW, Michener LA, Tate AR, Thigpen CA, Seitz AR, Young IA, Salvatori R: Virginia Commonwealth University, Richmond, VA, and Arcadia University, Glenside, PA

Background: Subacromial impingement syndrome (SAIS) is the most frequent cause of shoulder pain, affecting primarily those involved with overhead sports or occupations. Two clinical trials support the use of therapeutic exercise and manual therapy to improve pain and functional loss associated with SAIS. However, not all patients with subacromial impingement responded to the treatment provided. In these clinical trials the treatment program was not adequately described or standardized to allow for replication. Moreover, standardized and validated outcome measures were not used to assess treatment effects. The purpose of this case series is to describe a standardized treatment program and to assess the outcome of this program. **Differential Diagnosis:** Consecutive patients (n = 10) with SAIS (5 females; 45.3 $\pm$ 17.7yrs; 50% had pain with sports participation) were evaluated to confirm the diagnosis of SAIS with 3/3 criteria of a positive: 1.) Hawkin's or Neer's test, 2.) Empty can or Full can, 3.) Painful arc. Patients could also have a concurrent secondary diagnosis of instability, rotator cuff tear, or labral tear. The primary presentation of their pain had to be SAIS. **Treatment:** Patients with SAIS were treated with an evidence-based standardized program of strengthening, stretching, manual therapy, and a home exercise program for 10 visits over 6-8 weeks. Specifically the protocol included a 3-phase progressive strengthening program (Phase 1: shoulder external and internal rotation with the arm at side, protraction, cervical and scapular retractions, and active elevation with upper trapezius relaxation; Phase 2: shoulder elevation, internal and external rotation with the arm elevated, prone middle and lower trapezius and quadrated serratus exercise; Phase 3 additional functional and endurance exercises), stretching (thoracic extension over a towel, cross-body, doorway pectoralis, shoulder internal and external rotation and

flexion), manual therapy (thoracic spine mobilization and manipulation, glenohumeral posterior and inferior glide and manual stretch), and a daily home exercise program of stretching and strengthening. Patients completed outcome measures at the first session, 6 weeks, and at 3 months of shoulder disability using the Disabilities of the Arm, Shoulder Hand (DASH; 0- 100, 0 = no disability) and overall change with the global rating of change (GROC). Treatment was defined as "successful" if both a 50 percentage improvement in DASH score, and GROC of "moderately better" was achieved. All other patients were considered "non-successful" outcome. At 6 weeks, 6 patients were "successful" with the standardized treatment (DASH initial: 33.9 $\pm$ 16.2, 6 weeks: 8.06 $\pm$ 9.2) and 4 patients were "non-successful" (DASH initial: 34.3 $\pm$ 5.5, 6 weeks: 23.3 $\pm$ 8.8). At 3 months, 8 patients were considered "successful" with the standardized treatment (DASH initial: 33.1 $\pm$ 14, 3 months: 8.3 $\pm$ 6.4) and 2 patients were "non-successful" (DASH initial: 37.8 $\pm$ 2.8, 3 months: 27.1 $\pm$ 1.1). **Uniqueness:** This case series describes a standardized treatment program and the use of validated outcome tools to assess outcome of treatment. **Conclusions:** In this case series, 6/10 patients had improved shoulder disability at 6 weeks when compared to the initial evaluation, and 8/10 patients at 3 months when compared to the initial evaluation scores. Self-report outcome tools were used to quantify the outcome, and determine success or failure with the treatment program. The DASH change scores for each patient exceeded the minimal detectable change value (13 points) in patients who were 'successful', and did not exceed it in patients who were 'non-successful'. Future research should investigate what factors predict response to this standardized treatment program. Additionally, understanding the time course of response or non-response may be useful in clinician decision-making.

Epidemiology Of Glenohumeral Joint Instability Among Athletes

Jones CJ, Owens BD, Cameron KL: United States Military Academy, West Point, NY

Context: Glenohumeral joint (GH) instability is a common problem among athletes that leads to pain, dysfunction, and a decrease in overall health; however, few population-based studies provide insight into the incidence and characteristics of GH instability. **Objective:** To examine the incidence and characteristics associated with GH instability among subjects competing in intramural athletics between 1994 and 2005

at the United States Military Academy (USMA). **Design and Setting:** All injuries sustained by cadets at USMA are treated through a closed healthcare system and the Cadet Injury Surveillance System (CISS) is used to document all time loss injuries in this population. Injury data was extracted from the CISS from August 1994 through May 2005 for all GH instability events resulting from participation in intramural athletics. Only sports for which at least seven years of data could be obtained were included. As a result, incidence rates (IR) were calculated per 1000 athlete-exposures for ten different sports. Incidence rates were also calculated by type and direction of GH instability. Injury was defined as any glenohumeral instability event that resulted in one or more days of limited activity. Exposure was defined as one subject participating in one activity session. All injuries and exposures were prospectively documented in the surveillance system.

Participants: The study population included all male and female cadets involved in intramural athletics during the study period. **Main Outcome Measures:** The primary outcome measures in this study were IR per 1000 athlete-exposures and the average time lost due to injury. **Results:** A total of 40,666 subjects participated across ten intramural activities during the study period. There were a total of 234 GH instability events documented in this population among 642,323 athlete-exposures to injury. The overall incidence rate for GH instability was 0.36 (CI=0.32-0.41) per 1000 athlete-exposures. Subluxation events accounted for 83.3% of all injuries and 90.2% of all instability events were anterior in nature. Subluxations occurred five times more frequently when compared to dislocations (IRR=5.00, CI=3.55-7.05) and subjects were over nine times more likely to experience anterior instability events (IRR=9.17,

CI=5.97-14.11). Subjects with dislocation injuries experienced significantly greater time loss following injury when compared to those with subluxation events ($F=10.67$, $df=1$, $p<.001$). On average, athletes with dislocations missed 89 days following injury compared to 45 days among athletes with subluxation injuries. The highest rate of injury was observed in boxing (IR=0.88, CI=0.62-1.13), followed by rugby (IR=0.75, CI=0.56-0.95) wrestling (IR=0.71, CI=0.46-0.96) and football (IR=0.67, CI=0.52-0.82). **Conclusions:** GH instability is common among athletes participating in contact sports and these injuries result in significant time loss, particularly following dislocation events. Future research efforts should focus on more clearly identifying risk factors for GH instability in order to develop appropriate injury prevention initiatives.

Evidence-Based Forum #5: Shoulder

Friday, June 19, 2009, 10:30AM-11:30AM, Room 214B; Discussants: Tracey Spigelman, PhD, ATC, and Sheri Walters, MPT, ATC, CSCS; Moderator: Christopher Jones, MA, ATC

Free Communications, Oral Presentations: The Overhead Athlete

Friday, June 19, 2009, 4:30pm-5:30pm, Room 214B; Moderator: Brian Hatzel, PhD, ATC

Bilateral Scapular Muscle Activation In Overhead Athletes With Unilateral Shoulder Impingement During A Push-Up

Tucker WS, Armstrong CW, Gribble PA, Timmons MK, Yeasting RA: University of Toledo, Toledo, OH, and University of Central Arkansas, Conway, AR

Context: Research has demonstrated that patients with shoulder impingement syndrome (SIS) have an overactive upper trapezius (UT) and suppressed serratus anterior (SA) during open kinetic chain activities. Studies on closed kinetic chain exercises have not demonstrated the same patterns in patients with SIS. There have been no studies comparing the scapular muscle activation of the involved side and uninvolved side of patients with SIS during closed kinetic chain exercises. **Objective:** To compare the bilateral muscle activation of the SA, UT, middle trapezius (MT) and lower trapezius (LT) in overhead athletes with and without unilateral SIS during a standard push-up. **Design:** One-between (Group), one-within (Side) mixed model. **Setting:** Controlled laboratory environment. **Patients or Other Participants:** Eleven overhead sport athletes (7 females: 20.57±0.98 yrs, 172.72± 7.02 cm, 73.44±11.22 kg, 4 males: 23.0±4.24 yrs,

185.42±4.28 cm, 90.91±11.27 kg) demonstrating with unilateral SIS (SI) and 11 overhead sport athletes (7 females: 20.14±1.57 yrs, 173.26±9.24 cm, 71.43±12.17 kg, 4 males: 22.0±7.35 yrs, 183.52±6.92 cm 85.0±6.86 kg) with no shoulder pathologies (NP). **Interventions:** Subjects completed five individual trials of a standard push-up while bilateral electromyography of the SA, UT, MT and LT was sampled at 1000 Hz. There was a one-minute rest period between trials. Trunk and shoulder positioning were normalized to the subject's height. Trial velocity was controlled using a metronome. The mean electromyography data for the four muscles were normalized to a maximum voluntary isometric contraction. The independent variables were Group (SI and NP) and Side (involved and uninvolved). The four dependant variables were the normalized mean electromyography of each included muscle (SA, UT, MT and LT). For each dependent variable, a one-between, one-within repeated measures ANOVA was performed. Level of significance was set at $p<.05$. **Main Outcome Measures:** Normalized mean electromyography of the SA, UT, MT and LT. **Results:** Post-hoc analysis revealed a statistically significant interaction for UT ($F_{1,20}=6.775$; $p=0.017$). The non-dominant

side of the SI group (58.52±31.71%) had significantly greater activation compared to the dominant side of the SI group (43.66±29.69%) and the non-dominant side of the NP group (39.97±19.23%). There were no statistically significant influences of Group or Side for the SA, MT or LT. **Conclusions:** Differences in UT activation were evident within the side and between the groups during the push-up. No differences were found in the SA, MT or LT. These results were not consistent with the scapular muscle activation previously reported in patients with SIS during open chain activities. However, they were consistent with previous research investigating closed chain activities. Scapular muscle activation of patients with SIS may differ during open chain activities compared to closed chain activities such as the push-up. This may assist clinicians in determining a more effective rehabilitation strategy for overhead sport athletes.

Bi-lateral Posterior Capsule Thickness And Its Correlation With Glenohumeral Internal Rotation In Collegiate Baseball Players

Thomas SJ, Swanik CB, Swanik KA, Nazarian L, Bartolozzi AR, Reisman A: University of Delaware, Newark, DE; Neumann College, Aston, PA; Thomas Jefferson Hospital, Philadelphia, PA; Pennsylvania Hospital, Philadelphia, PA

Context: It is well documented that baseball players develop glenohumeral internal rotation deficits (GIRD) in their throwing arm. However, the cause of this adaptation is still unknown. Some authors believe that this adaptation is due to rotator cuff tightness and others believe it is due to a hypertrophied posterior capsule. It has been shown in previous studies that a thick and tight posterior capsule will cause the humeral head to shift posterior and superior which may lead to SLAP tears. **Objective:** To compare in-vivo posterior capsule thickness bi-laterally and examine its correlation to glenohumeral (GH) rotation. **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). Posterior capsule thickness was measured with an ultrasound system (Sonosite Titan, Sonosite Inc., Bothell, WA) and GH internal rotation (IR) was measured with a Saunders Digital Inclinator (The Saunders Group Inc. Chaska, MN). A 2-way ANOVA was performed for posterior capsule thickness. Pearson product moment correlation coefficients assessed the relationships between posterior capsule thickness and GH IR; and posterior capsule thickness difference (PCTD) and GIRD. **Main Outcome Measurements:** Posterior capsule thickness was measured from an upright seated position with the shoulder in 0° abduction and neutral rotation. Glenohumeral IR was measured with the subject supine and scapula stabilized. **Results:** The dominant arm had a significantly thicker posterior capsule compared to the non-dominant arm (dominant arm = 2.03 ± 0.27 mm, non-dominant arm = 1.65 ± 0.28 mm, $p=0.0001$). Posterior capsule thickness was significantly correlated with GH IR (-0.498 , $p=0.0001$) and PCTD was also significantly correlated with GIRD (-0.594 , $p=0.002$). **Conclusion:** This was the first in-vivo study to demonstrate, with ultrasound, posterior capsule thickness and

its association with GIRD in the dominant arm. These observations suggest that the posterior capsule does hypertrophy and is likely due to excessive stress during the deceleration phase of the overhead throw. Secondly, the increase in capsular thickness may also contribute to the loss of GH IR. This methodology could be used as a non-invasive screening evaluation for overhead athletes to identify those with posterior capsule thickening, in conjunction with GIRD, who may be at risk for shoulder injuries, and to design rehabilitation programs to help counteract this potentially deleterious adaptation.

Total Rotation Range Of Motion Deficit Attributed To Glenohumeral External Rotation Deficit In Collegiate Overhead Athletes

Oyama S, Myers JB, Goerger BJ, Rucinski TJ, Blackburn JT: University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Decreased glenohumeral total rotation range of motion (ROM) in the dominant shoulder compared to the non-dominant limb is considered as one of the signs of posterior shoulder tightness and internal rotation ROM deficit, and has been linked to injury. However, it is unclear if the loss of total rotation ROM results from restriction of internal rotation or external rotation ROM. **Objective:** To evaluate the relationship between the total rotation ROM deficit and the glenohumeral internal and external rotation deficits corrected for humeral torsion, in order to determine the direction of the glenohumeral rotation ROM limitation contributing to the loss of total ROM. **Design:** Correlational study. **Setting:** A university biomechanics laboratory. **Patients or Other Participants:** Forty-six healthy collegiate overhead athletes (30 male baseball players: age = 19.5 ± 1.0 yrs, height = 183.4 ± 8.0 cm, mass = 87.6 ± 11.0 kg, years of experience = 14.5 ± 3.1 yrs, and 16 female softball players: age = 19.4 ± 1.5 yrs, height = 169.7 ± 6.9 cm, mass = 71.8 ± 11.0 kg, years of experience = 12.3 ± 2.2 yrs) participated. **Interventions:** Bilateral humeral rotation ROM and humeral torsion angles were measured using a digital inclinometer and diagnostic ultrasound. All measurements were taken while the subjects lay supine in 90° degrees shoulder abduction and elbow flexion. Pearson correlation coefficients were calculated between the total rotation ROM deficit and internal/external rotation deficits corrected for humeral torsion. An alpha level was set 0.05 a priori. **Main Outcome**

Measures: Humeral torsion was measured as the angle of the forearm with respect to horizontal when the proximal humerus (bicipital groove) was placed in a standardized position using a diagnostic ultrasound. Total rotation ROM (internal rotation ROM + external rotation ROM), external rotation ROM corrected for humeral torsion, and internal rotation ROM corrected for humeral torsion were calculated bilaterally. The deficits on the dominant limb were calculated (dominant - non-dominant). **Results:** A significant moderate correlation was found between the total rotation ROM deficit and the external rotation deficit corrected for humeral torsion ($r=0.663$, $p<0.001$). The correlation between the total rotation ROM deficit and the internal rotation deficit corrected for humeral torsion was non-significant ($r=-0.170$, $p=0.266$). **Conclusions:** The total glenohumeral rotation ROM deficit is more strongly correlated with the deficit in external rotation than in internal rotation following correction for humeral torsion. This may suggest that a deficit in total ROM indicates tightness of the musculature limiting glenohumeral external rotation, such as the pectoralis major and latissimus dorsi muscles, instead of the posterior shoulder structures. Instead of improving the posterior shoulder flexibility, stretching of the global shoulder muscles may be recommended for those overhead athletes with total rotation ROM deficits.

Influence Of Humeral Torsion On Posterior Shoulder Tightness Measures In Overhead Athletes

Myers JB, Oyama S, Goerger BM, Rucinski TJ, Privette G, Blackburn JT: University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Measures of glenohumeral internal rotation and horizontal adduction range of motion (ROM) are common clinical indicators of posterior shoulder tightness in throwing athletes. However, these measures may be influenced by the amount of humeral torsion that is present in the throwing limb, affecting interpretation of clinical findings. Ultrasonography provides a non-invasive alternative to traditional radiological methods used to assess humeral torsion, providing a means for clinicians to adjust for this influence when assessing posterior shoulder tightness. **Objective:** To demonstrate the influence of humeral torsion on interpretation of measures of posterior shoulder tightness in throwing athletes. **Design:** Cross-sectional study. **Setting:** A university biomechanics laboratory. **Patients or Other Participants:**

Fifty-four participants volunteered including 29 male varsity baseball players (BP) (age=19.5±1.0yrs, height=183.5±8.0cm, mass=87.5±11.1kg, years participated=14.8±1.9yrs), and 25 male control participants (CP) (age=20.0±1.1yrs, height=182.3±8.4cm, mass=81.8±12.4kg) with no history of participation in overhead athletics. **Interventions:** Bilateral humeral rotation ROM at 90° of abduction and horizontal adduction with the scapula stabilized was measured using digital inclinometry. Humeral torsion was measured using ultrasonography and digital inclinometry as the angle of humeral rotation (forearm angle from horizontal) when the proximal humerus was placed in a standardized position where the humeral tubercles were aligned with the horizontal plane (visualized with ultrasound) (ICC=.96-.98, SEM=2.0-2.3°). ANOVA (Bonferroni post-hoc) was used to compare the dependent variables across groups (CP vs. BP) and limbs (dominant vs. non-dominant) while bivariate correlational analyses were

used to establish the relationship between humeral torsion and clinical measures of posterior shoulder tightness in the dominant limb. **Main Outcome Measures:** Humeral torsion (HT), internal rotation (IR), internal rotation corrected for humeral torsion (IRC), and horizontal adduction (HA). **Results:** Compared to control participants and the non-dominant limb (NDL) in both groups, the dominant limb (DL) of the baseball players demonstrated greater ($P<.001$) humeral torsion (DLHT:BP=83.0±11.0°, CP=70.5±13.5°; NDHT:BP=65.3±11.4°, CP=64.3±12.3°) and less ($P<.001$) internal rotation (DLIR:BP=36.9.0±7.9°, CP=48.74±11.1°; NDIR:BP=51.2±9.7°, CP=53.4±8.8°). Once corrected for torsion, no differences in internal rotation ($P=.508$) were present (DLIRC:BP=29.8±9.9°, CP=29.3±13.0°; NDIRC:BP=26.5±11.9°, CP=27.7±10.4°). Dominant limb horizontal adduction in baseball players was significantly lower than their non-dominant limb ($P=.002$), but was not different from the

control participants' dominant/non-dominant limbs (DLHA:BP=99.9±6.1°, CP=100.2±8.3°; NDHA:BP=103.9±4.2°, CP=99.3±9.3°). Humeral torsion was significantly correlated with internal rotation ($r=-.482$, $P=.004$) and horizontal adduction ($r=-.401$, $P=.016$). **Conclusions:** While limb differences in measures of posterior tightness exist in baseball players, these measures appear to be influenced by humeral torsion rather than soft tissue tightness. Once torsion is accounted for, the limb differences observed clinically are minimal. When possible, accounting for humeral torsion when interpreting ROM measurements may aid in treatment decisions for posterior shoulder tightness. If torsion data is not available, comparison of ROM to baseline measures obtained during pre-season screening may allow clinicians to detect changes in tissue tightness over the course of the season.

Free Communications, Oral Presentations: Contemporary Issues Related to Concussion #1

Saturday, June 20, 2009, 10:15am-12:30pm, Room 214B; Moderator: Jason P. Mihalik, MS, CAT(C), ATC

Knowledge And Recognition Of Concussion By Youth Athletes And Their Parents

Gourley MG, Bay RC, Valovich McLeod TC: A.T. Still University, Mesa, AZ

Context: Little is known about the degree of knowledge and recognition of concussion by youth athletes and parents. There is concern that many misconceptions about concussion still exist among lay persons. **Objective:** To assess knowledge and recognition of concussion by youth athletes and parents. **Design:** Cross-sectional. **Setting:** Practice fields and online at home. **Patients or Other Participants:** 73 youth athletes (45 males, 29 females, age=11.64±1.26 years, range 10-14 years) and 100 parents (39 males, 61 females) were recruited to participate. The percentage of youth athletes who reported participating in organized, coached sports for 1-2 years was (15.1%), 3-5 years (30.1%), 5-10 years (41.1%), 10+years (13.7%). The parents reported having 2.6±1.3 boys and 1.1±.79 girls participating in organized, coached sports. **Interventions:** A previously published survey was used (Chronbach's =.83), with a small modification in wording, to create athlete and parent versions. Both surveys consisted of subject demographics, concussion history, recognition of concussion signs and symptoms and return to play (RTP) scenarios. Participants completed the survey

at practice or via online link at home. Frequency distributions and independent samples t-tests ($p<.05$) were calculated to summarize survey responses between athletes and parents, athletes with/without concussion history, and parents with/without first aid certification or medical training. **Main Outcome Measures:** Symptom recognition and concussion knowledge scores. **Results:** Athletes and parents did not differ ($p=.935$) on the ability to recognize concussion symptoms, with correct response scores of 9.2±3.1 and 9.2±3.0 (out of 16) respectively. Youth athletes who reported having their "bell rung" (9.6±2.0) did no better ($p=.357$) than those who did not report a previous concussive episode (8.9±3.5). Parents with first aid certification (10±2.8) or general medical training (10±2.8) recognized significantly more symptoms ($p=.012$, $p=.006$) than those without certification (8.5±2.8) or training (8.4±2.8). 77% of youth athletes and 85% of parents knew a concussion may occur without loss of consciousness; 75% and 87% knew a concussion requires removal from a sporting event, and 18% and 5% thought a concussed athlete could return to play while symptomatic. When presented a scenario in which an athlete is hit but awake and has a headache with activity, only 22% of youth athletes and 43% of parents thought the athlete should not return to play.

Conclusions: Our main finding was that there is a knowledge deficit regarding symptom recognition and issues about sport-related concussion among youth athletes and their parents. We feel all youth sports athletes and parents should receive specific education on signs, symptoms, and recognition of sport-related concussion. Moreover, it is suggested that the presence of certified athletic trainers at the youth sports level may reduce the number of athletes playing symptomatically.

An Assessment Of The Effectiveness Of An Educational Intervention On Youth And Recreational Sports Coaches Knowledge Of Concussions

Van Lunen BL, Brigham H, Covassin T, Manspeaker S, Oñate JA: Old Dominion University, Norfolk, VA, and Michigan State University, Lansing, MI

Context: Concussion related educational materials for youth and recreational sports coaches (YRSC) are available, but an assessment of YRSCs current knowledge and of the effectiveness of the materials has not been determined. **Objective:** To determine base concussion knowledge for YRSCs and to determine the effects of a small scale educational program designed for YRSCs by the Center for Disease Control and Prevention (CDC). **Design:** Descriptive Survey.

Setting: Youth sports and recreational facilities. **Patients or Other Participants:** 160 YRSCs from a convenience sample (age=40.78±9.06yrs, youth coaching experience 6.35±5.22yrs). 38 YRSCs completed the post-test. **Interventions:** A single researcher attended YRSCs orientation meetings. Participating YRSCs were asked to complete the concussion knowledge assessment (CKA), symptom checklist (SC) and demographic questionnaire. The CKA consisted of 21 multiple choice questions (7 per area) in the areas of concussion recognition, management, and prevention, and the SC consisted of identifying eight primary symptoms of 18 possible choices. The demographic component consisted of items related to age, gender, and experience with concussion. After initial assessment, coaches were provided with the pamphlet and informational clipboard from the CDCs Head's Up: Concussion in Youth Sports tool kit. YRSCs were instructed to review the material as much as they deemed necessary, but the material was not reviewed with them, mimicking the intended distribution of the CDC. A follow-up survey was mailed four weeks following the initial assessment and returned (24% return rate). Repeated measures ANOVAS were utilized for change of scores between sections over time. Paired and independent t-tests, and Pearson correlations, were used to assess relationships between demographic characteristics and assessment scores. **Main Outcome Measure:** CKA and SC scores. **Results:** The pre-educational CKA score was 19.03±1.68 and the symptom checklist score was 6.40±1.20. Significant differences were found between recognition (6.53±.801) and prevention (5.90±1.077)(p<.001, t=6.524) and concussion management (6.60±.665) and prevention (p<.001, t=7.336) for the pretest CKA. A statistically significant difference was found between pre-education CKA and those with HSD or GED (18.62±1.945) and those subjects with a degree of higher education (19.27±1.490)(p=.020, t=-2.358). CKA post scores were higher (p=.022, F=5.72)(19.89±1.11) than pretest scores(19.39±.95)(N=35) and no differences were seen in pre (6.39±1.18) and post (6.55±.76) SC scores (p=.35, F=4.61). No significant differences or relationships were found for CKA or SC in personal concussion experience (p=.33, t=.97; no experience =18.94±1.78, experience =19.22±1.51) : (p=.287, t=1.07, no experience=6.31±1.18, experience=6.53±1.23), athlete concussion experience(p=.239, t=1.181, no experience =10.03±1.68, experience =19.64±1.12); (p=.126, t=1.614, no experience =6.37±1.22, experience =6.73±.68), and time spent reviewing the material(p=.308, r=

-.170)(p=.776, r=-.048), respectively. **Conclusions:** YRSCs appear to have a base of knowledge for the recognition and management of concussion, and a decreased knowledge in injury prevention. Providing the CDCs Head's Up Youth Sports pamphlet and clipboard increased overall scores. Further investigation is needed on a larger sample size of YRSCs following distribution of educational materials. This study was supported by the Mid-Atlantic Athletic Trainers' Association Research and Scholarship Committee.

Headache And Headache-Related Quality Of Life In Adolescent Athletes: Implications For Concussion Assessment

Piebes SK, Snyder AR, Valovich McLeod TC: A.T. Still University, Mesa, AZ

Context: Headaches are the most commonly reported symptom following concussion and are also prevalent in otherwise healthy adolescent athletes. Athletes often also experience headache as a result of participation in sport or in daily activities. The use of headache scales as a baseline measure for concussion assessment may allow clinicians to identify pre-existing headache conditions, further ensuring a more accurate clinical assessment following a concussion. **Objective:** To evaluate self-reported headache status in relation to base rate scores on a graded symptom scale (GSS), the Headache Impact Test (HIT-6) and Pediatric Migraine Disability Assessment (PedMIDAS) for future use in concussion assessment. **Design:** Cross-sectional. **Setting:** High school athletic training facilities. **Patients or Other Participants:** 176 adolescent athletes were classified according to their response on the headache question from the GSS into no headache (NONE; n=73, age=15.5±1.1 years), mild headache (MILD; n=90, age=15.3±1.1 years), and moderate/severe headache (MOD/SEV; n=13, age=15.4±0.8, years). **Interventions:** All subjects completed the GSS, HIT-6, and PedMIDAS. Internal consistency was found to be .88 for the HIT-6 and .72 for the PedMIDAS. The GSS is an 18-item self-report instrument, scored using a Likert scale, with higher scores indicating greater symptom severity. The HIT-6 and PedMIDAS are 6-item self-report instruments, with the higher composite score indicating a great impact of headache/migraine on health-related quality of life. The Kruskal-Wallis test was used to determine differences between groups (3 levels) on each dependent variable, followed by pairwise Mann-Whitney U tests (pd".05). **Main Outcome Measures:** Dependent

variables were the modified GSS (mGSS: total score not including headache), HIT-6 and PedMIDAS total scores. **Results:** Significant differences between groups were noted on the GSS (p<.001), HIT-6 (p<.001) and PedMIDAS (p<.001). Pairwise tests revealed a higher mGSS total score for MOD/SEV (25.4±12.9) compared to MILD (16.9±13.8) and NONE (4.2±5.5). MILD was also significantly greater than NONE. On the HIT-6, a greater impact of headache was identified for MOD/SEV (59.4±7.9) compared to MILD (47.0±7.3) and NONE (42.2±6.6). MILD also had a significantly greater impact of headache compared to NONE. Similar results were found with the PedMIDAS with MOD/SEV (6.2±6.1) reporting more days of migraine-related disability compared to MILD (1.7±3.6) and NONE (.75±2.4). MILD also reported higher PedMIDAS scores compared to NONE. **Conclusions:** We found that 58.2% of this otherwise healthy sample of adolescent athletes reported base-rate headache. Athletes reporting mild and severe headaches also reported more concussion-like symptoms in general and a greater impact of headache on their quality of life. The HIT-6 and PedMIDAS were sensitive to detect differences among otherwise healthy adolescent athletes with varying degree of self-report headache. Future studies should address the responsiveness of these measures to changes in headache status following sport-related concussion.

Increased Frequency Of Prior Concussions Is Associated With Greater Impact Of Headache And Lower Health-Related Quality Of Life In Collegiate Athletes

Kuehl MD, Freeman WK, Erickson SE, Snyder AR, Valovich McLeod TC: A.T. Still University, Mesa, AZ, and Arizona State University, Tempe, AZ

Context: Sport-related concussion (SRC) may have an impact on health-related quality of life (HRQOL), a concept that encompasses physical, psychological, and social domains. Understanding the impact of SRC on HRQOL may help determine the extent that athletes are affected by these injuries and identify areas for improving patient care. **Objective:** To investigate how self-report SRC history affects HRQOL in collegiate athletes using the Medical Outcomes Short Form (SF-36) and the Headache Impact Test (HIT-6). **Design:** Cross-sectional. **Setting:** Collegiate sports medicine facilities. **Participants:** Athletes participating on intercollegiate athletic teams were grouped according to the number of previous concussions: 0 SRC

($n=169$, $\text{age}=19.8\pm2.0$), 1-2 SRC ($n=93$, $\text{age}=19.6\pm1.5$), 3+ SRC ($n=40$, $\text{age}=20.0\pm2.1$). **Interventions:** Participants completed a demographic information sheet, SF-36, HIT-6, and concussion history form. The independent variable was group. Preliminary omnibus tests (Kruskal-Wallis; $p<.05$) were conducted to assess differences across the three groups (0, 1-2, or 3+ SRC). Follow-up pairwise Mann-Whitney U tests ($p<.05$) were conducted to identify group differences on the significant subscales. **Main Outcome Measures:** Dependent variables included the HIT-6 total score, 8 SF-36 subscales: physical functioning (PF), role physical (RP), bodily pain (BP), general health (GH), vitality (VT), social functioning (SF), role emotional (RE), and mental health (MH), and 2 composite scores: mental composite (MCS) and physical composite (PCS). Higher scores on the HIT-6 indicate greater impact of headache on health status and lower scores on the SF-36 indicate lower HRQOL. **Results:** Significant differences between groups were noted on the BP, VT, and SF subscales of the SF-36 and the HIT-6 total score. Pairwise tests revealed the 3+ group (48.1 ± 8.9) had significantly lower scores for BP compared to the 1-2 group ($p=.028$, 52.1 ± 7.7) and the 0 group ($p<.01$, 53.5 ± 8.3). The 3+ group (48.5 ± 9.4) had significantly lower scores on SF than the 1-2 group ($p=.028$, 51.6 ± 7.3) and the 0 group ($p=.003$, 51.9 ± 8.1) and lower scores on VT (52.4 ± 8.4) than the 0 group ($p=.011$, 55.9 ± 8.6). On the HIT-6, the 3+ group reported greater impact of headache (46.7 ± 6.4) than the 1-2 group ($p=.05$, 44.6 ± 6.4) group and the 0 group ($p<.001$, 42.9 ± 5.8). The 1-2 group also had higher HIT-6 scores compared to the 0 group ($p=.033$). **Conclusions:** Collegiate athletes who self-report a history of 3 or more SRC experience more impact from headache on their overall health status than their peers with fewer or no prior concussions and demonstrate lower HRQOL related to pain, vitality, and social interactions. These findings suggest that concussion affects many aspects of health status, beyond the somatic and cognitive, and support the idea that multiple concussions may have a cumulative and lasting impact on HRQOL. Proper recognition of concussions is necessary so that treatments and interventions may be targeted towards limiting these potentially long-term negative effects.

Sensitivity And Specificity Of The ImPACT Test Battery For Concussion In Collegiate Athletes

Resch J, Lee HR, Olejnik S, Ferrara MS, Brown CN: University of Georgia, Athens, GA

Context: Computerized neuropsychological testing is commonly utilized in the management of sport-related concussion. Few studies have addressed the sensitivity and specificity of these tools with a matched-control group design. It is important to provide statistical evidence regarding computerized testing and its ability to discern between concussed and non-concussed athletes.

Objective: To determine the sensitivity and specificity of the ImPACT Test Battery in a collegiate athlete sample. **Design:** Cross-sectional study from 2004-2008 sport seasons. **Setting:** Research Laboratory. **Patients or Other Participants:** Sixty-six collegiate athletes were classified as concussed or non-concussed ($n = 33$ per group; 25 males, 8 females each). Concussed group: $\text{age } 19.73 \pm 1.4$ years, $\text{education } 13.24 \pm 1.2$ years, non-concussed group: $\text{age } 19.03 \pm 1.7$ years, $\text{education } 12.76 \pm 1.2$ years. The non-concussed group reported no prior history of concussion and was matched to concussed participants by sex, sport, and position.

Interventions: All participants completed baseline ImPACT testing prior to the start of their competitive season. All concussed participants were evaluated 24 hours post-injury. MANOVAs and post-hoc ANOVAs were utilized to identify group differences with $\alpha \leq .05$. Discriminant function analysis was utilized to determine sensitivity and specificity with priors set at (.5, .5) and the external rule was applied for interpretation. The I score was calculated to determine how much better than chance a participant could be correctly classified as concussed or non-concussed. **Main Outcome Measures:** ImPACT scores including verbal and visual memory, visual motor speed, reaction time, impulse control, and symptom scale score were analyzed. **Results:** Groups did not differ on age, years of education, handedness, history of special education, or diagnosis of learning disabilities ($P \geq .05$). Box's test of equality of covariance matrices was significant, $M = 128.83$, $F = 5.52$, $P < .001$. Due to the sensitivity of the test and the fact we utilized equal sample sizes, we continued the analysis utilizing the linear rule. Significant differences were found between groups, Wilk's $\lambda = .744$, $F(6,59) = .744$, $P = .006$, $\eta^2 = .256$. Post-hoc ANOVAs revealed a significant difference between groups for symptom score, $F(1,65) = 17.48$, $P < .001$ and all other variables were non-significant ($P > .05$).

Discriminant analysis correctly predicted overall group membership at 68.2%. Using predictive discriminate analysis, healthy participants were correctly predicted at 78.8% and concussed participants were correctly predicted at 57.6%. We found a strong I score ($Z = 2.95$, $P \leq .05$) which suggests 36.4% fewer classification errors would occur than if classification was done by chance. **Conclusions:** Overall, ImPACT had a 68.2% correct classification rate but significantly reduced classification errors. We advocate a battery of tests including a physical/neurological examination in evaluating a concussion and making return to play decisions.

Dynamic Postural Stability During Gait Initiation Is Impaired Following A Concussion: A Preliminary Analysis

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

Context: Understanding recovery from sports related concussion remains challenging for athletic trainers. Previous investigations have identified impairments in static postural stability (e.g., BESS, SOT) and gait following a concussion, however dynamic postural stability during transitional movements, commonplace to the performance of athletics, has not been assessed in this population.

Objective: The purpose of this study was to identify impairments in center-of-pressure (COP) excursion and stepping parameters during gait initiation (GI) following concussion. **Design:** A prospective repeated measures design. **Setting:** Laboratory. **Patients or Other Participants:** Four college student-athletes who suffered a concussion ($\text{age}=19.8\pm1.3$ years, $\text{height}=182.5\pm6.8\text{cm}$, $\text{weight}=70.0\pm15.6\text{kg}$, $\text{BMI}=20.9\pm3.6$; 3 Grade II and 1 Grade I; Cantu Revised Grading Scale) and four ($\text{age}=25.5\pm1.3$, $\text{height}=173.0\pm13.3\text{cm}$, $\text{weight}=78.8\pm23.5\text{kg}$) healthy controls with no history of concussion.

Interventions: Concussion subjects completed three trials of GI within 24 hours of suffering a concussion and again on the day they self-report symptom free on the graded symptom checklist. Control subjects completed one testing session of GI. Kinetic data was collected by two forceplates (AMTI, Watertown, MA) at 1000hz. **Main Outcome Measures:** Spatiotemporal stepping parameters and the translation of the COP during GI. **Results:** At 24 hours post concussion, velocity of the initial step was significantly reduced (0.76 ± 0.11 m/s and 1.32 ± 0.23 m/s respectively, $p=0.005$) and there was a trend towards a reduction in the initial posterior movement of the COP

(3.4 ± 3.4 cm and 7.6 ± 1.5 cm respectively, $p=0.09$) for the concussed group compared to controls. On the day the concussed group self-reported being asymptomatic, there were no differences between them and controls for any dependent variable. Finally, when comparing self-reported asymptomatic day to 24 hours post-injury, the asymptomatic day group had significantly greater initial posterior movement of the COP (3.4 ± 3.4 cm and 7.7 ± 2.2 cm respectively, $p=0.05$). **Conclusions:** Excursion of the COP during GI has been used to quantify postural instability in aging, diseased, and disabled populations. Specifically, reductions in the initial postural shift of the COP leads to a reduction in forward displacement of the center-of-mass which thereby reduces the moment arm for the ground reaction force to act for momentum generation. This reduction likely limits the threats to the individual's postural stability and the balance control systems. Interestingly, the posterior movement of the COP in recently concussed individuals was similar to previous reports for transitionally frail elderly adults and Parkinson disease patients. It is encouraging to note, within this small sample, that self-reported asymptomatic individuals demonstrated COP excursions similar to healthy controls suggesting their postural control systems have recovered. The key finding of this preliminary analysis is impaired dynamic postural stability in individuals who have suffered a concussion; however caution must be taken in extrapolating the results from this small sample size.

The Relationship Between Cognitive And Postural Control Performance With Self-Report Concussion Symptoms

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Context: Medical organizations recommend a battery of tests for concussion assessment that typically include measures of cognitive function, postural control, and self-report symptoms. Symptom reports commonly include items related to balance and memory, but it is unclear if concussed athletes are able to accurately identify the presence or absence of these symptoms. **Objective:** To elucidate the relationship between subjective symptom reports and objective measures of postural control and cognitive functioning. We hypothesized that strong relationships would exist between symptom reports of impaired postural control and dynamic posturography and symptom reports of impaired memory and computer-based cognitive testing. **Design**

and Setting: This longitudinal investigation was completed in a University research laboratory. **Patients:** College athletes ($N=32$, 75% male, 19.7 ± 1.2 years with a diagnosed concussion). **Interventions:** All individuals received a baseline and post-morbid assessment (within 48 hour of diagnosis) for postural control with the NeuroCom Sensory Organization Test (SOT) and cognitive functioning and symptom reports with the ImPACT. **Main Outcome Measures:** Spearman's correlations were calculated between Likert scores for the post-injury balance symptoms of "dizziness" and "balance problems" and the SOT output change scores for composite balance, visual ratio, vestibular ratio, and somatosensory ratio. Separate correlation coefficients were completed for the cognitive symptoms of "feeling mentally foggy," "difficulty concentrating," and "difficulty remembering" with the change in ImPACT output variables of verbal memory, visual memory, processing speed, and reaction time. **Results:** Balance related symptoms were reported in 39% of the sample and cognitive symptoms in 59%. Spearman correlation calculations between the self-report balance symptom of "dizziness" and SOT composite balance ($r_s = -.55$, $p < .00$) and the vestibular ratio ($r_s = .50$, $p = .01$) were significant. Reports of "balance problems" were significantly correlated with change scores of composite balance ($r_s = -.52$, $p < .00$), somatosensory ratio ($r_s = -.41$, $p = .03$), visual ratio ($r_s = .39$, $p = .04$), and the vestibular ratio ($r_s = .57$, $p < .00$). The correlation calculations between the cognitive symptom of "feeling mentally foggy" and the changes scores of the ImPACT output variables were significant with reaction time ($r_s = -.36$, $p = .03$). Significant correlations were also noted between "difficulty concentrating" and composite verbal memory score ($r_s = -.41$, $p = .01$) and "difficulty remembering" with the composite verbal memory score ($r_s = -.48$, $p < .00$) and reaction time ($r_s = -.36$, $p = .03$). **Conclusions:** Each aspect of the concussion assessment supplies the clinician with unique information that can be used in conjunction with the clinical exam. These results suggest that athletes are able to self-identify some deficits to postural control and cognitive functioning following a concussive event. Clinicians solely relying on symptom reports for diagnostic purposes are encouraged broaden their assessment protocol to encompass other measures that athletes may not adequately recognize.

Apolipoprotein E Polymorphisms And Concussion In College Athletes

Tierney RT, Mansell JL, Higgins M, McDevitt J, Toone N, Mishra A, Krynetskiy E: Temple University, Philadelphia, PA; Towson University, Towson, MD; Temple University, Philadelphia, PA

Context: There has been conflicting evidence regarding the association between apolipoprotein E (APOE) gene polymorphisms and the incidence of concussion. Little research has been performed examining the association between APOE gene polymorphisms and experiencing multiple concussions. **Objective:** To evaluate the association between APOE polymorphisms (E2, E4, and Promoter) and history of concussion in college athletes. **Design:** Retrospective. **Setting:** University athletic facilities. **Participants:** One hundred and ninety-six football ($n = 163$) and female soccer ($n = 33$) college athletes (age = 19.65 ± 1.51 yrs, height = 180.26 ± 15.21 cm, body mass = 92.06 ± 23.16 kg) participated. Institutional Review Board approval and participant written informed consent were obtained prior to data collection. **Interventions:** Athletes completed a concussion history questionnaire and reported their number of previous concussions documented by a certified athletic trainer or physician. Athletes also provided a saliva sample which was used to determine presence of APOE polymorphisms. Specifically, APOE E2 (C/T Arg158Cys), E4 (T/C Cys112Arg), and promoter (g-219t) polymorphisms were assessed using TaqMan Allele Discrimination assays. Descriptive, chi square (χ^2), and fisher's exact test (fisher's p) statistics were determined using SPSS 15.0 and odds ratios (OR) were calculated when significant associations were identified ($p \leq .05$). **Main Outcome Measures:** Self reported history of a documented concussion (yes, no), the number of previous concussions, and presence of an APOE polymorphism (yes = homozygous or heterozygous, no). **Results:** Forty-eight athletes (24.5%) reported a documented concussion, and 9 athletes (4.6%) reported 2 or more documented concussions. The APOE E2, E4, and promoter polymorphisms were present in 35 (17.8%), 62 (31.6%), and 99 (50.1%) athletes, respectively. There was no significant association between carrying the APOE E2 ($\chi^2 = 1.11$, $p = .292$) and E4 ($\chi^2 = .004$, $p = .948$) polymorphisms and having a history of concussion. There was, however, a significant association (fisher's $p = .035$, OR = 8.4) between carrying the APOE promoter polymorphism and experiencing 2 or more concussions. Specifically, 8 of the 9 athletes (89%) who reported experiencing 2 or more concussions carried the APOE promoter polymorphism. Four athletes (2.0%) carried all APOE polymorphisms and 3 of the 4 (75%) experienced a previous concussion

(fisher's $p = .046$, OR = 9.8). **Conclusion:** Experiencing a previous concussion was not associated with carrying the individual E2 or E4 APOE polymorphisms. Athletes with the promoter polymorphism were 8.4 times more likely to report multiple concussions and may be at greater risk of multiple concussions versus non-carriers. Carriers of all three

polymorphisms were nearly 10 times more likely to report a previous concussion and may be at greater risk of concussion versus non-carriers. Research involving larger samples of individuals with multiple concussions and multiple APOE polymorphisms is warranted.

Evidence-Based Forum #7: Concussion

Saturday, June 20, 2009, 12:45PM-1:45PM, Room 214B; Discussants: Kevin Guskiewicz, PhD, ATC, and Jennifer Hootman, ATC; Moderator: David Klossner, PhD, ATC

Free Communications, Oral Presentations, Case Reports: General Medical #1

Saturday, June 20, 2009, 2:00PM-3:00PM, Room 214B; Moderator: J. Jordan Hamson-Utley, ATC, LAT

Pulmonary Embolism In Female Division III Collegiate Soccer Athlete

Erickson KR, Powers ME: Shenandoah University, Winchester, VA

Background: We present a unique case of pulmonary embolism associated with a common genetic mutation in an otherwise healthy 19-year-old female soccer player. The athlete initially complained of progressively decreased exercise tolerance, which she attributed to stress and lack of sleep, and a cough, which she attributed to a recent illness. These symptoms were reported to the athletic training staff approximately three days after the initial occurrence. At the time the athlete reported the symptoms, the team was warming up for an away match that required a five hour bus ride the previous day. The marked fatigue observed prior to the match resulted in the athlete being held out of competition on that day. After returning home later that evening the athlete reported to the local emergency department complaining of shortness of breath and pleuritic pain. The athlete initially complained of pain during deep breathing only, however she later complained of pain during shallow breathing as well. The athlete also reported oral contraceptive use for endometriosis which began approximately one month prior to this incident. The endometriosis and contraceptive use had not been reported to the athletic training staff. Upon physical examination, tachycardia and tachypnea were noted. The lungs were clear to auscultation and no use of accessory muscles were observed during respiration. There were also no clinical signs of deep venous thrombosis and was later confirmed through ultrasound examination. Laboratory tests revealed a markedly elevated D-dimer, while the prothrombin time (PT), partial thromboplastin time (PTT) and international normalized ratio (INR) were within the normal ranges. A computed tomography scan revealed

the presence of pulmonary emboli in the lower lobes of the left and right lungs, as well as left lower lobe infarction. The athlete was admitted for anticoagulant therapy and observation. Activated protein C (APC) resistance testing later revealed that she was heterozygous for Factor V Leiden. **Differential Diagnosis:** Pulmonary embolism, pericarditis, pleuritis, and/or gastroesophageal reflux disease. **Treatment:** Intravenous heparin therapy was initiated immediately in the emergency department. This was followed by in-patient Coumadin therapy for five days. The athlete was also administered Protonix to help reduce gastric irritation and Lortab to help control her chest pain. At discharge the patient was prescribed oral Coumadin for continued anticoagulation, Levaquin, an antibiotic to protect against potential pneumonia, and Lortab as needed for analgesia. The athlete returned to class three days after discharge and began non-contact soccer activities two weeks later. During this time the athlete continued to experience decreased exercise tolerance. Coumadin therapy continued for approximately one year. Because of this, the athlete was unable to participate in any contact drills or return to competition due to the risk of increased bleeding time. **Uniqueness:** This is a unique case because a young, active, apparently healthy individual developed pulmonary emboli with many confounding factors, some unknown to the athletic training staff. For example, the team commonly travels long distances for competition, the athlete recently began oral contraceptive use, and she has a common genetic mutation. This mutation is prevalent in 5% of the Caucasian population; however, most are unaware of this until they develop one of the outward signs such as pulmonary embolism, deep venous thrombosis, or stroke. **Conclusions:** Many athletes unknowingly have genetic factors that might predispose them to cardiovascular disease. We as athletic

trainers need to be aware of the other predisposing factors for pulmonary embolism, such as sedentary long road trips and oral contraceptive use. We need to keep our athletes informed and encourage them to keep us informed about any changes in medications or new symptoms that may arise.

Spontaneous Pneumopericardium In A Female Volleyball Athlete

Collins T, Reifsteck F, Bryant S: University of Georgia, Athens, GA

Background: A 19-year-old female volleyball athlete presented to the athletic training room with intense chest pain and difficulty breathing. Symptoms had progressively increased over a period of three hours. She felt like her throat had begun to swell. She reported no known mechanism of injury, no athletic activity in the past 45 hours, no recent illness and no known exposure to allergens. She stated that the pain had begun in her upper back and progressed to anterior midline of chest over an hour. Athlete reports a pain scale of 7/10 at rest, 8/10 during deep inspiration, and pain and difficulty breathing increased when lying supine. Athlete appeared very apprehensive throughout examination. Blood pressure was mildly elevated (132/83mmHg) with a fast, strong pulse (101 bpm). Oxygen saturation and body temperature were both normal. Auscultation revealed normal bilateral lung sounds and normal heart rhythm. During examination, physician noted the presence of a pronounced pericardial rub which increased with the patient lying supine. **Differential Diagnosis:** Pericardial inflammation, pneumomediastinum, pneumopericardium, cardiac tamponade. **Treatment:** Athlete was immediately referred to the emergency room for diagnostic testing. She underwent a chest X-ray, EKG, chest and throat CT. Chest X-ray revealed "free air" in the pericardial sac.

EKG showed normal cardiac activity. CT of lungs and esophagus revealed no tears or trauma. Athlete was diagnosed with a spontaneous pneumopericardium. She was placed on IV Toradol for the associated chest pain. She was released after consultations with a cardiologist and cardiothoracic surgeon, with instructions to do no athletic activity for at least one week and come back immediately if she had any additional problems. Symptoms decreased progressively over the next few days and athlete underwent follow-up diagnostic tests one week later. Chest CT showed no free air in the pericardium. Athlete was progressed slowly back into activity over two days, with an extended progression into any activities that required a valsalva maneuver, such as power-lifting. **Uniqueness:** Spontaneous pneumopericardium is extremely rare in healthy, young athletes. When this condition does occur, CT imaging typically reveals a tear which can be cited as the cause. In this case, no tear was found in either the athlete's throat or chest tissue. Since there was no trauma or illness in this case, there was very little suspicion for this condition. **Conclusions:** Clinicians should consider the possibility of serious medical conditions such as pneumopericardium even if the athlete does not report circumstances which would typically lead to this injury. Athletic trainers should also be familiar with "red flags" to observe for during auscultation and vital sign assessment.

Near Syncope In A High School Basketball Player

Williams SJ, Smoot K, Booth DC:
University of Kentucky, Lexington, KY,
and Gill Heart Institute, University of
Kentucky, Lexington, KY

Background: A seventeen-year-old male basketball player complained of dizziness and near syncope after running stairs during pre-season conditioning. The patient stated he had been drinking water during conditioning, but he did not complain of nausea and had no other symptoms. Over the previous eighteen months, he had experienced three other episodes of near-syncope. The first episode included symptoms of a headache and the athlete was taken by his parents to a local emergency department. A CT scan of the head was performed with no clinical findings. Poor hydration and nutrition were thought to be a cause of these symptoms. All episodes were associated with confusion, dizziness, and lightheadedness. The athletic trainer asked the athlete to keep a food diary after his second episode, but the athlete was non-adherent. His mother stated that she had been making him drink more water and eat a

balanced diet. Other pertinent information relating to the athlete includes the fact that his father passed away at the age of 42 due to a pulmonary embolism. The athlete was examined by the team physician after the most recent episode. Even though his vital signs and exam were normal after the final episode, the doctor wanted to refer him for further medical testing because of his previous episodes and because of his father's sudden death at a young age. **Differential Diagnosis:** Inadequate hydration, inadequate nutrition, general deconditioning, heart condition. **Treatment:** The athlete was seen by a cardiologist three days after being evaluated by the team physician. His electrocardiogram was normal; however, the echocardiogram detected concentric left ventricle hypertrophy with a thickened septum. The septum measured 1.2 cm in thickness. The left atrial dimension was slightly elevated and minimal systolic anterior motion of the anterior mitral leaflet (SAM) was detected. SAM was more pronounced on stress echocardiogram. During a repeat stress echocardiogram the next day, the symptoms were reproduced. A systolic murmur was appreciated at peak stress and there was also an outflow obstruction. With the results of these tests, the athlete was diagnosed with hypertrophic obstructive cardiomyopathy (HCM). The athlete and his mother were informed of this diagnosis and the need for medical disqualification from organized sports. The cardiologist recommended that the athlete and his immediate family be genetically tested to try to solidify the diagnosis. **Uniqueness:** This athlete was fortunate to have had symptoms that concerned his coaches, certified athletic trainer, and team physician to warrant further testing. Sudden death is most often the first clinical manifestation of HCM. It accounts for approximately 50% of all sudden cardiac deaths in athletes. It is important for athletic trainers to appreciate that typically benign symptoms associated with improper fitness may in reality be symptoms of a much more serious condition. Family history, persistent symptoms, and previous events of near-syncope may be good indicators of the presence of HCM. When any symptoms present themselves repeatedly without a clear cause in combination with a family history of sudden death, immediate medical referral may be warranted. The current recommendations by the 36th Bethesda Conference state that athletes with probable or unequivocal diagnosis HCM should be excluded from most organized sports. **Conclusions:** A high school basketball player with multiple episodes of near-syncope during basketball practices and games was diagnosed with hypertrophic obstructive cardiomyopathy. In some

instances, near-syncope can be attributed to a simple reason, such as poor conditioning or the inadequate dietary habits of adolescents. Certified athletic trainers should look into all possibilities for a cause and work with coaches, parents, and team physicians to best care for an athlete.

Direct Trauma To Supraorbital Rim Of Female Soccer Player Causing Optic Neuropathy Without Fracture: A Case Report

Ulrich SM, Brucker JB: University of
Northern Iowa, Cedar Falls, IA

Background: This case report deals with a 20-year old female, Division I soccer player that was struck in the head by an opposing player's elbow. Athlete remained conscious, motionless and complaining of vision impairment. After ruling out neck injury, athlete stated vision in her right eye seemed black with cloudy spots. The athlete also said that there was an orange line that seemed to span across both eyes. When asked if she saw a "flash" she said that she was not certain. Further evaluation revealed equal and reactive pupils to light and no signs of retrograde or anterograde amnesia, so athlete was removed from the playing field. Sideline evaluation by our team physician led to the decision to call EMS for transportation to the hospital due to the increasing gross amount of swelling, to rule out fracture and place her in an environment with higher level of care. Since she remained stable a CAT scan was performed. The results were negative for a fracture and revealed no cranial bleeding. **Differential Diagnosis:** Concussion, detached retina, orbital fracture and traumatic optic neuropathy. **Treatment:** An ophthalmologist was summoned to further assess her unchanging vision. The ophthalmologist ruled out detached retina, but requested a follow-up appointment. During this follow-up appointment the doctor diagnosed the athlete with a Traumatic Optic Neuropathy (TON) that would not resolve itself. However, a treatment option using corticosteroids was discussed, along with its unsuccessful likelihood. In an attempt to confirm the initial diagnosis a second opinion was obtained within 7 days. This physician confirmed the initial diagnosis of TON; but stated she might regain her vision. The difference between the outcomes was based on present vision that was not detected consciously. Moreover, the doctor felt that physical activity would be beneficial. Along with the vision impairment, the athlete was

experiencing headaches that never disappeared and increased when reading or after 25 minutes of aerobic activity. The athlete attended an appointment with a neurologist 2 weeks after the second ophthalmologist visit. At this time an oral medication was prescribed to eliminate the headaches along with one week of no physical activity. Within 24 hours the athlete no longer experienced headaches. At the end of the week of rest the athlete was cleared for physical activity and the certified athletic trainer prescribed two 30-minute lower body

ergometry exercise bouts separated by 24 hours. Thirty minutes was chosen to see if symptoms returned which they did not and have not. Currently, the athlete is performing more skill specific cardiovascular training, but no resistance training. More importantly, vision is more reactive to light, but cannot depict objects. **Uniqueness:** This athlete suffered from traumatic optic neuropathy without a concurrent orbit fracture. These fractures tend to produce bone fragments that lacerate the optic nerve fibers, whereas our athlete's optic nerve

has not been physically compromised. **Conclusion:** A fracture does not have to be present for TON to cause irreversible vision loss. Traumatic Optic Neuropathy does not seem to affect cardiovascular training once acute symptoms have subsided. Receiving unfavorable news sooner versus later and by continually working with newly impaired athletes seems to help psycho-emotional healing.

Free Communications, Oral Presentations, Case Reports: General Medical #2

Saturday, June 20, 2009, 3:15PM-4:15PM, Room 214B; Moderator: P. Cody Malley, PA, ATC

Acute Illness In A High School Football/Baseball Player

Blair DF, Parker CR: Wenatchee High School, Wenatchee, WA

Background: Our subject is a 16 y/o male high school football/baseball player. He sustained a grade one concussion in a junior varsity football game (October 1, 2007). Sideline examination by the athletic trainer found minor, quickly resolving concussive symptoms. However, on further inquiry he also described flu-like symptoms that had been present for the past two weeks (extreme fatigue, lymph node swelling, etc.). The subject was also extremely pale. He was referred to his pediatrician to investigate these symptoms. His initial lab results were: white blood cell count 83.0 K/ μ l (normal range=4.5-13.5), red blood cell count 1.98 M/ μ l (4.1-5.3), hemoglobin 6.3 g/dl (12-16), hematocrit 18.1% (36-49), platelets 7 K/ μ l (130-400). The lab comments on his CBC were: anemia, thrombocytopenia, and leukocytosis. He was taken by ambulance to a pediatric specialty hospital in Seattle, Washington. He had a computerized tomography (CT) scan to look for any concussive cerebral abnormalities from the previous day. The results were negative and they concluded there was no connection between the concussion and his illness. **Differential Diagnosis:** mononucleosis (Epstein-Barr virus), influenza, rhinovirus, anemia, acute lymphoblastic leukemia, acute myelogenous leukemia, lymphomatous involvement of the bone marrow, anemia-Fanconi, juvenile rheumatoid arthritis, leukocytosis, neuroblastoma, Non-Hodgkin Lymphoma, osteomyelitis, parvovirus B19 Infection, rhabdomyosarcoma **Treatment:** The diagnostic testing confirmed the diagnosis of acute lymphoblastic leukemia (ALL). Chemotherapy was started that day and a bone marrow biopsy to determine the amount of leukemia cells in his bone marrow

(89%). He also received a blood and platelet transfusion. His course of treatment required eight months of treatment in Seattle away from his home. Medication administered during his treatment included: prednisone (corticosteroid anti-inflammatory), dexamethasone (corticosteroid anti-inflammatory), mercaptopurine (anti-metabolic), methotrexate (antimetabolic), vincristine (antineoplastic), doxorubicin (antibiotic/antineoplastic), asparaginase (antineoplastic), cytarabine (antimetabolic) cyclophosphamide (antineoplastic), thioguanine (antimetabolic). As of August 26, 2008, his white blood count was 6.4, red blood cell count 4.96, hemoglobin 15.8, platelets 157, hematocrit 45.3%. His leukemia is considered in a state of remission at this time. However, the side effects of the long-term use of corticosteroids, prednisone and dexamethasone, caused an avascular necrosis of his hips and knees. One study suggested that long-term, systemic corticosteroid use is associated with 35% of all cases of nontraumatic avascular necrosis. The symptoms of the avascular necrosis became so severe that a bilateral percutaneous drilling procedure of proximal and distal femoral articular surfaces (femoral heads and lateral/medial condyles) was performed. The subject was non-bearing for six weeks following the procedure. **Uniqueness:** This case is unique in that his symptoms came to light because of another unrelated condition. The athletic trainer needs to consider all possible differential diagnoses, even if rare and/or serious, when evaluating an athlete with internal medical issues. Although acute lymphoblastic leukemia is a relatively rare diagnosis, it is one of many possibilities that must be considered. **Conclusion:** Our subject's early diagnosis and an aggressive course of treatment have sent the acute lymphoblastic leukemia into remission. However, the aggressive treatment did come with a price. The high dose corticosteroids

therapy caused avascular necrosis that may lead to long-term hip and knee dysfunction. His rehabilitation program is progressing on-schedule at this point in time. Our subject is presently continuing on a program of maintenance medication for his leukemia and will continue this phase for the next two years.

Abdominal Injury In A Sixteen-Year-Old Football Player

Frey KM, Smoot MK, Parish KD: University of Kentucky, Lexington, KY

Background: A sixteen-year old male football player was participating in the high school summer football camp. About 90 minutes into practice, the team began to run routes and the athlete jumped up to catch the ball. Another player directly hit the athlete in the left side with their helmet. The athlete reported that he was fine and that he just had the "breath knocked out" of him. After a couple of minutes, the athlete reported no pain or difficulty breathing and was asked to run before returning to practice. While running, the athlete reported a sharp pain along his left side and all activity was stopped. On exam, there was no obvious deformity and no swelling. There was no discoloration or warmth to the area. The athlete did have tenderness to palpation over the last two ribs and below the rib cage along the left upper quadrant. He had moderate guarding in his abdomen and reported his pain level to be 4/10. Blood pressure, pulse, and breathing were normal and he was in no acute distress. He had a positive rib compression test. He also reported pain with deep breathing and, when he sat down and relaxed, his pain intensified to a 9/10 pain level. **Differential Diagnosis:** Rib contusion; Rib fracture; Internal organ contusion; or Internal organ laceration. **Treatment:** The athlete was sent to a local

hospital emergency department. There, a CT scan was obtained and revealed a splenic laceration. He was evaluated by a general surgeon who decided on non-surgical treatment since the laceration was not large enough to require removal of the spleen. He followed up with the surgeon 1 week later and another CT scan was obtained and showed that the laceration was healing. He was instructed to avoid contact sports until his next follow-up and CT scan. He was referred to a sports medicine physician for further follow-ups. He was re-examined 7 weeks from his initial injury with a repeated CT scan. The CT scan showed that the laceration had improved between the scans. He was released to start back to football 8 weeks after the initial injury and was monitored closely. **Uniqueness:** Splenic injuries in sports are uncommon and only account for .23% of all reported high school football injuries according to the National Center for Sport Injury Research. Spleen injuries are most often seen in motor vehicle accidents or in aerial or equestrian sports. Also, patients with injuries to the spleen usually demonstrate swelling to the area or symptoms of shock such as weak pulse, nausea, dizziness, confusion, and/or shortness of breath. This athlete had none of these symptoms and the only time he experienced severe pain was at complete rest. Once at the hospital and the several days after the initial injury, the athlete still did not have any symptoms except for severe pain, which is very rare. The athlete also did not require surgery and was able to be monitored over several weeks. **Conclusions:** This athlete was fortunate that he did not have to have surgery to remove the spleen. The athlete was able to gradually return to football 8 weeks after his initial injury by progressing from running to non-contact drills to full contact drills over the period of a week to assure that the athlete had no further problems. He was given a flak jacket to help prevent further injury. He finished out the season by playing in the last 2 regular season games and 4 post-season games. He continues to do well and has not had any difficulty or symptoms since the injury.

Synchronized Swimmer With Monoarthritis Secondary To Lyme Disease

Sparrow SL, Dodge TM: Boston University, Boston, MA

Background: The patient is a 21-year-old female synchronized swimmer who presented with left knee pain in the medial meniscal window. There was no relevant prior history of lower extremity injury; however, her

relevant social history was that she is a summer camp counselor in Maine. No specific mechanism of injury was reported. Clinical evaluation indicated limited AROM of the knee, decreased hamstring flexibility, full quadriceps strength, and increased pain with ambulation. The patient exhibited a valgus posture at the knee upon squatting. **Differential diagnosis:** Medial meniscal tear, tibial plateau stress fracture, infrapatellar fat pad inflammation, hamstring tendonosis, patellofemoral pain syndrome (PFPS). **Treatment:** Initial symptoms were treated with therapeutic modalities and resolved within 9 days. The patient was discharged on 2/14/07. She returned on 2/29/07 complaining of left knee pain located along the medial patellar border. Edema was also present at the medial and inferior patella. The patient then began a treatment plan aimed at strengthening the quadriceps and gluteus minimis, and correcting her patella tracking as she demonstrated maltracking. The patient returned on 3/26/07 reporting that she was diagnosed by her personal physician with a meniscal tear and referred for physical therapy. The patient started rehabilitation but decided to seek a second opinion. On 4/3/07 the patient presented to an orthopedic surgeon with 1+ effusion, and tenderness at her anteromedial joint line and medial femoral condyle. She was diagnosed with PFPS, but was also referred for an MRI to rule out medial meniscal tear. At the 4/17/07 follow up appointment, the diagnosis was a contusion of the medial femoral condyle. The patient was prescribed NSAID's and a patellofemoral treatment protocol aimed at increasing proprioception and strengthening the hamstrings and quadriceps. On 5/1/07 the patient reported increased pain on the medial aspect of knee during ambulation and stair climbing. There was thick effusion superior to the patella, causing an antalgic gait. The patient was referred for X-rays (negative) and another MRI. On 5/22/07 the MRI showed decreased medial femoral condyle edema but increased edema in the medial tibial plateau. The diagnosis was changed to articular cartilage damage and the patient was instructed to continue rehabilitation. The patient went home for 3 months with a home exercise program. The patient contacted her athletic trainer in July because she had increased swelling that was inhibiting her ADLs. The patient was referred back to the orthopedic surgeon where they performed a full lab work up. It was determined that the patient had Lyme disease and she was referred to a rheumatologist. The patient presented to the rheumatologist with synovial thickening, effusion, and tenderness over the medial joint line, but full ROM. The patient's inflammatory monoarthritis, which caused her

clinical symptoms, was confirmed to be secondary to Lyme disease. The patient required two rounds of the antibiotic doxycycline before her symptoms resolved. At a follow up in September, the patient had not returned to baseline but was cleared to return to play. The patient has been continuing her patellofemoral rehabilitation protocol. **Uniqueness:** The patient is not in an age group that commonly contracts Lyme disease. Maine is not a state where Lyme disease is endemic, and the patient never developed erythema migrans, the most common symptom of Lyme disease. **Conclusion:** This case highlights the importance of looking beyond orthopedic diagnoses in the clinical setting. Many of the injuries that athletic trainers evaluate and treat are orthopedic in nature, and when symptoms don't resolve the next logical step is to evaluate anatomical or biomechanical causes. It is important to consider all possible causes for orthopedic issues, including general medical conditions.

Autoimmune Dysfunction And Subsequent Renal Insufficiency In A Collegiate Female Athlete: A Case Study

Leone JE, Kern A, Colandreo RM, Williamson JD: Bridgewater State College, Bridgewater, MA; George Washington University, Washington, DC; Washington and Lee University, Lexington, VA

Background: We present the case of a 21 year old female college basketball player who was presented to a rheumatologist, urologist, and nephrologist after complaining of visual disturbances, extreme fatigue, and upper bilateral flank pain. Upon consultation by each physician, the medical staff diagnosed her with an unusual autoimmune disorder called Wegener's granulomatosis and IgA kidney disease. Symptoms began at 19 years of age, including severe, stabbing eye pain, and bilateral flank pain of unknown origin. At the age of 20, during routine tests for preseason physicals, protein levels in her urine were markedly elevated (greater than 3g/ml), necessitating an immediate biopsy of her kidney tissue. Results from the kidney biopsy showed IgA kidney disease, another autoimmune disorder causing her renal insufficiency, in addition to the Wegener's granulomatosis. **Differential Diagnosis:** sinus infection, scleritis, lymphomatoid granulomatosis, Churg-Strauss Syndrome, lupus, general granulomatosis infections due to viral or bacterial infection **Treatment:** Initial assessment revealed all symptoms consistent with Wegener's disease in the eyes

including intense pain and a bloodshot appearance. Her corneas were examined by a cornea specialist who then prescribed various medications until relief of symptoms were found with the steroid prednisone. When prednisone dosages were reduced, her symptoms returned. Further tests were conducted revealing ANCA, a protein associated with Wegener's, thus confirming the original diagnosis. The following year, routine tests showed abnormal protein levels in her kidneys warranting a biopsy. Biopsy results of her kidneys revealed renal insufficiency and she was formally diagnosed with IgA kidney disease. The athlete has been under the care of an ophthalmologist who specializes in Wegener's and was seen every two months. In addition to the ophthalmologist, a nephrologist was consulted every four months for her IgA kidney disease and she saw a rheumatologist every six weeks to monitor her medication dosages at the time of this case report.

Uniqueness: This athlete presented two rare autoimmune disorders in an early stage in her life. The various medications left this athlete fatigued on a daily basis and she was placed on three immunosuppressant drugs, which left her open to various other medical issues, such as opportunistic infections. Despite these challenges, the athlete was able to successfully compete at the college Division I level. Additionally, this athlete had no family history of renal disease, respiratory or autoimmune disorders, which are strongly linked to genetics. She also presented some of the more rare symptoms for this particular diagnosis. **Conclusions:** The athlete presented with severe eye pain, which led to a diagnosis of Wegener's granulomatosis, an autoimmune disease. Within a year post diagnosis, the athlete was undergoing routine tests with a rheumatologist and was found to have abnormal protein in her urine suggesting renal insufficiency. This led to a kidney biopsy and a diagnosis of IgA kidney disease. The athlete showed signs of improvement in over two years of medications and treatments. At the time of the study, the athlete was decreasing in prednisone dosage, which was the main immunosuppressant, and has continued to compete at a high level of competition.

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

Thursday, June 18, 2009, 8:15AM-9:30AM, Room 214C; Moderator: Kimberly S. Peer, EdD, LAT, ATC

Differences In Lateral Drop-Jumps From Unknown Heights Among Individuals With Ankle Instability

Rosen AB, Swanik CB, Kaminski TW, Thomas SJ, Knight CA: University of Delaware, Newark, DE

Context: Ankle instability (AI) is a debilitating condition that occurs after 20-50% of all sprains. Landing from a jump is one of the main causes of ankle injury, yet literature is lacking on lateral jumping maneuvers that explore the role of visual cues and anticipatory muscle contractions, which may influence functional stability. **Objective:** The purpose of this study was to examine electromyographic (EMG) activity of the tibialis anterior (TA), peroneus longus (PL) and lateral gastrocnemius (LG) muscles in unstable and stable ankles during lateral drop-jumps from unknown heights. **Design:** Posttest only control group. **Setting:** Controlled, laboratory setting. **Patients or Other**

Participants: Forty subjects participated. Twenty subjects with unstable ankles qualified for the unstable group with a Cumberland Ankle Instability Tool (CAIT) score of 24.5 or below (age=20.9±2.3 yrs, mass=76.2±16.2 kg, height=173.1±8.1cm, CAIT=20.4±4.15). Twenty matched (age, gender, ankle) subjects without ankle sprains (CAIT score of 29 or 30) were controls (age=20.6±2.4 yrs, mass=75.6±18.5 kg, height=173.9±9.9 cm, CAIT=29.8±.52).

Interventions: Independent variables were instability, vision, and jump height. MANOVAs were used to establish mean differences between EMG activity of the TA, PL, and LG muscles. An 8-channel Konigsberg EMG transmitter was used for collection. Subjects performed lateral jumps off a platform, set to heights of either 35cm or 50cm, onto a force plate, followed by an immediate jump for maximum height. Subjects performed ten jumps with eyes open (5 jumps at 50cm and 5 at 35cm) followed by 10 jumps, with their eyes closed, heights randomized and subjects were unaware of the height of the jump. **Main Outcome**

Measures: The dependent variables measured were amplitude normalized EMG area(%/ms), peak(%), and time to peak(TTP) from 150 ms prior to ground contact and 250 ms after landing, in the TA, PL, and LG muscles. **Results:** Unstable subjects had significantly decreased reactive EMG area in the TA (2.75±2.87%/ms) versus stable ankles (4.79±4.76%/ms, p<.050) and reactive TTP (unstable TTP 161±41ms, stable 141±47ms, p<.047). Significantly decreased or latent

EMG was observed across all eyes closed conditions in the TA (preparatory area: open 1.30±1.67%/ms, closed 82±9.55%/ms, p<.028; preparatory peak: open 18.54±14.28%, closed 14.77±15.85% P<.019), PL (reactive area: open 6.09±10.48%/ms, closed 4.45±9.2%/ms, p<.007; reactive peak: open 64.61±101.61%, closed 41.71±61.67% p<.021; reactive TTP: open 128±44ms, closed 141±49ms, p<.024) and LG (reactive area: open 5.65±10.44%/ms, closed 3.23±5.74%/ms, p<.050). No significant differences were observed between heights.

Conclusions: By removing visual cues, unanticipated lateral joint loads occur simultaneously with decreases or delayed muscle activity, which reduces ankle stiffness and dynamic restraint capabilities. Patients with unstable ankles exhibit even greater TA inhibition, which may limit talonavicular stability and intensify lateral joint surface compression and pain. Patients with AI may also present with a confounding overreliance on visual information during functional activities.

The Effect Of Attentional Focus On The Acquisition And Transfer Of Postural Stability In Individuals With Chronic Ankle Instability

Sulewski AL, Tripp BL, Wikstrom EA: University of Florida, Gainesville, FL, and University of North Carolina at Charlotte, Charlotte, NC

Context: Research indicates balance training may restore normal ankle neuromuscular control in patients with chronic ankle instability (CAI). Empirical evidence also suggests employing an external attentional focus (EAF) during balance training leads to better acquisition, retention, and transfer of automated skills compared to an internal attentional focus (IAF). **Objective:** To compare the effects of balance training that employs an EAF to an IAF in the acquisition and transfer of postural stability in subjects with CAI. **Design:** Quasi-randomized controlled trial. **Setting:** Controlled laboratory setting. **Patients:** Sixteen healthy college-aged volunteers with a history of CAI were randomly assigned to an IAF group (n=8, 21.4±2.2yrs, 173.6±8.3cm, 87.1±16.0kg) and EAF group (n=8, 22.3±3.9yrs, 166.1±7.6cm, 74.8±21.0kg). All subjects had a history of a moderate to severe lateral ankle sprain that required at least three days of immobilization and at least one recurrent injury within the past twelve months. Groups did not differ

(p>.05) in number of days immobilized after their initial injury (EAF: 8.6±6.9, IAF: 13.3±18.2), or number of recurrent injuries (EAF: 5.6±8.0, IAF: 2.38±0.7). **Interventions:** Subjects completed balance training sessions on three consecutive days which included 20, 20 second trials on a Biodex Stability System (BSS-level 6). Prior to the first practice trial and after every second trial subjects were prompted, based on group assignment, where to focus their attention. The IAF group was instructed to "keep your balance by stabilizing your body" and the EAF group was instructed to "keep your balance by stabilizing the platform." Training and testing trials were conducted in a unilateral stance on the involved limb. **Main Outcome Measures:** Prior to and immediately after balance training, 2 test trials recorded the overall stability index (OSI), anterior/posterior stability index (APSI), and medial/lateral stability index (MLSI) using the BSS-level 6 and average reach (cm) of all eight Star Excursion Balance Test (SEBT) directions normalized to leg length. Independent sample T-tests compared pre to post training change scores between the IAF and EAF groups.

Results: Pretest scores were not different (p>.05) between IAF and EAF groups for SEBT (0.78±0.11, 0.75±0.08), OSI (2.69±1.76, 2.38±1.29), APSI (2.13±1.45, 1.85±.90), or MLSI (1.78±1.23, 1.66±1.02). Balance training failed to improve BSS measures (p>.05) but improved SEBT (Pre: .77±.10, Post: .81±.09) reach distance (p<.01). Change scores for the OSI [T_{14} = -1.04, p=0.32], APSI [T_{14} = -1.39, p=0.19], and MLSI [T_{14} = 0.05, p=0.961] did not differ between EAF (OSI: 0.42±0.81, APSI: 0.31±0.47, MLSI: 0.37±0.96) and IAF groups (OSI: 0.04±0.65, APSI: -0.12±0.75, MLSI: 0.39±0.87). Additionally, change scores for the normalized SEBT did not differ [T_{14} = 1.30, p=0.22] between the EAF (0.35±0.03) and IAF (0.06±0.04) groups. **Conclusions:** Balance training improved postural stability skill transfer but neither an IAF or EAF resulted in better skill acquisition or transfer in CAI subjects after three training sessions.

Estimated Survival Probabilities For Return To Play Outcomes From Ankle Sprains, Knee Sprains, And Concussion In High School Athletes

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Context: In the U.S., there are more than 7.3 million athletes participating in interscholastic athletics. Although this represents 18 times more athletes than at the collegiate level, there is a surprising lack of epidemiological information for the high school athletic population. **Objective:** To examine sex differences for time to return-to-play (T-RTP) outcomes and to estimate T-RTP probabilities for ankle sprains, knee sprains, and concussions in interscholastic athletes. **Design:** Descriptive retrospective epidemiological study. **Setting:** Interscholastic injury data for the 2007-08 academic year were collected by full-time ATCs employed at 7 central Kentucky high schools. **Patients or other Participants:** High school athletes (freshmen through seniors) who participated in at least 1 of the following interscholastic sports: football, soccer, volleyball, cross country, basketball, wrestling, baseball, softball, tennis, and track and field for the 2007-2008 academic year. **Interventions:** Kaplan-Meier survival analyses were used to examine T-RTP curves for ankle sprains, knee sprains, and concussions. Statistical comparison of sex differences in these survival curves were evaluated by separate log-rank analyses. Estimated survival probability for T-RTP was determined by Kaplan-Meier Estimator (censored data). Statistical significance for log-rank analyses was set at $P < .05$. **Main Outcome Measures:** For the survival analyses, variables included T-RTP (return, no return) at specified time points (same day return, 1-day return, 3-days, 7-days, 10-days, 22-days, no return by season's end[censored]). Separate survival analyses were performed for ankle sprains, knee sprains, and concussions. Statistical comparison of the sexes (male, female) was performed for each survival curves (T-RTP). **Results:** 105 ankle sprains, 40 knee sprains, and 38 concussions were reported for the 2007-2008 academic year. There were no statistical significant sex differences of T-RTP (Average Days $\pm$ Standard Deviations) for ankle sprains (males = 3.89 ± 8.8 vs. females = 6.28 ± 2.9 , $P = .30$), knee sprains (males = 20.52 ± 28.7 vs. females = 31.82 ± 53.8 , $P = .31$), or concussions (males = 13.10 ± 21.2 vs. females = 14.67 ± 38.5 , $P = .52$). Since no sex differences were identified, injuries were entered into survival probability estimators separated by injury type only (ankle sprain,

knee sprain, concussion). T-RTP survival estimates indicate that there is a 90% chance that an athlete will return from an ankle sprain in 7 days, and a concussion in 10 days. For knee sprains, there was only a 75% calculated probability that an athlete will return to participation at 22 days. For a 1-day return, there was a 45% chance for those with ankle sprains, a 30% chance for knee sprains, and only 6% probability of return from a concussion. **Conclusions:** Time lost from ankle, knee, or concussion injuries was similar between males and females. Survival analyses can be applied to estimate return-to-play timelines for injuries. Estimated survival probabilities can be useful information for the ATC to provide to the athlete or coach. Future research might evaluate differences in return-to-play survival curves between new and recurrent injuries, and in response to therapeutic intervention.

Effect Of Various Cooling Methods In Reducing Core Body Temperature During Recovery From Exercise In The Heat

DeMartini JK, Ranalli GF, Casa DJ, Lopez RM, Ganio MS, McDermott BP, Stearns RL, Armstrong LE, Maresh CM: University of Connecticut, Storrs, CT

Context: Hyperthermia, which can become dangerous and/or influence performance, is common in the athletic population and in a variety of environments. This study will provide some direction for certified athletic trainers and other medical personnel as to what cooling methods have the best efficacy to cool hyperthermic athletes during a brief recovery period. **Objective:** The purpose of this study was to evaluate and compare the effectiveness of different cooling methods in lowering the core body temperature of individuals following exercise in the heat. **Design:** Randomized crossover design. **Setting:** Outdoor sports complex in warm environment (mean $\pm$ SD: WBGT: $26.64 \pm 4.71^\circ\text{C}$). **Patients or Other Participants:** Sixteen males ($n=9$) and females ($n=7$) (24 ± 6 yr, 182 ± 7 cm, 74.03 ± 9.17 kg, $17.08 \pm 6.23\%$ body fat). **Interventions:** Subjects exercised for two to three one hour sessions over four days. After each exercise bout subjects were cooled for 10 minutes in a shaded pavilion (WBGT: $22.37 \pm 4.55^\circ\text{C}$) by one of 9 cooling modalities including cold water immersion (CWI), shade, Port-a-Coolâ (fan), Emergency Cold Containment Systemâ (ECCS), Rehab Hoodâ (hood), Nike Ice Vestâ (NIV), Game Ready Active Cooling Vestâ (GRV), ice buckets, and ice towels. These cooling rates were compared to sun (control).

Main Outcome Measures: Rectal temperature (T_{RE}), heart rate (HR), thirst sensation, thermal sensation, and a modified Environmental Symptoms Questionnaire (ESQ). **Results:** The average T_{RE} following exercise (pre-cooling) across all trials was $38.73^\circ\text{C} \pm .12$. After 10 minutes of cooling CWI ($-.65 \pm .29^\circ\text{C}$), ice buckets ($-.74 \pm .34^\circ\text{C}$), and ECCS ($-.68 \pm .24^\circ\text{C}$) had significantly ($p < 0.006$) greater decrease in T_{RE} compared to sun ($-.42 \pm .15^\circ\text{C}$). HR at the ten minute mark was significantly ($p < 0.006$) lower for CWI (82 ± 15 bpm), fan (88 ± 12 bpm), ECCS (87 ± 14 bpm), and ice towels (84 ± 15 bpm) as compared to sun (101 ± 15 bpm). Thermal sensation scores between modalities were all significantly ($p < 0.006$) lower (CWI: $1.7 \pm .6$; fan: $3.2 \pm .8$; ECCS: $4.6 \pm .7$; hood: $4.6 \pm .6$; NIV: 4.5 ± 1 ; GRV: $4.0 \pm .5$; ice buckets: 4.0 ± 1 ; ice towels: 3.0 ± 1) when compared to sun ($5.5 \pm .5$) except for shade (5.0 ± 0.8). There were no significant differences ($p > 0.006$) in thirst scores between all modalities when compared to sun. ESQ scores were significantly ($p < 0.006$) lower for CWI (1 ± 6), fan (4 ± 5), and ice towels (3 ± 8) when compared to sun (13 ± 12). **Conclusions:** Our findings indicate when athletes are experiencing mild hyperthermia following intense exercise in the heat that CWI, ice buckets, and ECCS offer superior cooling rates (as compared to rest in the sun) during a brief break period.

A Randomized, Controlled Study Of The Acute Effects Of Muscle Energy Techniques On Posterior Shoulder Tightness

Moore SD, Laudner KG, Somers AK, McLoda TA, Shaffer M: Illinois State University, Normal, IL, and University of Iowa, Iowa City, IA

Context: Overhead athletes often exhibit posterior shoulder tightness, which has been associated with lost shoulder range of motion (ROM) and increased risk of shoulder pathology. Stretching protocols aimed at improving posterior shoulder motion have revealed inconsistent results. Although utilization of muscle energy techniques (MET) has been hypothesized to lengthen muscle and fascia, limited empirical data exist describing the effectiveness of such stretches for treating posterior shoulder tightness. **Objective:** To determine if MET provides acute improvements in glenohumeral horizontal adduction and internal rotation ROM. **Design:** Randomized, single-blinded, pre-test post-test design. **Setting:** Collegiate athletic training room. **Participants:** Sixty-one NCAA Division I baseball players were

randomly assigned to one of three groups. Nineteen participants (age=19.5±1.0 years, height=184.4±6.2 cm, mass=86.9±7.0 kg) received a MET to increase the flexibility of the horizontal abductors (MET for HAbd), 22 participants (age=20.4±1.1 years, height=183.7±6.5 cm, mass=88.2±11.2 kg) received a MET to increase the flexibility of the external rotators (MET for ER), and 20 participants (age=19.8±1.1 years, height=186.2±6.5 cm, mass=89.4±7.8 kg) received no treatment (control). Participants had no recent upper extremity injury or surgical history. **Interventions:** We measured pre and post-test glenohumeral horizontal adduction ROM (ICC=0.93, SEM=1.6°) and internal rotation ROM (ICC=0.98, SEM=2.0°) using the Pro Digital Inclinator (SPI-Tronic, Garden Grove, CA). Participants were supine with the scapula stabilized for ROM measurements and MET application. Muscle energy technique

application consisted of a 5 second isometric contraction against the examiner in the direction of either glenohumeral horizontal abduction (MET for HAbd) or external rotation (MET for ER) at 25% of maximum force followed by a 30 second active-assisted stretch. The active assisted stretch involved moving the glenohumeral joint into end range horizontal adduction (MET for HAbd) or internal rotation (MET for ER). This procedure was performed a total of 3 times. We conducted a mixed model ANOVA, followed by a one-way ANOVA and Tukey post hoc analysis for significant group-by-time interactions ($P<.05$). **Main Outcome Measures:** Dependent variables included glenohumeral horizontal adduction and internal rotation ROM. **Results:** A significant group-by-time interaction was found for glenohumeral horizontal adduction ROM ($P=.02$) (MET for HAbd group: pre-test=-10.0±9.6°, post-test=-3.4±9.9°; MET for

ER group: pre-test=-13.5±7.7°, post-test=-8.5±8.9°; control group: pre-test=-7.8±6.0°, post-test=-8.9±7.2°). A significant group-by-time interaction was also found for glenohumeral internal rotation ROM ($P=.02$) (MET for HAbd group: pre-test=43.5±10.1°, post-test=47.7±11.7°; MET for ER group: pre-test=44.5±8.6°, post-test=44.7±8.6°; control group: pre-test=50.7±11.3°, post-test=50.5±12.1°). The MET for the HAbd group had a significantly greater improvement in glenohumeral horizontal adduction ($P=.02$) and internal rotation ROM ($P=.03$) compared to the control group. No significant differences were found for any other variables ($P>.05$). **Conclusions:** Our results indicate that an application of a MET for the horizontal abductors provides acute improvements in both glenohumeral horizontal adduction and internal rotation ROM among baseball players.

Free Communications, Oral Presentations: Doctoral Student Award Finalists

Thursday, June 18, 2009, 9:45AM-11:00AM, Room 214C; Moderator: Kimberly S. Peer, EdD, LAT, ATC

Adolescents Demonstrate Lower Spatiotemporal Postural Control Compared To Healthy Adults

Hoch MC, McKeon PO, Medina
McKeon JM, Silkman CL: University of Kentucky, Lexington, KY

Context: Time-to-boundary (TTB) is a spatiotemporal measurement technique that has been shown to be effective in detecting postural control alterations. There is no evidence whether adolescents display similar TTB values as adults. **Objective:** To examine postural control in adolescents and healthy adults using TTB measures. **Design:** Cross-sectional study. **Setting:** Research Laboratory. **Participants:** 64 healthy adolescents (30 males, 34 females, age: 15.52 ±1.05 years, range: 13-17 years) participated. Inclusion criteria were no history of lower extremity injury in the past six weeks or history of balance disorders. A reference group of 50 healthy adults (25 males, 25 females, age: 25.38±5.99 years, range: 18-45 years) was used for comparisons of postural control measures. **Intervention(s):** All subjects performed three, ten-second trials of barefoot single-limb stance on a forceplate with eyes open (EO) and eyes closed (EC) on their left limb. The mean of each measure for the three trials was used for analysis. **Main Outcome Measures:** The mean of TTB minima(s) and the standard deviation of TTB minima(s) in the mediolateral (ML) and anteroposterior (AP) directions were the dependent variables. The independent variables included group

(adolescent, adult) and vision (EO, EC). Separate group by vision ANOVAs with repeated measures were used to compare each TTB variable. Post hoc Tukey HSD tests were calculated to explain any significant interactions. The alpha level was set *a priori* at $p\leq 0.05$. **Results:** Significant group by vision interactions were found for the mean of TTBML minima ($p<.001$), the mean of TTBAP minima ($p<.001$), the standard deviation of TTBML minima ($p=.02$), and the standard deviation of TTBAP ($p<.001$). For both groups, TTB-EO values were significantly higher than TTB-EC values ($p<.05$). For the mean of TTB minima, adolescents (TTBML-EO: 1.49±0.45s, TTBML-EC: 0.74±0.22s, TTBAP-EO: 4.48±1.26s, TTBAP-EC: 1.99±0.56) performed significantly worse than adults (TTBML-EO: 2.93±1.69s, TTBML-EC: 1.46±0.67s, TTBAP-EO: 9.14±4.37s, TTBAP-EC: 4.06±1.72s) for EO and EC trials in both directions ($p<.05$). There were no differences between adolescent EO values and adult EC values in either direction. Similar significant differences were found between groups for the standard deviation of TTB minima where adolescents (TTBML-EO: 1.11±0.48s, TTBML-EC: 0.69±0.37s, TTBAP-EO: 2.75±0.95s, TTBAP-EC: 1.30±0.49s) performed significantly worse than adults (MLEO: 2.31±1.72s, MLEC: 1.40±0.84s, APEO: 5.57±2.77s, APEC: 2.68±1.23s) on all measures ($p<.05$). There were no differences between the adolescent EO values and adult EC values in either direction. **Conclusions:** Adolescents

displayed significantly lower TTB magnitude and variability in the ML and AP directions compared to healthy adults. This suggests sensorimotor function may not be fully developed until adulthood. The reduction in magnitude and variability of TTB minima indicated that the adolescent group had significantly less time and fewer strategies to make postural corrections compared to adults. Therefore, level of maturity appears to be a constraint on sensorimotor function.

Neuromuscular Fatigue Impacts Lower Extremity Biomechanics When Transitioning From Non-Weight Bearing To Weight Bearing

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University of North Carolina at Greensboro, Greensboro, NC

Context: Neuromuscular fatigue is suggested as a risk factor for non-contact ACL injury. Specifically, fatigue has been shown to impair neuromuscular control as well as passive stability of the knee joint. However, few studies have examined the effect of neuromuscular fatigue on knee biomechanics during the transition from non-weight bearing (NWB) to weight bearing (WB) in-vivo, the point in time when ACL injury is thought to occur. Examining this relationship may further clarify possible non-contact ACL injury mechanisms. **Objective:** To investigate the effect of neuromuscular fatigue on anterior tibial translation (ATT), knee flexion excursion

(KF_{exc}) and axial compressive force (ACF) in healthy knees during the transition from NWB to WB. **Design:** Single cohort, descriptive. **Setting:** Controlled, laboratory. **Patients or Other Participants:** Ten (5M, 5F) healthy participants (25.3 ± 4.0 yrs, 170.9 ± 6.7 cm, 68.5 ± 9.8 kg) with no history of knee ligament injury. **Interventions:** Subjects were tested on the dominant limb (stance leg when kicking a ball) in supine and the knee flexed to 20 in the Vermont Knee Laxity Device (VKLD; University of Vermont, Burlington, VT). The VKLD provides a controlled axial load to the knee joint by first creating a zero shear load across the joint while NWB, then applies a 40% body weight (BW) compressive load through the ankle and hip axes to simulate WB. Three loading trials were applied before and immediately after a fatigue protocol while electromagnetic sensors and a force transducer measured ATT, KF_{exc} , and ACF. Lower extremity muscle fatigue was induced while positioned in the VKLD via repeated leg extension and flexion exercise (range 10 to 40 of knee flexion) against a 60% BW load applied to the bottom of the foot at a standardized pace (3s per repetition via a metronome). Subjects completed continuous cycles of 15 repetitions and 10 seconds rest until unable to complete a full cycle at the prescribed pace. Separate repeated measures ANOVA compared ATT, KF_{exc} , and ACF before and after fatiguing exercise. **Main Outcome Measures:** ATT (mm), and KF_{exc} ($^{\circ}$) were obtained by subtracting initial values at zero ACF (NWB) from values at peak ACF (N). **Results:** From pre-to post fatigue, ATT (6.7 ± 1.7 mm < 8.2 ± 1.9 mm; $p < .001$), KF_{exc} ($8.0 \pm 4.0^{\circ}$ < $10.2 \pm 3.7^{\circ}$; $p = .046$), and ACF (351.8 ± 44.3 N < 374.0 ± 47.9 N; $p = .018$) increased. **Conclusions:** After fatigue, individuals experienced greater ATT, likely a result of higher ACF due to altered control of knee joint motion (small increases in KF_{exc} then rapid stiffening). Hence, neuromuscular fatigue may impair knee joint biomechanics in a way that may place greater tension on the ACL, and increase injury risk during functional activities. Supported by NIH-NIAMS Grant R01-AR53172, and 2008 UNCG Summer Research Assistantship.

Postural Alignment Risk Factors For Patellofemoral Pain In A Military

Population: The JUMP-ACL Study

Boling MC, Padua DA, Marshall S, Guskiewicz K, Pyne S, Beutler AI: University of North Florida, Jacksonville, FL; University of North Carolina, Chapel Hill, NC; United States Naval Academy, Annapolis, MD; Uniformed Services University of the Health Sciences, Bethesda, MD

Context: The etiology of patellofemoral pain (PFP) is not well understood, most likely due to the lack of large-scale prospective investigations assessing risk factors for this condition. Increased quadriceps angle (Q-angle) and excessive pronation are theorized risk factors for the development of PFP due to their influence on the alignment of the patella within the femoral trochlea; however, these factors have yet to be determined as true risk factors for the development of PFP.

Objective: To determine the association between Q-angle and navicular drop, and incident PFP. **Design:** Prospective cohort.

Setting: US Military Academy. **Patients or Other Participants:** The cohort consisted of 1,319 cadets (females=513, males=806) who were freshmen at the time of enrollment in the current investigation. This cohort is part of a larger scale investigation of risk factors for ACL injury (JUMP-ACL).

Interventions: Q-angle and navicular drop were assessed on the dominant lower extremity. Q-angle ($^{\circ}$) was measured in a weight-bearing stance as the angle formed between a line from the ASIS through the center of the patella and a line from the tibial tuberosity through the center of the patella. Navicular drop (mm) was measured as the difference between the navicular tuberosity height in a non weight-bearing subtalar joint neutral position and a weight-bearing position. Each measurement was taken three times and participants were asked to march in place between each measurement. Participants were followed for a maximum of 2.5 years to determine those who developed PFP. Incident PFP was determined by a manual review of medical records by the principal investigator over the 2.5 years in which the following criteria needed to be met for inclusion in the injured group: retropatellar knee pain with physical activity, pain on palpation of either the patellar facets or femoral condyles, and negative findings on examination of the knee ligaments, menisci, bursae, and synovial plica. **Main Outcome Measures:** The average of the three Q-angle and navicular drop measurements were used for data analysis. Separate Poisson regression analyses were performed to determine the

association between Q-angle and navicular drop and incident PFP ($P \leq 0.05$). **Results:** Forty midshipmen were diagnosed with PFP during the follow-up period (females=24, males=16). Quadriceps angle was not a significant predictor for incident PFP (Rate ratio (RR)=0.99, 95% Confidence interval (CI)=0.47, 2.09, $P=0.98$). Increased navicular drop was a significant predictor for incident PFP (RR=2.52, 95% CI=1.25, 5.08, $P=0.01$).

Conclusions: The rate of development of PFP was 2.52 times greater for individuals with increased navicular drop (navicular drop 3 10.67mm); however, increased Q-angle was not associated with an increased risk of PFP. Multiple theorized risk factors for PFP have yet to be investigated, therefore, more large-scale prospective cohort investigations are needed to truly understand the risk factors for PFP. (Funded by the NIAMS Division of the National Institutes of Health, #R01-AR050461001, National Academy of Sports Medicine, and the National Basketball Athletic Trainers' Association)

Intralimb Coordination During Gait In People With And Without Patellofemoral Pain Syndrome

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Context: Comparison of gait in those with and without patellofemoral pain syndrome (PFPS) has yielded conflicting results. However, previous studies have frequently been limited to analysis of single joint movements, leaving lower extremity intralimb coordination relatively unexplored.

Objective: To determine if there are differences in intralimb coordination between the hip and knee in those with and without PFPS.

Design: Single-session repeated measures design. **Settings:** All data were collected in a research laboratory setting.

Participants: Sixteen subjects with PFPS (12 females, 4 males; 21.63 ± 3.76 yrs; 172.7 ± 7.15 cm; 68.19 ± 10.78 kg) and eleven control subjects (9 females, 2 males; 19.91 ± 2.70 yrs; 169.90 ± 9.85 cm; 66.37 ± 11.90 kg) participated in the study. All subjects were free from any traumatic injury to the lower extremity or vestibular disorders. Subjects in the PFPS group presented with diffuse anterior knee pain for at least 8 weeks, which was elicited or increased with activities, but unrelated to a traumatic event. Members of the control group had a designated matched side to the symptomatic and asymptomatic sides of the PFPS group for the purpose of between group comparisons. **Interventions:** Independent variables were group (PFPS,

Control) and side (symptomatic, asymptomatic). Subjects walked across the laboratory at a self-selected speed, while being recorded with an 8-camera motion analysis system. Hip and knee kinematic data were obtained through OrthoTrak software. Sagittal, frontal and transverse joint coupling angles between hip and knee at heel strike (HS) and toe off (TO) during the gait cycle were calculated using the vector coding technique. Joint coupling angles ranged between 0° and 90°, with 45° indicating an equal amount of motion between the two joints and an angle greater than 45° representing relatively greater hip motion. **Main Outcome Measurements:** The six dependent variables were joint coupling angles for hip-knee flexion, hip-knee abduction, and femoral-tibial rotation at HS and TO. For each DV, a one-between (group), one-within (side) repeated measures ANOVA was calculated. **Results:** A significant group by side interaction was observed for frontal plane joint coupling angle at HS ($F_{1,25}=8.60$; $p=0.007$). Post-hoc analysis revealed the symptomatic side of the PFPS group presented with more equal amount of motion between the two joints than the asymptomatic side of the PFPS group or matched "symptomatic" side of the Control group (PFPSsymp=56.36±24.60°; PFPSasymp=76.19±10.84°; CONTsymp=77.89±10.65°; CONTasymp=67.83±21.09°). No significant differences were observed at TO. **Conclusions:** The symptomatic leg of the PFPS subjects demonstrated a more equal hip-knee movement at HS compared with the asymptomatic leg. PFPS subjects may be forced to reduce freedom of movement due to pain, and therefore present with a relatively equal motion to avoid the exacerbation of painful symptoms. Our observation may support dynamic systems theory that PFPS causes people to walk with more predictable, constrained patterns. Further research is warranted to verify this finding.

Improvements In Landing Technique From An Injury Prevention Program Are Retained In Youth Soccer Athletes
DiStefano LJ, Padua DA, DiStefano MJ, Marshall SW: University of North Carolina, Chapel Hill, NC

Context: Previous research indicates that anterior cruciate ligament injury prevention programs can reduce injury rates and modify potential neuromuscular risk factors for injury. However, it is unknown how long changes are retained after the completion of an injury prevention program. **Objective:** To evaluate whether improvements in landing technique are retained 4-9 months after an injury prevention program is completed and to determine if the response is similar between sexes. **Design:** Repeated measures design. **Setting:** Soccer field. **Participants:** 114 youth soccer athletes (Males: $n=33$, age=12±2 years, height=165±13cm, mass=53±11kg; Females: $n=77$, age=12±2 years, height=159±7cm, mass=49±10kg) who improved their landing technique following an injury prevention program. **Intervention:** Sex and three assessment times (pre-intervention, immediately post-intervention, and 4-9 months post-intervention) were the independent variables for this study. Participants' landing technique during three trials of a jump-landing task was videotaped from the frontal and sagittal planes. The videos were graded by one rater using the Landing Error Scoring System (LESS). Assessment of landing technique occurred before and after the completion of an injury prevention program, as well as four to nine months following the post-test (retention test). The participants did not perform the program between the post-test and the retention test. The twelve-week injury

prevention program consisted of flexibility, strengthening, agility, balance, and plyometric exercises and was performed as a ten-minute warm-up prior to practice three days per week. **Main Outcome Measures:** The LESS evaluates multiple landing characteristics including frontal and sagittal plane motion of the foot, knee, hip, and trunk. A low LESS score indicates fewer landing errors and better landing technique. The average LESS score across three trials was used for analysis. A mixed model analysis of variance was conducted to evaluate changes in LESS score between the three time points and sexes after controlling for the differences in length of time between the post-test and the retention test ($\alpha \leq 0.05$). A Bonferroni test was performed for post hoc analyses. **Results:** A significant main effect for time was observed ($F_{(2,193)}=10.89$, $P<.001$). LESS scores were significantly lower during the post-test (3.28±1.40) and the retention test (3.72±1.27) compared to the pre-test (5.02±1.73, $P<.001$), but LESS scores were significantly higher during the retention test compared to the post-test ($P=.02$). No other significant differences were observed ($P>.05$). **Conclusions:** Improvements from an injury prevention program are retained months after discontinuing the program. However, there appears to be some decay over time in the intervention effect as participants demonstrated deteriorating landing technique during the retention test compared to the post-test. These results indicate injury prevention programs may need to be performed more than once in order for improvements in landing technique to continue for an extended period of time. *Funded by the National Academy of Sports Medicine*

Evidence-Based Forum #2: Modalities

Thursday, June 18, 2009, 11:15am-12:15pm, Room 214C; Discussants: Lennart Johns, PhD, ATC, and Susan Saliba, PhD, ATC; Moderator: David Gish, MED, LAT, ATC

Free Communications, Oral Presentations: Therapeutic Modalities

Thursday, June 18, 2009, 12:15PM-1:15PM, Room 214C; Moderator: Timothy J. Demchak, PhD, ATC

Effects Of High Voltage Pulsed Current On Recovery Following Grade I And II Lateral Ankle Sprains
Dolan MG, Mendel FC, Fish DR, Marzo JM, Wilding GE: Canisius College, Buffalo, NY, and University at Buffalo, Buffalo, NY

Context: Ankle sprains are the most common injury in intercollegiate athletics, and result in significant time loss from practices and games. High voltage pulsed current (HVPC), a form of electrical stimulation, is known to curb edema formation in animals, and is commonly applied to ankle sprains in the belief that HVPC hastens recovery. Clinical effect(s), however, remain(s) undocumented. **Objective:** Determine whether, as an adjunct to routine acute and subacute care, subsensory HVPC applied nearly continuously for the first 72 hrs following lateral ankle sprains affected time lost to injury. **Design:** Multi-center, randomized, double blind, placebo controlled trial. **Setting:** Data were collected at nine colleges/universities, and one professional football training site. **Patients or other Participants:** 50 intercollegiate and professional athletes, 32 males, 18 females, age=20.0±1.54 years, BMI=24.9±3.9. **Interventions:** As soon after injury as practically possible near-continuous live (n=22) or placebo subsensory HVPC (n=28) was applied for 72 hours post injury adjunctive to routine acute and subacute care. HVPC (cathodal, 120 pulses per second) was delivered by miniature stimulators via sock electrodes. 'Placebo' stimulators provided this same output, but for just 3 minutes after the final intensity settings were entered. Units appeared to be active regardless of actual output, and 'reactivated' with any adjustment of amplitude. Subjects, data collectors, and investigators remained blind to group assignment until after the study concluded. Statistical analysis of the primary outcome (time from injury to time declared fit to play) was conducted using inference procedures based on a linear model fit to the data via restricted maximum likelihood methods. Specifically, the outcome was modeled as a function of treatment, grade of injury, and the interaction between the two to allow for grade specific effects of treatment. **Main Outcome Measure:** Time lost to injury, measured from time of injury until declared fit to play by supervising athletic trainers or team physicians. **Results:** Overall, time lost to injury was not different between treated and control groups ($p = .55$). However, grade of injury was a significant factor; time lost to

injury following grade I lateral ankle sprains was greater for athletes receiving live HVPC (5.3 ± 1.9 days) than for those receiving placebo HVPC (4.1 ± 1.3 days, $p = .049$). However, we found no differences between groups for grade II sprains (live= 12.6 ± 6.1 days, placebo= 13.9 ± 7.0 days, $p = .079$). **Conclusions:** Application of subsensory HVPC, as applied in this randomized clinical trial, had no clinically meaningful effect on return to play following lateral ankle sprains in college and professional athletes.

Arthrogenic Muscle Inhibition Occurs With Pain And Is Removed With Cryotherapy

Long BC, Knight KL, Hopkins JT, Feland JB, Parcell AC, Schaale BG: Brigham Young University, Provo, UT, and Oklahoma State University, Stillwater, OK

Context: Clinically it is assumed pain contributes to arthrogenic muscle inhibition. Cryokinetics, a rehabilitation technique involving cold application and exercise, is thought to facilitate exercise by reducing pain and arthrogenic muscle inhibition. **Objective:** Determine if experimentally induced anterior knee pain contributes to arthrogenic muscle inhibition and if cold application influences either pain or arthrogenic muscle inhibition. **Design:** A randomized controlled laboratory study. **Setting:** Laboratory. **Patients or Other Participants:** Forty physically active, healthy male participants (age = 21.8 ± 2.2 yrs, ht = 176.3 ± 26.9 cm, mass = 76.0 ± 8.7 kg) volunteered. **Interventions:** We examined 4 treatments (saline infusion, saline infusion/cryotherapy, saline infusion/sham, and no-saline infusion) at 3 different times (pretreatment, immediate posttreatment, and 30-minutes posttreatment). **Main Outcome Measures:** H_{max} , M_{max} , pain rating index, visual analogue scale (pain perception), and patella, popliteal, and ambient air temperature were measured. **Results:** Pain resulted in arthrogenic muscle inhibition immediately post and 30-minutes post hypertonic saline infusion (pre: 0.41 ± 0.20 , post: 0.26 ± 0.24 , 30-minutes post: 0.28 ± 0.23 ; $P < .0002$). Cryotherapy removed inhibition immediately post (pre: 0.37 ± 0.12 and post: 0.55 ± 0.18 ; $P < .0001$), but not at 30-minutes post (0.36 ± 0.18 ; $P > .87$). Pain for the 3 saline infusion groups increased immediately post infusion (saline; pre: 0.0 ± 0.0 and post: 49.5 ± 23.7 ; saline/cryotherapy; pre: 0.0 ± 0.0 and post: 28.6 ± 7.7 and saline/sham; pre: 0.0 ± 0.0 and post: 45.5 ± 24.3 , $P < .0001$). Pain decreased

immediately post cryotherapy application ($P < .0001$) and 30-minutes post application ($P < .002$). Pain caused by saline infusion and saline infusion/cryotherapy were greater than no-saline at 30-minutes post ($P < .0001$). At 30-minutes post infusion, pain caused by cryotherapy and sham application were greater than no-saline ($P < .04$). Cryotherapy decreased patellar and popliteal surface temperatures more than no cryotherapy ($P < .0001$). **Conclusions:** Arthrogenic muscle inhibition occurred with anterior knee pain. A knee joint cryotherapy treatment disinhibited the quadriceps motoneuron pool and reduced pain.

The Effects Of Ultrasound Heating On Intramuscular Blood Flow Characteristics In The Gastrocnemius

Eberhardt MJ, Bova SM, Miller MG, Cheatham CC, Baker RJ, Webb D, Michael TJ: Western Michigan University, Kalamazoo, MI

Context: Therapeutic ultrasound continues to be a popular modality despite the fact that many of its proposed therapeutic effects remain controversial. One such proposed effect of interest is that ultrasound treatments will result in an increase in local muscular blood flow. **Objective:** To determine intramuscular blood flow and temperature with an application of ultrasound within the gastrocnemius. **Design:** Within-subjects repeated measures design. **Setting:** Human Performance Research Laboratory. **Patients or Other Participants:** Eleven subjects (7 males, 4 females; age = 22.3 ± 1.8 years, height = 171.6 ± 9.8 cm, mass = 68.8 ± 15.4 kg). **Interventions:** Intramuscular temperature and blood flow were measured in the posterior gastrocnemius at a depth of 2 cm below the subcutaneous tissue layer using a 26-gauge thermocouple needle probe and a laser-Doppler needle probe, respectively. Baseline measurements of these variables were recorded at the end of a 20 minute supine rest-period. Ultrasound treatment (Vectra, Chattanooga, TN) was then applied until the intramuscular temperature increased 2°C from baseline within a template of 10 cm^2 on the posterior gastrocnemius using 3.3MHz ultrasound with a 5 cm^2 sound head at 1.0 W/cm^2 and BNR of 5:1. Measurements of intramuscular temperature and blood flow were then recorded for 20 minutes post-treatment with blood flow averaged over 5 minute increments. **Main Outcome Measures:** Separate one-way repeated

measures ANOVA were used to analyze intramuscular temperature and blood flow. Statistical significance was set *a priori* at $P \leq 0.05$. **Results:** The mean time required to reach the two degree increase in intramuscular temperature ($34.86 \pm 0.70^\circ\text{C}$ to $36.94 \pm 0.65^\circ\text{C}$) was 3 minutes and 48 seconds. For intramuscular temperature, there was a significant main effect for time ($F_{2,4, 24,2} = 141.30$ $P < 0.001$). Intramuscular temperature was significantly greater than baseline for the first 8 minutes of the post treatment period ($F_{2,4, 24,2} = 141.3$, $P < 0.001$). For intramuscular blood flow, there was a significant main effect for time ($F_{1,7, 16,9} = 3.7$, $P = 0.050$). Compared to baseline (41.15 ± 26.14 perfusion units (PU)), intramuscular blood flow was significantly greater at time periods 6-10 minutes (64.14 ± 52.89 PU) and 11-15 minutes (60.30 ± 42.52 PU) of the post treatment period. However, there was no difference in blood flow between baseline and time period 0-5 minutes (66.14 ± 63.99 PU) and baseline and 16-20 minutes (58.40 ± 50.48 PU). **Conclusions:** Ultrasound treatment was effective at increasing intramuscular blood flow in response to a 2°C increase in intramuscular temperature. However, this increase was only evident during the first 15 minutes of the post treatment period.

The Ability Of A New Thinner Gel Pad To Conduct Ultrasound Energy And Increase Tissue Temperature Of The Achilles Tendon

Edvalston C, Draper DO, Knight KL, Shurtz J, Eggett DL: Brigham Young University, Provo, UT

Context: Ultrasound gel pads were originally manufactured at 2cm thick as an optimal viewing distance medium for diagnostic ultrasound imaging of internal structures such as the gall bladder, thyroid and breast tumors. Clinicians began using these pads during therapeutic ultrasound for hand and ankle therapy due to the ability to smoothly glide over areas with bony prominences. We surmised that these pads were too thick to be used as a coupling medium in orthopedic conditions. Clinically only a thin layer of gel is used, not 2cm. **Objective:** To compare the temperature rise 1 cm deep in the human Achilles tendon during a 10 min 3MHz ultrasound treatment (1 W/cm^2) of three different ultrasound media: ultrasound gel; 1cm thick gel pad; 2 cm thick gel pad. **Design:** A randomized block design was used to assign each of the 48 subjects to one of the three treatment groups. The dependent variables were total temperature increase and time to peak temperature. The independent variable was type of coupling medium. **Setting:** University therapeutic modalities research

laboratory. **Patients or Other Participants:** Forty-eight active volunteers (24 females, 24 males) between 18-30 years of age. **Interventions:** A thermistor was inserted 1cm deep into the center of the Achilles tendon. The treatment was then performed for 10 minutes at 3MHz continuous ultrasound, 1 W/cm^2 . **Main Outcome Measures:** Intra-tissue temperature, recorded every 30 seconds for the duration of the ultrasound treatment. An Anova was used to determine difference in temperatures. **Results:** Temperature in the Achilles tendon increased 13.3°C , 9.2°C and 6.5°C respectively in the gel, 1cm and 2cm gel pads. There was a significant difference between the heating of the 3 techniques: gel ($p < .0007$; $\text{SE} = 0.72$). The 1cm pad heated up the tendon 29.4% higher than the 2cm gel pad ($p < .03$; $\text{SE} = 0.71$). **Conclusion:** When performing an ultrasound treatment the use of ultrasound gel as a coupling medium will result in higher temperatures in the Achilles tendon. However, both ultrasound treatments using the gel pads as mediums produced temperature increases in the vigorous range. Thus if the area is bony in nature, is a wound, or contoured like the Achilles tendon, an ultrasound treatment using the 1 cm Aquaflex® gel pad will produce on average ~ a 2.7°C higher increase in temperature than the 2 cm thick Aquaflex® gel pad.

Free Communications, Oral Presentations: Clinical Education

Friday, June 19, 2009, 8:15AM-9:15AM, Room 214C; Moderator: Joseph Murphy, ATC

Relationships Of Approved Clinical Instructors' Evaluations Of Athletic Training Student Clinical Performance And Grade Point Average
Ambegaonkar JP, Caswell SV, Caswell AM: George Mason University, Manassas, VA

Context: Approved Clinical Instructors (ACIs) are integral to athletic training students (ATS) Development. In this role, ACIs often evaluate ATSS' clinical performance using measurement tools provided by the Athletic Training Education Program (ATEP). However, little research has examined relationships between ACI ratings of students' specific clinical performance (SCP), overall clinical performance (OCP), and grade point average (GPA). **Objective:** We examined relationships between ACI evaluations of ATSS' clinical performance using a clinical performance assessment inventory (Athletic Training Student Clinical

Performance Inventory; ATSCPI) and ATSS' GPA over the clinical experience. **Design:** Correlational **Setting:** Large metropolitan university. **Participants:** 48 ACIs ($M = 20$; $F = 28$; Board of Certification certified for 7.5 ± 3.2 yrs; ACIs for 3.2 ± 1.5 yrs) evaluating 62 undergraduate ATSS ($M = 20$; $F = 42$). **Interventions:** ACIs completed the ATSCPI twice (mid-semester, and end-of semester) during an ATSS' clinical field experience over 4 academic years (AY 2004-05 to 2007-08). The ATSCPI is a 21-item instrument where items 1-20 assess student SCP based on specific constructs and item 21 requires ACIs to rate the student's OCP. ACIs also appraised student performance using the standard GPA scale ($4.0 = A$, $0.0 = F$). Pearson product-moment correlations examined relationships between SCP, OCP, and GPA with separate paired t-tests ($p < .05$) examining differences. **Main Outcome Measures:** The ATSCPI uses a 4-point Likert-type scale anchored by 1 (Rarely) and 4 (Consistently).

Aggregate mean scores were calculated for the three variables SCP, OCP, and GPA. **Results:** Two-hundred-and-sixty-six completed ATSCPI instruments were included in the final analyses. Cronbach's Alpha of the ATSCPI (items 1-21) demonstrated acceptable reliability (.88). All three measures were positively correlated (SCP and OCP, $r(264) = .65$, $p < .001$; SCP and GPA $r(264) = .63$, $p < .001$; OCP and GPA $r(264) = .55$, $p < .001$). No differences were found between ACIs assessments of student SCP (3.5 ± 0.4) and GPA (3.5 ± 0.7 ; $t = .60$, $p = .55$). However, ACIs assessment of students' OCP (3.6 ± 0.7) was significantly higher ($t = -3.45$, $p < .000$) than their ratings of student SCP and GPA ($t = 2.05$, $p = .04$). **Conclusions:** ACIs were remarkably accurate when assessing students on specific clinical performance (SCP) and providing a letter grade (GPA). However, ACIs may have overestimated students' overall clinical performance (OCP), as compared to SCP and

GPA. Overall, our results suggest that the ATSCPI may be a valuable tool for ATEP faculty and ACIs to measure athletic training student clinical performance. Further research is warranted to investigate how other variables (e.g. years of ACI experience, number of students supervised, education level, and clinical setting) may affect ACIs' assessments of student performance.

Unplanned Peer Learning And Peer Leadership Occur Frequently During Clinical Experiences In The Collegiate Clinical Setting

Henning JM, Marty MC, Weidner TG, Fearnow-Kennedy M: University of North Carolina at Greensboro, Greensboro, NC, and Ball State University, Muncie, IN

Context: Peer assisted learning (PAL) is considered to be appropriate for athletic training students (ATS). However, it is unknown how frequently it is occurring during athletic training clinical experiences in the collegiate setting. **Objective:** To determine the frequency of student engagement in five types of PAL (peer teaching, peer learning, peer feedback/assessment, peer mentoring, and peer leadership) during clinical experiences, and whether it occurs randomly or as a planned component of clinical education. **Design:** Cross-sectional. **Setting:** Accredited entry-level athletic training education programs (ATEPs). **Participants:** Collegiate-setting clinical instructors (CIs) associated with a geographical stratified (by NATA district) random sample of ATEPs (n=53, 91.4% return rate). A total of 208 CIs (105 males, 50.5%; 103 females, 49.5%) participated in this study. **Interventions:** The previously validated Athletic Training Peer Assisted Learning Survey (AT-PALS) was adapted for this study. It contained 15 student behaviors grouped into five categories of PAL representing peer teaching, peer learning, peer assessment, peer mentoring, and peer leadership. For each of the 15 behaviors (e.g., "practicing a previously learned skill"), the CIs indicated on a checklist (yes or no) whether they regularly observe the behaviors during students' clinical experiences, and whether such behaviors were deliberately planned/fostered or were occurring naturally in the collegiate clinical setting. CIs also indicated the typical number of ATS they supervise at one time. Internal consistency of the instrument was acceptable KR-20 was .82 and .80 for the planned and unplanned behaviors, respectively. **Main Outcome Measures:** We computed mean scores for each of the 5 categories of PAL by averaging

the CI binary responses within a category of behaviors (thus yielding a frequency of observation for a given category). A 2-way repeated measures ANOVA with condition (planned vs. unplanned) by category of PAL was performed. **Results:** There was a main effect of condition ($F(1, 199) = 45.38, P < .001$). CIs observed unplanned PAL (mean=.62) more frequently than planned PAL (mean=.46). Regardless of condition, there were significant differences across categories of PAL ($F(4, 199) = 97.40, P < .001$), with peer learning (mean=.69), occurring most frequently and peer assessment/feedback (mean=.32) least frequently. The frequency of all types of PAL increases as the number of students being supervised increases $F(4, 196) = 3.15, p = .015$). However, peer learning (mean=.85) and peer leadership (mean=.67) were particularly reported to occur when 2 students are being supervised. **Conclusions:** Unplanned PAL occurs frequently during clinical experiences in the collegiate clinical setting, with peer learning and peer leadership being reported the most often. Assigning two students to one ACI seems to be an optimal number for encouraging these two more common types of PAL.

Athletic Training Students' Skills Application During Their Clinical Education Experience

Botto T, Fuller D, Botto A: Quinnipiac University, Hamden, CT, and Baylor University, Waco, TX

Context: Athletic training education programs are required to teach and evaluate a variety of clinical skills. During a student's assigned clinical experiences (CEs), the clinical instructors (CIs) are responsible for teaching and evaluating these skills in a realistic or simulated environment. In order to make these experiences more educational, the clinical instructors and students must practice multiple skills on a regular basis. **Objective:** Purpose of this study was to determine the perceptions of athletic training students regarding skills application during their clinical rotations. **Design:** This was descriptive research. **Setting:** Surveys were distributed to students at the 2007 Southeast Athletic Trainers' Association (SEATA) conference and data was collected at that time. Participants were asked perceptual questions pertaining to their 2006 fall clinical experience. IRB approval was obtained. **Patients or Other Participants:** There were 444 participants: 171 males, 272 females. The average age was 21.58 +/- 2.12 years, 56 (12.6%) were sophomores, 155 (34.9%) were junior students and 233 (52.5%) were seniors. **Interventions:** 20-question descriptive

survey was developed. Inter-rater reliability, content and construct validity of the survey instrument were established. The paper survey was distributed to students at the beginning at the SEATA conference. **Main Outcome Measurements:** Frequencies and percentages were calculated on SPSS 15.0. **Results:** Of the respondents, most (62.4%) felt their CEs were not crowded with other AT students. When asked about the value of these CEs, most felt positive (36.5% excellent, 52.5% good). 87.6% felt their daily responsibilities were made clear to them by their CIs, while 6.8% felt it was assumed they knew them. Reviewing the emergency action plan initially at the clinical site was always done (65.3%), assumed AT students knew them (22.7%), or were not done (9.9%). The CI provided a variety of opportunities for students to apply following athletic training skills: therapeutic modalities (35.8% excellent, 38.7% good, 18.7% fair), rehabilitation (34% excellent, 39.9% good, 20.3% fair), evaluation of injuries (28.2% excellent, 42.8% good, 23% fair), emergency response (20.9% good, 43.5% fair, 26.4% poor), and first aid (40.5% excellent, 36.5% good, 17.1% fair). Opportunities to consult with physicians during their clinical experience were equally distributed (21.8% excellent, 29.1% good, 27.9% fair, 19.4% poor). Most of the students (41.4% excellent, 40.3% good) felt that their CIs were available for clinical instruction. **Conclusions:** These data reveal some valuable insights about the educational experiences between students and CIs. Students need more opportunities to practice their evaluation, emergency response, and to consult with physicians. Students and CIs should utilize any available slow time to practice these athletic training skills, ideally, on real patients or in simulations with other students.

Novice Clinical Provide Less Feedback To Athletic Training Students Than Their More Experienced Clinical Instructors

Stemmans CL: Indiana State University, Terre Haute, IN

Context: Feedback is a critical aspect of skill proficiency used by clinical instructors (CI) to assess and communicate student performance. Prior research has identified a paucity of feedback available to athletic training students (ATS). **Objective:** The purpose of this study was to determine if the frequency of feedback provided to ATSs is dependent on the experience level of CIs. **Design:** This study used a quasi-experimental design. **Setting:** This research was conducted at 11 clinical instruction sites approved by

two CAATE-accredited athletic training education programs. These sites included college and high school level athletic practices, and games, a university sponsored rehabilitation clinic, and skill assessment meetings. **Patients or Other Participants:** A volunteer sample was taken at each program. Twenty-four of the 29 CIs consented to participate. Five clinical instructors were excluded due to scheduling conflicts (n=19; M=9, F=10; age= 26.7±4.6 yrs; yrs BOC certified =3.9±3.7). Thirty-three of the 41 ATS consented to participate. Four ATSs were excluded due to scheduling conflicts (n=29; M=13, F=16; age=21.5±2.3 yrs; Srs=9, Jrs=8, Soph=12). **Interventions:** The independent variable used was experience of the clinical instructor. Three levels of CI experience were used to group CIs; novice (≤1 yr), intermediate (2-4 years), and

advanced (≥ 5 years). Observations of the 19 CIs and 29 ATSs yielded 45 data collection encounters. These encounters were based on the programs clinical instruction assignments and not contrived for research purposes. 10 minutes of real-time observation was completed for each CI/ATS pair. Data was collected using a IBM ThinkPad R-52 enabled with Behavioral Evaluation Strategy & Taxonomy (BEST) Collection (v 7.0) and BEST Analysis (v 6.0) software (Educational Consulting, Inc). **Main Outcome Measures:** The dependent variable was frequency of feedback. A Chi-square analysis was used to determine if equal distribution among the CI groups existed. **Results:** In a 10 minute clinical education session, novice CIs provided 0.8 ±1.2 instances of feedback, intermediate CIs provided 5.5±1.2 and advanced CIs provided 5.8±1.3. Differences among CI

experience levels existed in the frequency of feedback ($X^2 = 9.6$, $P = .008$). Post hoc comparisons identified differences in the frequency of feedback when novice CIs were compared with intermediate ($F_{2,44} = 5.48$, $P = .026$) and advanced ($F_{2,44} = 5.77$, $P = .021$) **Conclusions:** Even with clinical instructor training the use of feedback is almost nonexistent among CIs with less than 1 year of experience. Program directors and supervisors of novice CIs should encourage the use frequent feedback so that ATSs can better refine their clinical performance and consider the efficacy of a clinical instructor when determining student placement.

Evidence-Based Forum #4: Education

Friday, June, 19, 2009, 9:30AM-10:30AM; Discussants: Kimberly Peer, EdD, LAT, ATC, and Gretchen Schlack, PhD, LAT, ATC; Moderator: Tory Lindley, MA, ATC

Free Communications, Oral Presentations: Electronic Pedagogical Strategies

Friday, June 19, 2009, 10:45AM-11:30AM, Room 214C; Moderator: Susan Rozzi, PhD, ATC

Influence Of Asynchronous Physician Augmented On-line Discussion On Learning Outcomes In A General Medical Clinical Education Experience

Clements C, Dodge T, Brown S: Boston University, Boston, MA

Context: Athletic trainers require skill in evaluating injuries and illnesses to make proper diagnostic, care and treatment decisions. We developed a general medical practicum course and related clinical education experience to provide exposure to rich, physician-patient interactions in a general medicine setting for athletic training students. To address a perceived lack of connection of the general medical clinical experiences to athletic training practice, we added an asynchronous, physician augmented, on-line discussion (APAOD) to the general medical practicum course. This entailed an asynchronous on-line discussion among the students in the course related to patient cases they had encountered and a follow-up posting by a physician to provide feedback to the students' discussion. Currently, nothing exists in the athletic training literature specific to the use of APAOD, and little exists related to on-line asynchronous discussion in general. However, student participation in on-line dialogues is positively correlated with achieving learning objectives. Asynchronous

discussions about case studies can also generate high-level cognitive analysis.

Objective: To determine if APAOD influences learning outcomes of a general medical education practicum. **Design:** Qualitative analysis was used to assess participants' perceptions of the influence of APAOD on meeting course objectives.

Setting: The study was conducted in a university setting.

Patients or Other Participants: The criterion for participation was enrollment in the course during the spring 2008 semester. Five out of six students (junior athletic training majors) who met the criterion agreed to participate in the study.

Data Collection and Analysis: Data were collected via semi-structured interviews after final grades for the course were posted. Responses were directly transcribed during the interviews. Member checking was utilized throughout the interviews in order to guarantee the accuracy of the transcriptions. Data were analyzed with a constant comparative approach. In order to insure trustworthiness, a data analyst triangulation scheme was used in which the three researchers independently coded the transcriptions and then negotiated over the coding categories until 100% agreement was reached. **Results:** Two themes emerged as the principal influences on meeting the course objectives: clinical experience and physician feedback. Results revealed that participants considered the clinical education experience to be the most

influential component in meeting course objectives. The physician feedback piece of the APAOD clarified discussion topics. The inter-student discussion piece of the APAOD did not appear to influence learning of general medical topics due to limited moderator interaction and a preference towards face-to-face discussions. **Conclusions:** Clinical education experiences in a general medical setting appear to positively influence learning outcomes of a general medical clinical education experience. Physician feedback via APAOD appears to positively influence learning outcomes of a general medical clinical education experience. Adding face-to-face discussion and/or increased guidance to APAOD inter-student discussions may influence meeting learning outcomes.

Online Flashcards Improve Athletic Training Students' Exam Scores In A Therapeutic Modality Course

Berry DC, Berry LM: Weber State University, Ogden, UT

Context: Athletic training educators are constantly looking at new methods of teaching and reinforcing cognitive and psychomotor information learned in the classroom. Online flashcards are an example of such a learning method. However, as a learning strategy, online flashcards have not been examined

within athletic training to provide evidence for its use as a pedagogical tool. **Objective:** To examine the effectiveness of online flashcards as a pedagogical tool to improve exam scores. **Design:** Pre-post test study. **Setting:** University classroom setting. **Participants:** Twenty-seven undergraduate junior athletic training students (males = 18, females = 9; 23.3 ± 2.45 years of age), enrolled in two separate therapeutic modality courses taught by the same instructor, participated in the study. **Interventions:** One class was designated the online flashcard group (treatment) and the other class the control group. The treatment group ($n=12$) was provided a web address to study online flashcards designed by the instructor during a one-week period. Thirty-five terms and concepts considered important by the instructor were used to construct the flashcards related to the transmission of energy. The flashcards were designed using Flashcard Exchange© (Tuolumne Technology Group, Inc. <http://www.flashcardexchange.com>). The control group ($n=15$) received no access to the online flashcards. Each group received identical lectures, labs, handouts, other classroom assignments and activities. Repeated measures of analysis of variance (ANOVA) with between-subjects (group) and within-subjects (time) effects were performed to assess pre to post changes in exam score and the time needed to complete the exam. Independent *t*-tests were used to analyze time dedicated to preparing for the exam (perceived hours studied). To ensure equivalency of the two groups prior to initiation of the study, independent *t*-tests were performed between the control and treatment groups on pre-test exam score and time to complete the exam. **Main Outcome Measures:** Pre and post exam scores, time to complete the exam, and study time were recorded with both groups. **Results:** Repeated-measures ANOVA revealed significant differences in the post-exam scores between the groups ($F(1, 25) = 5.86, p = .023$). The treatment group demonstrated a higher post-exam score ($92.8\% \pm 4.7\%$) compared to the control group ($77.0\% \pm 11.4\%$). No significant difference was noted between time needed to complete the exam ($F(1, 25) = 3.02, p = .094$). Independent *t*-test revealed no difference between perceived time spent studying for the exam ($t = .335, p = .714$). **Conclusions:** The results of the study indicate that using online flashcards as a course activity had a positive effect on student outcomes. As a pedagogical tool, online flashcards offer students another viable option toward learning and exam preparation. Further research needs to be conducted to examine the effects of flashcards on student learning using a larger sample size and other content areas.

Mobile Technology (Mlearning) Influences Student Acquisition Of Psychomotor Competency In Athletic Training

Wilder JN, Ritenour DM, Davie EE: Waynesburg University, Waynesburg, PA; Salisbury University, Salisbury, MD; Southern Connecticut State University, New Haven, CT

Context: Accredited athletic training education programs are expected to incorporate a competency-based approach to the learning and mastery of clinical proficiency among its students. Student learning has traditionally involved didactic and laboratory techniques. This study focuses on the use of mobile learning (PDA, SMS, or iPods) to expand the content knowledge of athletic training students. This method engages the student in clinical experiences that are removed from the traditional learning sites (libraries and classrooms) and away from connected computers and networks.

Objective: To determine if the acquisition of athletic training psychomotor knowledge can be enhanced by incorporating mlearning technologies into the structured learning environments. **Design:** Randomized controlled trial. **Setting:** Controlled classroom and laboratory setting. **Patients or Other Participants:** Twenty-nine (11M, 18F) first-year undergraduate students (18 ± 1 year) were recruited from an athletic training class. Participants have not been enrolled in any athletic training-related course prior to the study. **Interventions:** Each participant was randomly assigned to one of the three instructional delivery groups: elearning (EL), mlearning (ML) or traditional learning (TL). The TL group participated in a standardized classroom PowerPoint™ lecture and a two-hour lab on knee evaluation. The ML group participated in a blended learning environment composed of a standardized classroom PowerPoint™ lecture, a two-hour lab on knee evaluation and the use of mlearning technology (iPod Video, Apple, Inc, Cupertino, CA). The EL group had access to an elearning environment that utilized a PowerPoint™ lecture and a module of knee evaluation competencies delivered via online video (Blackboard Learning System™). After a 1-week study period, each participant was formally assessed on the content in the lesson through a practical assessment. **Main Outcome Measures:** Competency was evaluated using a practical assessment composed of seven items. This test was evaluated for content validity by three athletic training educators. A one-way analysis of variance (ANOVA) was conducted to evaluate the group differences between instructional

delivery mechanisms on psychomotor competency as measured by the practical test at a significance level of $p < .05$. **Results:** Significant difference between the instructional delivery mechanisms on outcomes to the practical assessment, $F(2,26) = 5.611, p = .009$ were revealed. Tukey's Post-hoc analysis revealed a significant difference between EL (19 ± 12) and ML (32 ± 4), $p = .007$. No significant differences were detected between TL (26 ± 7) and ML or EL ($p > .05$); however, trends were observed as demonstrated by large effect sizes ($d = .93$ and $d = .75$, respectively). **Conclusions:** The study suggests that with the inclusion of mobile technology to the traditional classroom lecture and laboratory instruction, it is possible to acquire psychomotor competency to a greater extent. Additional research is needed to determine if mlearning influences the acquisition of psychomotor competency.

Free Communications, Oral Presentations: Professional Issues

Friday, June 19, 2009, 4:30PM-5:30PM, Room 214C; Moderator: Andrew P. Winterstein, PhD, ATC

Perceptions Of Wellness And Burnout In Athletic Trainers In The Southeastern Athletic Trainers' Association NATA District (9)

Naugle KN, Borsa PB, Dodd V, Tillman M, Behar-Horenstein L, Garvan C:
University of Florida, Gainesville, FL

Context: Burnout increases the prevalence of disease and dictates the severity of illness health care professionals. Certified Athletic Trainers (ATCs) are suggested to be susceptible to stressful job settings, long hours, and an increased number of job stressors thus increasing the likelihood of burnout and decreasing perceived wellness.

Burnout and perceived wellness can result from a number of different variables such as: years of experience, hours worked per week, gender or lack of social support. **Objective:** To determine the relationship between gender, hours worked, years experience, burnout, perceived wellness and social support in District 9 (SEATA) of the NATA.

Design: A cross sectional web based survey design determined the relationships between demographic factors such as age, gender, hours worked per week, and years of experience and the dependant variables of burnout, perceived wellness and social support. **Setting:** District 9 (SEATA) of the NATA. **Participants:** ATCs listed in the SEATA district mailing list (n=412) (239=males, 165=females, age 36.5 ±9.6).

Interventions: Demographic were collected along with a 12-item burnout instrument, a 36-item perceived wellness instrument and a 12-item social support instrument. The covariates included: demographics (age, gender, hours worked, years of experience), Copenhagen Burnout Inventory, Perceived Wellness Survey, and the Medical Outcomes Study (MOS) Social Support Survey. Permission to use all instruments was obtained and all instruments are previously proven valid and reliable (Kristenson 2005, Adams 1997, and Sherbourne 1991). **Main Outcome Measures:** A total of 1,560 District 9 members were surveyed, 412 responded (response rate of 26.4%) 59% male, 41% female, with an average age of 36.5±9.6. Average hours worked per week was 52.8±26.7, Mean years of experience 12.6±9.0. Job setting responses included: professional (5.5%), collegiate (36.4%), high school (34.2%), and clinical (17.1%).

Results: An independent t test (p<.01), determined that men (38.57±17.3) had lower burnout scores than women (46.29±17.3). Pearson correlations showed significant

negative relationships between the variables of burnout and age (r=-.188, p<.001), burnout and years experience (r=-.173, p<.001), burnout and social support (r=-.265, p<.001), and burnout and perceived wellness (r=-.515, p<.001). Additionally a significantly positive correlation was revealed between burnout and hours worked (r=.124, p<.01). **Conclusions:** The results indicate that older and more experienced ATCs demonstrate less burnout. However, participant sex (female) and increased work hours lead to increased burnout scores. Based on these results, increased levels of social support and greater perceived wellness are needed to lower burnout scores. By knowing some potential cause of burnout and decreased wellness in athletic trainers, future research can work to decrease burnout by reducing work hours, increasing levels of social support, leading to higher levels of perceived wellness, decreased burnout, less diseases and severity of illnesses.

You Never Get A Second Chance To Make A First Impression: Physical Appearance And The Perceived Effectiveness Of An Athletic Trainer

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Context: While some aspects of one's physical appearance are unchangeable (i.e. gender), some are controllable and can influence how one is perceived as a competent professional (i.e., dress and body-build). While the influence of dress and body-build on athletic trainers (ATs) have yet to be investigated, numerous social psychology studies have revealed that both of these factors can impact perceptions of personal qualities, competence and effectiveness. **Objective:**

The goal of this study was to investigate how college athletes' first impressions of an AT's physical appearance (gender, body-build, and dress) influenced perceptions of the AT's competence as a professional. **Design:** Descriptive survey. **Setting:** University classroom. **Patients or Other Participants:** 134 college varsity student-athletes from two regional universities (70% male, 40% minority, 70% had previously worked with AT in college). **Interventions:** Participants were shown a series of 12 pictures, each representing an AT that differed on three variables: gender (M/F); clothing (business / coach/athlete attire; and body-build (in-shape/ out of shape). Participants were asked to rate

12 pictures on 18 characteristics that were considered qualities of an effective AT on a self-reported questionnaire. **Main Outcome Measures:** Exploratory factor analysis was used to establish groupings of the 18 characteristics for analysis. EFA revealed a three-factor solution among the characteristics of an AT: 1) knowledge of injury and treatment; 2) personality traits of a helping professional; and 3) sport involvement which accounted for a total of 78% of the extracted variance. These three factors were used as the dependent variables in a multiple repeated measures ANOVA to assess how athletes' perceptions of certain physical characteristics influenced competence. **Results:** Significant main effects were found on all three factors in this study, where body-build, clothing style, and gender of the AT were influential on participant ratings. ATs who were in shape and wearing coaching attire (27.11±4.52) were rated as having greater knowledge of injury and treatment than those who were under/ over dressed (22.99±5.87) and out of shape (22.16±6.45) (F(11, 1452) = 19.22, p < .001, η^2 = .023). The same trend was evident for personality traits, where those who were in shape and wearing coaching attire (36.26±4.94) were rated higher than those who were under/over dressed (32.27±7.16) and out of shape (33.96±6.01) (F(11, 1309) = 7.15, p < .001, η^2 = .022). Male, in shape ATs were rated as being more involved in sports (11.82±2.68) than female, out of shape ATs (7.31±2.94) (F(11, 1419) = 30.08, p < .001, η^2 = .189). **Conclusions:** How an ATs choose to present themselves professionally can impact an athlete's expectation of the service s/he will receive. Dressing in coaching attire and being in-shape, an AT may increase the outward perception of competence, therefore lowering barriers for athletes seeking services.

Assessment Of Certified Athletic Trainers' Levels Of Cultural Competence In The Delivery Of Health Care

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Context: The concept of culture and its relationship to athletic training beliefs and practices are virtually unexplored. The changing demographics of the United States

and the injuries and illnesses of people from diverse backgrounds have challenged health care professionals to provide culturally competent care. **Objective:** To assess the cultural competence levels of certified athletic trainers (ATCs) in their delivery of health care services. This study also examined the relationship between cultural competence and gender, race, years of athletic training experience, and National Athletic Trainers' Association (NATA) district. **Design:** Cross-sectional survey design. **Setting:** NATA database of certified members. **Patients or Other Participants:** Of the 13,568 ATCs surveyed, 3,102 (age=35.3 + 9.41 yrs; years experience = 11.2 + 9.87) responded for a response rate of 22.9%. **Intervention:** The Cultural Competence Assessment (CCA) was distributed to eligible participants electronically via SurveyMonkey.com through e-mail addresses purchased from the NATA. By completing and returning the online survey, participants consented to participate. All responses were returned to the survey website as anonymous data. The e-mail contained an overview and explanation of the study, as well as a hyperlink to the survey. The CCA took approximately 15 minutes to complete. **Main Outcome Measure:** The CCA and its two subscales, the Cultural Awareness and Sensitivity (CAS) and Cultural Competence Behavior (CCB). Test-retest reliability with Cronbach's Alpha range from $r=0.89$ to $r=0.92$. Demographic information and scores from the CCA were summarized using descriptive data. The CCA utilizes a 7-point Likert scale. A higher score indicates a healthcare professional is operating at a high level of cultural competence, while a low score indicates the participant has a low level of cultural competence. Separate univariate analysis of variance were conducted on each of the independent variables (gender, race/ethnicity, years of experience, or district,) to determine cultural competence. **Results:** ATCs self-reported a mean of 4.52 ± 0.63 out of 5.0 (90.4%) for overall cultural competence assessment. After completing the CCA, participants scored an overall mean of 4.80 ± 2.08 out of 7.0 (68.5%), including a mean of 5.65 ± 1.38 on the CAS (80.7%) and 3.95 ± 2.16 on the CCB (56.4%). Results revealed gender ($p=.000$) and race ($p=.000$) were found to be significant indicators of cultural competency levels. There were no significant differences on years of experience ($p=.093$) and NATA district ($p=.141$) and cultural competence levels. **Conclusion:** ATCs were found to be moderately culturally competent. The current findings provide a baseline for level of cultural competence among ATCs. Educators and employers can use results to help develop diversity training education for ATCs and athletic training students. ATCs

can utilize knowledge to provide culturally competent care to athletes and patients and promote a more holistic approach to sports medicine.

Effect Of Performance Feedback On Perceived Knowledge And Likelihood To Pursue Continuing Education

Eberman LE, Tripp BL: Indiana State University, Terre Haute, IN, and University of Florida, Gainesville, FL

Context: Research suggests that perceived knowledge (PK) drives behavior, yet a poor relationship exists between actual knowledge (AK) and PK. **Objective:** To assess the effect of performance feedback on Athletic Trainers' (ATs) PK and likelihood to pursue continuing education (CE). We measured the degree to which knowledge gap (difference between AK and PK) predicted CE-seeking behavior by providing performance feedback designed to change PK. **Design:** We used a pre-test post-test control-group design to measure PK and likelihood to pursue CE before and after assessing AK regarding the prevention, recognition, and treatment of exercise associated muscle cramps. **Setting:** Potential participants ($n=2000$) were randomly sampled from the National Athletic Trainers' Association membership directory and solicited via electronic mail. Participants used an on-line classroom website (Campus Edition 6; Blackboard Inc.) to complete the investigation. We randomly assigned potential participants to the control or experimental group. **Subjects:** The response rate was 5.1% ($n=103/2000$) with similar numbers in the control ($n=58$) and experimental groups ($n=45$). Levene's statistic indicated the groups were not significantly different in regards to occupational region, occupational setting, and level of expertise ($p>0.05$). **Interventions:** Both groups completed the AK assessment. The independent variable was performance feedback after the AK assessment. The experimental group received item-by-item and summative feedback, while the control group received no external feedback. **Main Outcome Measures:** We assessed PK and likelihood to pursue CE before and after the AK assessment. We calculated differences between pre-test and post-test scores and knowledge gap. Two independent samples t-tests examined the effects of performance feedback on PK and likelihood to pursue CE between groups. We also used multiple linear regression to predict post-test likelihood to pursue CE using three variables: PK, pre-test likelihood to pursue CE, and knowledge gap. **Results:** No significant differences were present between groups PK difference scores

($p=0.50$, $1-\beta=0.54$). However, there was a 68.2% significant difference (difference scores: experimental= 0.66 ± 0.9 , control= 0.21 ± 0.76 , $p=0.01$, $ES=0.45$) between groups for likelihood to pursue CE. The experimental group demonstrated a 13.8% (pre-test= 4.12 ± 1.32 , post-test= 4.78 ± 1.13) increase in the likelihood to pursue CE, while the control group increased only 4.4% (pre-test= 4.60 ± 1.07 , post-test= 4.81 ± 1.08). In participants with and without performance feedback, pre-test knowledge gap was a linear predictor of post-test likelihood to pursue CE ($p=0.01$, $R^2=0.10$). **Conclusions:** Participants were more likely to pursue CE when given performance feedback. Pre-test knowledge gap was a significant predictor of likelihood to pursue CE, regardless if performance feedback was provided. The results indicate that knowledge assessment alone increases the likelihood to pursue CE, yet when participants are given performance feedback they are even more likely to pursue CE. Our findings may be used to facilitate the pursuit of CE for vital clinical topics, especially those where our understanding continues to grow with advances in research.

Neuromuscular Fatigue Impacts Lower Extremity Biomechanics When Transitioning From Non-Weight Bearing To Weight Bearing

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Context: Neuromuscular fatigue is suggested as a risk factor for non-contact ACL injury. Specifically, fatigue has been shown to impair neuromuscular control as well as passive stability of the knee joint. However, few studies have examined the effect of neuromuscular fatigue on knee biomechanics during the transition from non-weight bearing (NWB) to weight bearing (WB) in-vivo, the point in time when ACL injury is thought to occur. Examining this relationship may further clarify possible non-contact ACL injury mechanisms. **Objective:** To investigate the effect of neuromuscular fatigue on anterior tibial translation (ATT), knee flexion excursion (KF_{EXC}) and axial compressive force (ACF) in healthy knees during the transition from NWB to WB. **Design:** Single cohort, descriptive. **Setting:** Controlled, laboratory. **Patients or Other Participants:** Ten (5M, 5F) healthy participants (25.3 ± 4.0 yrs, 170.9 ± 6.7 cm, 68.5 ± 9.8 kg) with no history of knee ligament injury. **Interventions:** Subjects were tested on the dominant limb (stance leg when kicking a ball) in supine and the knee flexed to 20 in the Vermont Knee Laxity Device (VKLD; University of Vermont, Burlington, VT). The VKLD provides a controlled axial load to the knee joint by first creating a zero shear load across the joint while NWB, then applies a 40% body weight (BW) compressive load through the ankle and hip axes to simulate WB. Three loading trials were applied before and immediately after a fatigue protocol while electromagnetic sensors and a force transducer measured ATT, KF_{EXC} , and ACF. Lower extremity muscle fatigue was induced while positioned in the VKLD via repeated leg extension and flexion exercise (range 10 to 40 of knee flexion) against a 60% BW load applied to the bottom of the foot at a standardized pace (3s per repetition via a metronome). Subjects completed continuous cycles of 15 repetitions and 10 seconds rest until unable to complete a full cycle at the prescribed pace. Separate repeated measures ANOVA compared ATT, KF_{EXC} , and ACF before and after fatiguing exercise. **Main Outcome Measures:** ATT (mm), and KF_{EXC} ($^{\circ}$) were obtained by subtracting initial values at zero ACF (NWB) from values at peak ACF (N).

Results: From pre-to post fatigue, ATT (6.7 ± 1.7 mm $< 8.2 \pm 1.9$ mm; $p < .001$), KF_{EXC} ($8.0 \pm 4.0^{\circ} < 10.2 \pm 3.7^{\circ}$; $p = .046$), and ACF (351.8 ± 44.3 N $< 374.0 \pm 47.9$ N; $p = .018$) increased. **Conclusions:** After fatigue, individuals experienced greater ATT, likely a result of higher ACF due to altered control of knee joint motion (small increases in KF_{EXC} then rapid stiffening). Hence, neuromuscular fatigue may impair knee joint biomechanics in a way that may place greater tension on the ACL, and increase injury risk during functional activities. Supported by NIH-NIAMS Grant R01-AR53172, and 2008 UNGC Summer Research Assistantship

Isolated Hip And Ankle Fatigue Alters Lower Extremity Kinematics

Thomas AC, Palmieri-Smith RM, McLean SG: University of Michigan, Ann Arbor, MI

Context: Lower extremity neuromuscular fatigue has been demonstrated to produce abnormal landing strategies, which may increase non-contact anterior cruciate ligament (ACL) injury risk. However, the precise impact of hip and ankle muscle fatigue, whose actions at their respective joints may contribute to hazardous knee joint postures and loads during dynamic activity, is unclear. Elucidating the impact of hip and ankle fatigue on lower limb landing mechanics may lead to developing more effective and sports-relevant prevention methods. **Objective:** To determine the effects of isolated hip rotator and triceps surae muscle fatigue on lower extremity mechanics during dynamic landing. **Design:** A single-group randomized pre-/post-test study. **Setting:** This study was performed in a controlled laboratory setting. **Patients or Other Participants:** Sixteen recreationally active, healthy, female volunteers (age = 18.75 ± 1.18 years, height = 1.64 ± 0.05 m, mass = 57.92 ± 6.87 kg). **Interventions:** Subjects reported for testing on two occasions, with one muscle group fatigued per session. Muscle group testing order was randomized prior to subject enrollment. Three single-leg landings were performed onto a force platform before and after substantial fatigue, defined as an 80% decrease in peak torque in the targeted muscle group. Hip rotator fatigue was induced through sets of alternating concentric contractions on an isokinetic dynamometer, while triceps surae fatigue was induced through concentric plantar flexion contractions only. **Main Outcome Measures:** Initial contact (IC) kinematics and

peak stance phase kinetics and kinematics at the hip, knee, and ankle were analyzed before and after fatigue via repeated measures ANOVAs. **Results:** Following fatigue of the hip rotators, subjects demonstrated an increase in IC (pre = $4.7 \pm 6.96^{\circ}$, post = $7.76 \pm 9.54^{\circ}$, $P = 0.05$) and peak (pre = $9.84 \pm 7.53^{\circ}$, post = $12.38 \pm 9.41^{\circ}$, $P = 0.04$) hip internal rotation angle. Following triceps surae fatigue, subjects landed in less knee flexion at IC (pre = $-14.43 \pm 5.5^{\circ}$, post = $-12.44 \pm 5.72^{\circ}$, $P = 0.01$). No changes were detected for the peak stance phase moments at the hip, knee, or ankle following fatigue of either muscle group ($P > 0.05$). **Conclusions:** Isolated fatigue of the hip rotators and triceps surae muscle groups each resulted in kinematic adaptations, which have been implicated in the non-contact ACL injury mechanism. With non-contact ACL injury increasingly considered to arise via a three-dimensional loading mechanism, however, these individual adaptations are likely not sufficient to precipitate ACL rupture. Rather, ACL injury appears to stem from gross lower extremity muscle fatigue, where combined and potentially hazardous three-dimensional kinetic and kinematic alterations are more likely to predominate.

Relationship Of Foot Type And Fatigue To Hip Neuromuscular Control And Lower Extremity Kinetics

Stearne DJ, Sato N, Sitler MR, Tierney RT: Temple University, Philadelphia, PA, and West Chester University, West Chester, PA

Context: Hip strength, muscle activation, and fatigue affect lower extremity alignment. Foot type may influence hip biomechanics and landing force attenuation and contribute to non-contact ACL injury risk. **Objective:** To determine the effect of foot type and fatigue on hip neuromuscular control and lower extremity kinetics during a functional landing task. **Design:** Cross-sectional design. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty-four healthy National Collegiate Athletic Association Division I male and female athletes with either a rectus or planus foot type (14 rectus: 19.5 ± 1.7 years, height = 166.1 ± 6.7 cm, mass = 64.1 ± 4.9 kg, navicular drop = 7.1 ± 0.92 mm; and 10 planus: 20.1 ± 1.3 years, height = 169.2 ± 7.3 cm, mass = 68.4 ± 8.4 kg, navicular drop = 11.9 ± 2.0 mm) volunteered to participate. **Interventions:** Independent variables were foot type (planus and rectus)

and fatigue (pre and post). Vernier calipers were used for the navicular drop test to measure arch height. A MicroFET Hand-Held Dynamometer was used to measure hip strength, a Noraxon Telemetry Electromyography (EMG) system was used to measure muscle activation, and a Kistler 9287-BA Force Plate was used to measure lower extremity kinetics during a standing broad jump-to-vertical jump maneuver in both pre- and post fatigue conditions. Statistical analyses consisted of multiple analyses of variance (ANOVA) and t-tests. Alpha level was set at $p \leq .05$. **Main Outcome Measures:** Dependent variables were hip ex-

tensor, abductor, and external rotator strength (lbs); EMG activation for the gluteus maximus, gluteus medius, and biceps femoris (reactive area by %MVC); and peak vertical, anterior shear, medial shear, and lateral shear ground reaction forces; and rate of loading at ground contact. **Results:** ANOVA tests revealed the following significance: Post-fatigue, the planus group showed a 49% decrease in biceps femoris EMG area ($F = 4.53, p = .045$, pre = 22.67 ± 18.94 , post = 11.45 ± 9.78), a 35% decrease in co-agonist gluteus maximus and biceps femoris EMG area ($F = 5.47, p = .029$, pre = 41.26 ± 27.83 , post = 26.77 ± 20.42), and a 31% increase in

medial shear force ($F = 50.72, p = .001$, pre = $.174 \pm .030$, post = $.228 \pm .030$). Rate of lower extremity loading decreased 24% post-fatigue ($F = 16.97, p = .001$, pre = 56.83 ± 21.81 , post = 43.43 ± 23.35) for both groups. No other significant differences were noted between foot types or pre- and post-fatigue. **Conclusions:** Under fatigue, athletes with a planus foot type have a reduced capacity to attenuate medial shear force. This may influence hip muscle activation strategies and lower extremity force attenuation, potentially increasing the risk of knee valgus and non-contact ACL injury.

Evidence-Based Forum #6: Knee

Saturday, June 20, 2009, 10:15AM-11:15AM, Room 214C; Discussants: Michael Shaffer, ATC, PT, OCS, and Glenn Williams, PhD, ATC, PT; Moderator: Kelli Snyder, MS, ATC

Free Communications, Oral Presentations: Chronic Knee Pain

Saturday, June 20, 2009, 11:30AM-12:45PM, Room 214C; Moderator: David Berry, PhD, LAT, ATC

A Lower Extremity Kinematic Analysis Of Stair Ascent And Descent In Osteoarthritic Knees

Hicks-Little CA, Hubbard TJ, Peindl RD, Scannell BP, Huet YM, Yengo CM, Mason JB, Springer BD, Fehring TK, Griffin WL, Cordova ML: University of Utah, Salt Lake City, UT; University of North Carolina at Charlotte, Charlotte, NC; Carolinas Medical Center, Charlotte, NC; OrthoCarolina, Charlotte, NC

Context: Knee osteoarthritis (OA) is a debilitating disease that affects an estimated 20 million Americans, and contributes significantly to functional limitations and disability. Normal activities of daily living (ADLs), such as climbing stairs, becomes more and more burdening for those who suffer from knee OA. Surprisingly, few studies have examined changes in lower extremity (LE) joint kinematics during stair climbing in subjects suffering from knee OA. **Objective:** To compare LE joint kinematics during stair ascent and descent between knee OA subjects and matched healthy controls. **Design:** A repeated measure, case-controlled study. **Setting:** Biodynamics Research Laboratory. **Patients or Other Participants:** Eighteen subjects with knee OA (age 60.17 ± 9.98 yrs, mass 90.27 ± 16.73 kg, ht 168.41 ± 9.92 cm) and 18 healthy matched controls (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 direction (ascent, descent). Subjects performed 5 ascending and descending trials on a custom-

built staircase while their motion was captured three-dimensionally using an 8 camera optical video motion capture system. Joint kinematic data were processed using Motion Analysis software. 2x 2 RM MANOVAs were performed on all kinematic variables clustered for each joint. **Main Outcome Measures:** Average angle at foot strike ($^{\circ}$), peak angle during support ($^{\circ}$), peak angle during swing ($^{\circ}$), average angle at toe off ($^{\circ}$) and time of peak angle during support and swing phase of gait cycle (%) in the sagittal and frontal plane for the LE joints were determined during stair ascent and descent. **Results:** Significant group by direction interactions were found for average hip flexion angle at foot strike [$p=0.041$], average ankle adduction angle at foot strike [$p=0.007$], and peak ankle dorsiflexion angle during swing [$p=0.015$]. Specifically, both groups demonstrated greater hip flexion angle at foot strike and ankle dorsiflexion angle during swing for stair ascent compared to descent. Further, additional main effect analyses revealed that the OA group demonstrated greater hip abduction at foot strike ($-3.08^{\circ} \pm 3.94$) and smaller peak knee flexion during swing ($86.73^{\circ} \pm 5.43$). The time of peak hip abduction ($34.18\% \pm 7.07$), peak knee flexion ($69.84\% \pm 4.57$) and peak ankle adduction ($37.27\% \pm 20.77$) during support and the time of peak hip flexion ($85.22\% \pm 3.7$), peak knee flexion ($77.67\% \pm 3.75$) and ankle dorsiflexion ($80.73\% \pm 4.50$) angle during swing occurred later in the gait cycle for the OA group compared to healthy controls. Additionally, all joint variables differed between ascent and descent. **Conclusions:** These data demonstrate that knee OA directly influences specific knee joint kinematics and

induces kinematic alterations at the hip and ankle perhaps to compensate for the existing knee joint pathology. Continuing to understand LE joint mechanics in knee OA patients during stair climbing is essential for optimal rehabilitation and for improving normal ADLs in these patients. *Funded by a Doctoral Research Program Grant from the NATA Research and Education Foundation.*

Transcutaneous Electrical Nerve Stimulation And Focal Knee Joint Cooling Immediately Increase Quadriceps Activation In Osteoarthritic Knees

Pietrosimone BG, Hart JM, Saliba SA, Hertel J, Ingersoll CD: University of Virginia, Charlottesville, VA

Context: Focal knee joint cooling (FKJC) and transcutaneous electrical nerve stimulation (TENS) have been reported to increase motor neuron pool excitability in the quadriceps of healthy subjects with artificially effused knees, yet it is unknown whether these modalities will affect voluntary quadriceps activation in a pathological population. **Purpose:** Determine if TENS and FKJC will affect quadriceps central activation ratio (CAR) in patients with knee osteoarthritis. **Design:** Blinded, randomized laboratory experiment. **Setting:** University laboratory. osteoarthritis were randomly allocated to the TENS (6m/4F, 56 ± 10.1 years, 174.1 ± 10.8 cm, 89.3 ± 21.3 kg), FKJC (6m/5F, 58 ± 8.4 years, 176.4 ± 8.3 cm, 83.2 ± 18.0 kg) and control (5m/7F, 54 ± 9.9 years, 166.4 ± 13.1 cm, 92.1 ± 25.4

kg) group. **Interventions:** Independent variables included time (change scores from baseline at 20, 30 and 45 minutes post intervention application) and treatment group (FKJC, TENS, control). The 20-minute FKJC intervention consisted of two, 1.5-liter ice bags secured to the anterior and posterior aspects of the knee. The TENS group received 45-minutes of a sensory, biphasic square wave stimulation (150's phase duration & 150pps) from four 2x2in electrodes positioned around the patella, while the control participants sat quietly. A 3x3 repeated measures ANOVA was used to determine differences in percent change of CAR from baseline between treatment groups over time. A one-way ANOVA with multiple comparisons was performed *post hoc* with an *a priori* level of $P \leq 0.05$. Standardized effect sizes were calculated for percent change of CAR in both treatment groups at each time interval. **Main Outcome Measures:** Quadriceps volitional activation was measured using the CAR at 70° of knee flexion, and was expressed as a percent change from baseline at 3 time intervals. **Results:** There were significant differences for CAR percent change scores between treatment groups ($F_{2,30} = 6.205$, $P = .006$) and over time ($F_{2,60} = 6.85$, $P = .002$). TENS resulted in a significantly higher percent change in CAR scores compared to control at 20 ($6.4\% \pm 4.8\%$ vs $-3.5\% \pm 8\%$, $P = .006$), 30 ($9.7\% \pm 10.16\%$ vs $-1\% \pm 7.9\%$, $P = .025$), and 45 minutes ($11.25\% \pm 6.96\%$ vs $.81\% \pm 9.4\%$, $P = .029$). FKJC resulted in significantly higher percent change scores compared to the control group at 20 minutes ($5.75\% \pm 7.25\%$ vs $-3.5\% \pm 8\%$, $P = .009$) and trended to be higher at 45 minutes (9.06 ± 9.63 vs $.81 \pm 9.4$, $P = .098$). Strong effect sizes were found at 20 ($d = 1.12$, 95%CI 0.28-2.05; 1.48, .48-2.36), 30 ($d = .93$, .04-1.76; 1.19, .24 - 2.05) and 45 (.96, .06-1.78; 1.25, .29-2.11) minutes for FKJC and TENS, respectively. No significant differences in percent change for CAR were found between the TENS and FKJC group. **Conclusions:** Both TENS and FKJC significantly increased quadriceps CAR immediately following application in participants with tibiofemoral osteoarthritis. These findings suggest that both of these interventions may be helpful for increasing quadriceps activation in patients with knee pathologies. This study was fully funded by a grant from the Eastern Athletic Trainers' Association.

Effects Of A Sacroiliac Joint Manipulation On Gait Mechanics Of Individuals With Patellofemoral Joint Pain

Grindstaff TL, Franz JR, Beazell JR, Hertel J, Kerrigan DC, Ingersoll CD: University of Virginia, Charlottesville, VA

Context: Decreased quadriceps activation is present in individuals with patellofemoral joint pain (PFJP) and has been shown to effect joint kinematics and kinetics during gait. A sacroiliac joint manipulation has been shown to decrease subjective reports of pain and alter quadriceps activation, but the effects on gait are unknown. **Objective:** To examine changes in knee joint kinematics and kinetics following a sacroiliac joint manipulation in individuals with PFJP. **Design:** A single-blind randomized control trial with one between-factor, treatment group (sacroiliac joint manipulation, lumbar passive range of motion, prone extension) and one within-factor, time (pre and post intervention) used to compare peak knee flexion angle and peak external knee flexion moments during the stance phase of running. **Setting:** University motion analysis laboratory. **Participants:** Eighteen subjects (9 female and 9 male, Age=23.7(6.6) Mass=80.7(15.2) Height=176.4(9.7)) with PFJP. **Interventions:** A 10 camera motion analysis system (VICON 624) was interfaced with a custom built treadmill (Advanced Mechanical Technology, Inc., Watertown, MA) with 3 embedded force plates used to capture kinetic and kinematic data while running at a self selected pace for 3 minutes. During this time 3, 15-second trials were recorded for data analysis. Motion analysis video were sampled at 250 Hz and ground reaction forces were collected at 1000 Hz. Next, participants were randomized to 1 of the 3 treatment interventions: sacroiliac joint manipulation, lumbar passive range of motion, or prone on elbows. Following experimental intervention gait kinetics and kinematics were reassessed using similar methods. Two separate single factor repeated measures ANOVAs were performed to compare changes in peak knee flexion angle and peak external knee flexion moments. The probability was set at $P \leq .05$ for all statistical tests. **Main Outcome Measures:** Peak knee flexion and peak external knee flexion moments during the stance phase of running were calculated using raw ground reaction forces and kinematic data through a commercialized full-inverse dynamic model (VICON Plug-In-Gait). Kinetic data were normalized by body mass and height, and reported in Nm/kg. **Results:** There were no significant differences ($F_{2,15} = 0.81$, $P = 0.46$) in peak knee flexion angle (degrees) between groups, Manipulation

Pre=41.48 (6.47), Post=41.54 (5.71); PROM 35.80 (10.79) Post= 36.30 (10.94); Prone on Elbows Pre=43.09 (3.92), Post=41.75 (4.57). There were no significant differences ($F_{2,15} = 1.22$, $P = 0.32$) in peak external knee flexion moments (Nm/kg) between groups, Manipulation Pre=0.57 (0.22), Post=0.49 (0.19); PROM Pre=0.44 (0.34), Post=0.46 (0.39); Prone on Elbows Pre=0.66 (0.16), Post=0.61(0.22). **Conclusions:** Interventions directed at the lumbopelvic region do not seem to have an acute effect on running mechanics in individuals with PFJP. Future studies should determine if there is a subset of individuals with PFJP who may demonstrate changes in running mechanics following sacroiliac joint manipulation. This study was supported by a **Doctoral Research Grant Program from the NATA Research and Education Foundation and a Doctoral Grant from the University of Virginia** Curry School of Education- Center for the Advanced Study of Teaching and Learning.

Intralimb Coordination During Gait In People With And Without Patellofemoral Pain Syndrome

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Context: Comparison of gait in those with and without patellofemoral pain syndrome (PFPS) has yielded conflicting results. However, previous studies have frequently been limited to analysis of single joint movements, leaving lower extremity intralimb coordination relatively unexplored. **Objective:** To determine if there are differences in intralimb coordination between the hip and knee in those with and without PFPS. **Design:** Single-session repeated measures design. **Settings:** All data were collected in a research laboratory setting. **Participants:** Sixteen subjects with PFPS (12 females, 4 males; 21.63 ± 3.76 yrs; 172.7 ± 7.15 cm; 68.19 ± 10.78 kg) and eleven control subjects (9 females, 2 males; 19.91 ± 2.70 yrs; 169.90 ± 9.85 cm; 66.37 ± 11.90 kg) participated in the study. All subjects were free from any traumatic injury to the lower extremity or vestibular disorders. Subjects in the PFPS group presented with diffuse anterior knee pain for at least 8 weeks, which was elicited or increased with activities, but unrelated to a traumatic event. Members of the control group had a designated matched side to the symptomatic and asymptomatic sides of the PFPS group for the purpose of between group comparisons. **Interventions:** Independent variables were group (PFPS, Control) and side

(symptomatic, asymptomatic). Subjects walked across the laboratory at a self-selected speed, while being recorded with an 8-camera motion analysis system. Hip and knee kinematic data were obtained through OrthoTrak software. Sagittal, frontal and transverse joint coupling angles between hip and knee at heel strike (HS) and toe off (TO) during the gait cycle were calculated using the vector coding technique. Joint coupling angles ranged between 0° and 90°, with 45° indicating an equal amount of motion between the two joints and an angle greater than 45° representing relatively greater hip motion. **Main Outcome Measurements:** The six dependent variables were joint coupling angles for hip-knee flexion, hip-knee abduction, and femoral-tibial rotation at HS and TO. For each DV, a one-between (group), one-within (side) repeated measures ANOVA was calculated. **Results:** A significant group by side interaction was observed for frontal plane joint coupling angle at HS ($F_{1,25}=8.60$; $p=0.007$). Post-hoc analysis revealed the symptomatic side of the PFPS group presented with more equal amount of motion between the two joints than the asymptomatic side of the PFPS group or matched “symptomatic” side of the Control group (PFPSsymp= $56.36 \pm 24.60^\circ$; PFPS asym= $76.19 \pm 10.84^\circ$; CONTsymp= $77.89 \pm 10.65^\circ$; CONTasym= $67.83 \pm 21.09^\circ$). No significant differences were observed at TO. **Conclusions:** The symptomatic leg of the PFPS subjects demonstrated a more equal hip-knee movement at HS compared with the asymptomatic leg. PFPS subjects may be forced to reduce freedom of movement due to pain, and therefore present with a relatively equal motion to avoid the exacerbation of painful symptoms. Our observation may support dynamic systems theory that PFPS causes people to walk with more predictable, constrained patterns. Further research is warranted to verify this finding.

Comparison Of Early Hip Strengthening To Early Quadriceps Strengthening In The Treatment Of Females With Patellofemoral Pain Syndrome

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Context: Multiple interventions exist for patellofemoral pain syndrome (PFPS). It is unclear whether early hip or quadriceps strengthening will better prepare patients for functional lower extremity exercises. **Objective:** This study compared early hip strengthening to early quadriceps

strengthening in the treatment of females with PFPS. **Design:** A prospective, crossover randomized clinical trial. **Setting:** Testing and rehabilitation were conducted in a musculoskeletal laboratory. **Patients or Other Participants:** 29 females with PFPS volunteered to participate in this study. 15 performed early quadriceps strengthening (26 ± 6 yrs, 1.7 ± 0.1 m, 76 ± 17.3 Kg) and 14 performed early hip strengthening (24 ± 5 yrs, 1.7 ± 0.1 m, 63 ± 11.7 Kg). Six subjects, three in each group did not complete the intervention. **Interventions:** In the first four weeks, subjects performed exercises designed to target either their hip or quadriceps muscle groups. After four weeks, both groups performed the same functional lower extremity exercises for an additional four weeks. Throughout the intervention, exercises were performed once weekly with an investigator and 2 days at home, for a total of 3 sessions/week. Testing was performed at baseline (B), after 4 weeks of exercises (4wk), and after completion of the 8-week protocol (8wk). Testing included assessment of pain measured by a 10cm visual analog scale (VAS) and self-reported function, measured by the Lower Extremity Functional Scale (LEFS). LEFS scores range from 0 to 80 (fully functional). **Main Outcome Measures:** The VAS and LEFS were assessed with repeated measures ANOVAs: group (hip, quadriceps) by time (B, 4wk, 8wk). All analyses were performed on an intention-to-treat basis. Last observations were carried forward for all who dropped. All data was analyzed at the .05 level of significance with a Bonferroni post hoc analysis as needed. **Results:** There were no significant interactions ($p=.08$) or differences between groups ($p=0.49$) with respect to pain. Mean VAS scores for the quad and hip group, respectively were at; B (4.3 ± 2.4 and 4.7 ± 2.7), 4wk (4.1 ± 2.6 and 2.3 ± 2.1), and 8wk (2.7 ± 2.1 and 2.5 ± 2.9). Pooled VAS scores for both groups significantly decreased across time; B (4.5 ± 2.5), 4wk (3.2 ± 2.5), and at 8wk (2.6 ± 2.5), ($p<.001$). LEFS scores demonstrated no significant interactions ($p=.75$) or significant group differences ($p=0.09$). However, pooled LEFS for both groups significantly improved over time: B (56 ± 13), 4wk (63 ± 13), and at 8wk (68 ± 12), ($p<.001$). **Conclusions:** Both early hip and quadriceps strengthening led to decreased pain and increased function. Although not a significant interaction, the hip group trended toward less pain than the quadriceps group, with the largest difference after the first 4 weeks of isolated strengthening. LEFS scores constantly improved regardless of approach, indicating that subjects perceived functional improvement in daily life. These results suggest a slight clinical, but not statistical, advantage to beginning rehabilitation with hip

strengthening exercises to reduce pain in females with PFPS. *Funded by a Master's Research Program from the NATA Research and Education Foundation.*

Free Communications, Oral Presentations: Factors Influencing Knee Valgus Motion

Saturday, June 20, 2009, 1:30PM-2:45PM, Room 214C; Moderator: Riann M. Palmieri-Smith, PhD, ATC

Influence Of Hip Internal Rotation Range Of Motion On Hip And Knee Motions During Landing

Nguyen A, Cone JR, Stevens LM, Schmitz RJ, Shultz SJ: University of North Carolina at Greensboro, Greensboro, NC

Context: Increased femoral anteversion has been associated with greater passive hip internal rotation (HIR). While greater HIR may increase the potential for functional valgus collapse, this has yet to be empirically studied. **Objective:** To compare hip and knee joint motions during the landing phase of a drop jump in those with above (HIR_{HIGH}) and below (HIR_{LOW}) average HIR. **Design:** Descriptive cohort. **Setting:** Controlled, laboratory. **Patients or Other Participants:** Thirty nine recreationally active females (22.4 ± 3.0 yrs, 163.1 ± 7.6 cm, 62.0 ± 9.1 kg). **Interventions:** HIR and three-dimensional hip and knee kinematics during 5 bilateral drop-jump landings (height=45cm) were assessed on the dominant stance limb. The landing phase (initial contact to peak knee flexion) of each trial was normalized to 101 data points, then averaged across the 5 trials for analysis. HIR_{HIGH} (N=20) and HIR_{LOW} (N=18) groups were classified based on the overall mean (36.0°). Separate group (HIR_{HIGH} , HIR_{LOW}) by time (% landing phase) RMANOVA compared groups on frontal and transverse plane hip and knee joint motions across the landing phase. For significant group by time interactions, post hoc comparisons for each 10% increment determined where in the landing phase groups differed. **Main Outcome Measures:** HIR ($^\circ$) and time normalized hip and knee motion ($^\circ$) during the landing phase. **Results:** Means $\pm$ SDs for HIR_{HIGH} and HIR_{LOW} were $43.0 \pm 6.1^\circ$ and $28.7 \pm 5.2^\circ$, respectively. No main effects for group (all $P \geq 0.08$) but group by time effects were observed for all joint motions (all $P < 0.02$). At the hip, both groups began the landing in similar abducted (4.1 - 4.3°) and externally rotated (1.2 - 1.4°) positions. Early in the landing phase (21-30%), both groups internally rotated ($\sim 3^\circ$) and HIR_{HIGH} adducted (1.4°) while HIR_{LOW} remained in 4.3° abduction. As landing progressed, HIR_{LOW} moved into further abduction (3.2°) and internal rotation (6.1°) while hip motions in HIR_{HIGH} remained relatively unchanged. This resulted in HIR_{HIGH} hips being in 4.1° more adduction and 3.0° less internal rotation than HIR_{LOW} at the end of the landing. At the knee, both groups began the landing phase in similar amounts of knee varus (1.3 - 3.0°) and external

rotation (4.0 - 5.3°). Early in landing (0-50%), both groups went into similar amounts of knee internal rotation ($\sim 9^\circ$), while HIR_{HIGH} went into less varus (1.0° vs. 2.3°) from 0-20%, then into more valgus (3.3° vs. 2.1°) from 21-40% compared to HIR_{LOW} . During the later half of landing, HIR_{LOW} continued into knee internal rotation (2.2°) and varus (2.7°) resulting in 5.1° more varus and 4.6° internal rotation than HIR_{HIGH} at the end of the landing.

Conclusions: Individuals with greater HIR remained in greater relative knee valgus and external rotation, and greater relative hip adduction and external rotation. Future research should consider both structural anatomy and joint range of motion when examining anatomical contributions of the hip to dynamic motion. Supported by NIH-NIAMS Grant R01-AR53172

Trunk Motion Influences Frontal Plane Knee Kinematics And Kinetics During A Single Leg Squat

Goerger BM, Norcross MF, Blackburn JT, Padua DA: University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Prospective research demonstrates greater knee valgus moment and angle in those who suffer ACL injury. During weight bearing tasks, trunk position may influence frontal plane knee biomechanics due to its superincumbent position relative to the knee and its significant mass. Therefore, assessing trunk motion in the screening of movement patterns may provide additional insight for knee injury risk. **Objective:** To determine the relationship between trunk kinematics and frontal plane knee kinematics and kinetics during a single leg squat. **Design:** Correlational study. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty-eight healthy, physically active subjects (Females: n=18, Age: 20.56 ± 0.70 yrs, Height: 166.17 ± 5.38 cm, Mass: 64.94 ± 7.77 kg; Males: n=10, Age: 21.00 ± 3.43 yrs, Height: 176.72 ± 5.42 cm, Mass: 70.24 ± 4.71 kg) participated in this study. **Interventions:** Subjects were required to perform five continuous repetitions of a single leg squat on their dominant leg (leg used to kick ball). Three-dimensional trunk and knee kinematic data were collected using a camera based motion capture system. All kinematic data were synchronized with kinetic data collected from a force plate. **Main Outcome Measures:** Joint angular displacement measures were calculated for knee valgus, trunk flexion, trunk rotation, and trunk lateral

bending during the descent phase of the single leg squat. The descent phase was defined as the initiation of knee flexion until peak knee flexion for each trial. Knee valgus moment was calculated at the time of peak knee flexion. Joint angular displacement and knee valgus moment values were determined for each trial and averaged for analysis. Pearson-product moment correlations were performed for each of the joint angular displacement and knee valgus moment variables ($\alpha < .05$). **Results:** Knee valgus displacement was significantly correlated with trunk flexion displacement ($r=0.440$, $p=0.019$). Knee valgus moment was significantly correlated with trunk flexion displacement ($r=0.436$, $p=0.020$), as well as medial trunk displacement ($r=0.513$, $p=0.005$), and lateral trunk displacement ($r=-0.569$, $p<0.002$). **Conclusions:** These results indicate that as individuals flexed their trunk more they displayed increased knee valgus displacement but had a decrease in knee valgus moment. As individuals went into more side bending toward (lateral trunk displacement) or away (medial trunk displacement) from their stance leg, knee valgus moment increased. These findings demonstrate that sagittal and frontal plane trunk motion does influence knee valgus moment and angle. Thus, trunk motion assessment may be important to consider when attempting to identify individuals at risk for ACL injury. Future research should examine parameters related to the ability to control trunk motion and knee injury risk. *Funding provided by the National Academy of Sports Medicine and National Basketball Athletic Trainers Association*

Limited Ankle Dorsiflexion Range Of Motion Alters Lower Extremity Kinematics And Muscle Activation Patterns

Macrum EC, Padua DA, Lewek M, Boling M, Bell DR, Hirth CJ: University of North Carolina, Chapel Hill, NC, and University of North Florida, Jacksonville, FL

Context: Limitations in gastrocnemius/soleus flexibility have been reported in individuals with patellofemoral pain (PFP); however, the rationale between decreased ankle range of motion (ROM) and PFP is not well understood. We hypothesize that restricted sagittal plane ankle motion may facilitate compensatory alterations in knee kinematics and muscle activity (EMG). **Objective:** To determine the effect of induced ankle dorsiflexion ROM restriction on lower

extremity kinematics and EMG in healthy individuals. **Design:** Cross-sectional. **Setting:** Research laboratory. **Patients or Other Participants:** Healthy, recreationally active volunteers (n = 30, 15m 15f, height = 173.5 ± 12.1 cm, mass = 72.0 ± 16.4 kg) with no history of lower extremity injury in the previous six months. **Interventions:** Three-dimensional hip, knee, and ankle kinematics and EMG of vastus medialis oblique (VMO), vastus lateralis (VL), lateral gastrocnemius (LG), and soleus (SOL) were collected during a double-leg squat. Each participant performed 5 double-leg squat trials with the forefoot elevated 12° (wedge (W) condition) and with no elevation (no-wedge (NW) condition). **Main Outcome Measures:** Sagittal and frontal plane joint angles at the hip, knee and ankle were calculated during the descending phase of the double-leg squat task (start angle, peak angle, joint displacement). Mean EMG values for the VL, VMO, SOL and LG were also determined during the descent phase of the squat task. Separate repeated measures ANOVAs were performed to determine changes in lower extremity kinematics and EMG between the W and NW conditions. **Results:** During the W condition there was a significant decrease in peak knee flexion angle (NW = 96.9 ± 16.9°, W = 80.6 ± 19.3°, $F_{(1,27)} = 105.5, p \leq 0.001$), knee flexion displacement (NW = 101.4 ± 17.5°, W = 85.0 ± 19.5°, $F_{(1,27)} = 90.6, p \leq 0.001$), and ankle dorsiflexion displacement (NW = -28.1 ± 6.1°, W = -20.0 ± 6.1°, $F_{(1,27)} = 158.3, p \leq 0.001$). There was also an increase in knee valgus displacement (NW = -1.8 ± 2.7°, W = -2.2 ± 2.9°, $F_{(1,27)} = 2.1, p = 0.02$) and peak knee valgus angle (NW = -3.7 ± 3.2°, W = -4.3 ± 3.3°, $F_{(1,27)} = 6.6, p = 0.02$) during the wedge condition. Additionally, mean VL (NW = 0.62 ± 0.22 %MVIC, W = 0.55 ± 0.19 %MVIC, $F_{(1,27)} = 12.2, p = 0.002$) and VMO (NW = 0.66 ± 0.26 %MVIC, W = 0.61 ± 0.21 %MVIC, $F_{(1,27)} = 4.2, p = .049$) activity decreased while soleus activity increased (NW = 0.24 ± 0.19 %MVIC, W = 0.26 ± 0.18 %MVIC, $F_{(1,27)} = 4.2, p = .049$) during the W condition. **Conclusion:** Based on these results, decreased ankle dorsiflexion range of motion may predispose individuals to PFP by causing alterations to knee joint kinematics and muscle activation patterns. Specifically, restricted ankle dorsiflexion causes increased knee valgus and decreased knee flexion, quadriceps activation, and gastrocnemius/soleus activation. Future investigations should determine if decreased ankle range of motion is a risk factor for PFP.

Influence Of Hip Motion And Strength On Knee Valgus Angle: The JUMP-ACL Study

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

Introduction: Knee valgus angle is described as a potential risk factor for non-contact ACL injury, thus, it is important to understand factors influencing knee valgus. Hip motion and muscle strength are thought to influence knee valgus angle; however, there is limited research investigating these relationships.

Objective: To determine the influence of hip motion and muscle strength on knee valgus angle during a jump-landing task. **Design:** Correlational. **Setting:** Research laboratory.

Participants: A total of 2,662 healthy, physically active participants (males=1,602; females=1060; age=18.6±0.6 yrs, ht=173.5±9.2 cm, wt=71.9±12.9 kg) volunteered for this study. **Intervention:** Participants performed a jump-landing task (3-trials) by jumping from a 30-cm high box. Following the initial landing, the participants immediately jumped upward for maximal vertical height. Joint kinematics were measured using an electromagnetic motion analysis system. A hand-held dynamometer was used to assess mean force (N) during a 5-second maximal voluntary isometric contraction (MVIC) for the following muscle groups: knee extensors, knee flexors, hip abductors, hip extensors, hip internal rotators, and hip external rotators.

Main Outcome Measures: Joint angles (hip adduction, hip rotation and knee valgus) at initial contact (IC) and peak angles during the landing phase (PK) were determined and averaged across 3-trials. The landing phase was defined as the time from initial contact (vertical ground reaction force >10 N) until the first local minima in vertical ground reaction force. Mean force values during each MVIC were averaged across 2-trials and normalized to body weight (N). Pearson product-moment correlations were performed between each of the joint kinematics and muscle strength variables. Separate forward stepwise multiple regression analyses were performed to determine the relationship for knee valgus IC and PK with hip kinematics and muscle strength variables. **Results:** Significant relationships were present between knee valgus IC and PK with hip adduction IC and rotation IC angles and strength of the hip external rotators, hip abductors, hip extensors, and knee extensors ($P < .05$). Regression analyses revealed that hip adduction IC, hip

rotation IC, hip external rotator strength, knee extensor strength, hip extension strength, and hip internal rotation strength were significant predictors of knee valgus IC (R^2 adjusted=.417, $P < .001$). Hip adduction PK, hip internal rotation PK, hip external rotator strength, hip internal rotator strength, and knee extensor strength were significant predictors of knee valgus PK (R^2 adjusted=.521, $P < .001$).

Conclusions: Greater knee valgus was associated with increased hip adduction and rotation motion and decreased muscle strength. Hip adduction and rotation angle were the strongest predictors of knee valgus angle as muscle strength only explained 2-3% more variance in knee valgus motion. Therefore, hip motion control is a more important factor influencing knee valgus than muscle strength. This may have implications in understanding ACL injury risk factors and designing injury prevention programs. (Funded by the NIAMS Division of the National Institutes of Health, #R01-AR050461001)

Effects Of Trunk Position On Knee Muscle And Joint Forces During A Single-Leg Squat

Kulas AS: East Carolina University, Greenville, NC

Context: Single-leg squats are commonly used for knee rehabilitation. Variations in squatting technique (i.e. deep vs. shallow knee flexion) affect the mechanical demands on the knee. While the effects of extended vs. flexed trunk angles on knee muscle and joint forces during a single-leg squat are unknown, knowing these effects could help clinicians to better prescribe squatting exercises for knee rehabilitation. **Objective:** To evaluate the effects of extended vs. flexed trunk angles on knee muscle and knee joint forces during a single-leg squat. **Design:** Repeated measures design. **Setting:** Controlled, laboratory setting. **Patients or Other Participants:** Twelve healthy college-aged volunteers (height=1.72±.09m, mass=70.35±15.73kg) with squatting experience and no history of lower extremity injury. **Interventions:** The independent variable was trunk flexion condition where subjects performed two sets of five single-leg squats on the right leg where peak trunk flexion angles were 5-25° (trunk extension condition, TEC) and 30-50° (trunk flexion condition, TFC). Squatting time (4-second squat) and peak knee flexion (75°±5) were standardized across conditions. Kinematics of the trunk and right lower extremity were acquired simultaneously with force plate and surface electromyography (sEMG) data (rectus femoris, vastus medialis,

vastus lateralis, semimembranosus, semitendinosus, lateral gastrocnemius, and medial gastrocnemius). Using a scaled musculoskeletal model in SIMM (Motion Analysis Corp.), muscle forces were estimated using a Hill-type muscle model incorporating sEMG normalized to maximal voluntary isometric contractions and muscle length and velocity data estimated from model kinematics. Group muscle forces (i.e. quadriceps, hamstrings, gastrocnemius) were represented by the summation of each group's individual muscles. Knee anterior shear forces (ASFs) directed the tibia anteriorly relative to the femur and were computed as the summation of the muscle and joint reaction force components acting perpendicular to the long axis of the tibia. Five trials for each condition were averaged and statistically analyzed. Forces in the quadriceps, hamstrings, gastrocnemius, and ASFs were compared across condition with five paired samples t-tests. Alpha adjusted (0.05/5) to $\alpha=0.01$.

Main Outcome Measures: Dependent variables analyzed (paired t-tests) were forces in the quadriceps, hamstrings, gastrocnemius (each averaged across the entire squat), and knee ASFs (peak and average). All dependent variables were normalized to body weight (BW).

Results: In comparison to TEC, the TFC produced higher average hamstring forces (TEC= 0.50 ± 0.21 BW, TFC= 0.67 ± 0.30 BW, $P=.001$) and lower ASFs (Peak: TEC= 0.34 ± 0.10 BW, TFC= 0.28 ± 0.09 BW, $P=.002$; Average: TEC= 0.18 ± 0.05 BW, TFC= 0.14 ± 0.05 BW, $P=.001$). Average quadriceps and gastrocnemius forces were not affected by trunk flexion condition (quadriceps: TEC= 3.09 ± 1.63 BW, TFC= 2.87 ± 1.43 BW, $P=.031$; gastrocnemius: TEC= 0.52 ± 0.18 BW, TFC= 0.51 ± 0.18 BW; $P=.676$).

Conclusions: Compared to extended trunk angles, increased trunk flexion produced lower ASFs and higher hamstring forces during the single-leg squat. Clinicians should therefore be aware that the magnitude of trunk flexion could affect knee muscle and joint forces during this rehabilitative exercise.

Free Communications, Poster Presentations: Student Award Finalists

Thursday, June 18, 2009, 8:00AM-12:00PM, Park View Lobby, Concourse Level; authors present 11:00AM-12:00PM

Difference In Latency Of The Peroneus Longus Between Dominant And Non-Dominant Leg

Knight AC, Weimar WH: Auburn University, Auburn, AL, and Department of Kinesiology, Mississippi State University, Starkville, MS

Context: The latency of the peroneus longus in response to an inversion perturbation is a key component in the prevention of lateral ankle sprains. While the dominant ankle is sprained more frequently than the non-dominant ankle, the difference in the latency between the two legs has not been extensively studied. **Objective:** To use an inversion perturbation that more accurately replicates the mechanism of a lateral ankle sprain to determine if there is a difference in the latency of the peroneus longus between the dominant and non-dominant legs. **Design:** A single group repeated measures study. **Setting:** The study was performed in a controlled laboratory setting. **Participants:** Fifteen healthy volunteers (age = 21.07 ± 1.10 years, mass = 63.46 ± 11.97 kg, height = 1.69 ± 0.093 m) with no previous history of an ankle sprain or lower extremity surgery. **Interventions:** The independent variable was the leg of the participant (dominant and non-dominant). Statistical analysis included a univariate analysis of variance with repeated measures to analyze the difference in the latency between the two legs. Muscle activity was recorded with a multichannel electromyography (EMG) amplifier/processor unit (MyoClinical, Noraxon USA INC; Scottsdale, AZ) using bipolar Ag/AgCl disc surface electrodes placed over the muscle belly of the peroneus longus. An outsole 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. A circuit was created between the fulcrum and landing area and interfaced with the EMG processor to signal contact with the ground and initiation of the inversion moment. **Main Outcome Measures:** The dependent variable was the latency of the peroneus longus, measured in milliseconds (ms). Latency was defined as the time from contact of the fulcrum with the landing area to when muscle activity exceeded 5 standard deviations from activity 200 ms before contact. A univariate analysis of variance with repeated measures was conducted to determine if there was a difference in the latency of the peroneus longus between the two legs. **Results:** There was a significant difference between the latency of the dominant leg and the non-dominant leg ($F_{1,13} = 9.34$, $P = .009$, $\eta^2 = .400$). The latency of the peroneus longus of the non-dominant leg was 34.40 ± 6.91 ms, while the

latency of the peroneus longus of the dominant leg was 44.90 ± 12.75 ms. **Conclusions:** These findings reveal the non-dominant ankle had a significantly shorter latency of the peroneus longus than the dominant ankle. This may be due to the different demands placed on the dominant and non-dominant legs during activity. Future research should investigate if this difference pre-disposes the dominant ankle to a greater number of ankle sprains.

Relationships Between Measures Of Core Stability and Dynamic Postural Control

Naick J, Lee SY, Cosby NL, Saliba S, Hart JM, Hertel J: University of Virginia, Charlottesville, VA

Context: Core stability and dynamic postural control have been recognized to have important roles in athletic performance, injury prevention, and rehabilitation. While the relationship between core stability and dynamic postural control has been theoretically linked, there has been little research examining the relationship between measures of these constructs. **Objective:** To examine the effect of core stability measures on dynamic postural control as assessed with the Star Excursion Balance Test (SEBT). **Design:** Observational study. **Setting:** Laboratory. **Patients or Other Participants:** 60 healthy subjects (23 males, 37 females; age = 22.8 ± 3.8 years, mass = 71.3 ± 12.8 kg, height = 171.3 ± 8.3 cm) with no lower quarter or abdominal within 6 months participated. **Intervention(s):** Predictor variables were maximum voluntary isometric force for hip abduction (ABD) and external rotation, lateral step down test score (on a 6 point scale), double limb lowering test (DLLT) angle, and maximum endurance time on the modified Biering-Sorenson test (MBST). All measures were performed using established and previously published testing protocols and were taken by the same examiner. The force measures were taken with a handheld dynamometer in kg and were normalized to subject body mass. The hip force and stepdown tests were each performed 3 times on each limb the means of the 3 trials from both limbs were calculated. The DLLT and MBST were each performed 3 times. For the DLLT the mean of the 3 trials was calculated, while for the MBST, the single highest value from the 3 trials was utilized. Stepwise multiple regression analysis was used to determine the influence of the 5 core stability measures on SEBT performance. The alpha level was set a priori $p < .05$. **Main Outcome Measures:** The dependent variable was SEBT reach distance. Subjects performed 3 trials in

each of 3 directions (anterior, posteromedial, posterolateral) while balancing on the right and left limbs. Reach distances were normalized to subject leg length. The scores of all 3 trials from all 3 reach directions across both limbs were used to calculate the mean SEBT reach distance. This value served as the dependent measure. **Results:** The only significant predictor was hip abduction strength which explained 8% of variance of SEBT reach distance ($R^2 = .08$, $p = .03$). None of the other measures of core stability significantly predicted SEBT reach distance ($p > .05$). Means and standard deviations for the measures were: SEBT ($88.8 \pm 7.2\%$), hip abduction force (162.3 ± 36.7 N), hip external rotation force ($269.061.0 \pm 67.0$ N), stepdown test (2.6 ± 0.9 points), DLLT ($68.1 \pm 9.5^\circ$), and MBST (161.0 ± 74.4 s). **Conclusions:** There were minimal relationships between measures of core stability and dynamic balance with only maximum voluntary hip abduction force being a significant performance of SEBT performance. It is apparent that dynamic postural control and core stability are mostly independent constructs.

The Presence Of Methicillin Resistant Staphylococcus Aureus (MRSA) In Collegiate Volleyball Players And Volleyball Equipment

Wolfe E, Torres-McGehee T, Carson J, Cairns M, Steinberg J, Stacy J, Mensch J: University of South Carolina, Columbia, SC

Context: Community Acquired methicillin-resistant Staphylococcus aureus (CA-MRSA) is an emerging pathogen found to be carried in the anterior nares, groins, and axillas of people, and these carriers have been shown to have increased rates of infection. Research has shown an increase in colonization during the season, thought to be due to increased contact. To date, no research studies have calculated the prevalence of CA-MRSA on the skin of multiple team members and/or their shared equipment. **Objective:** To calculate the prevalence of CA-MRSA in volleyball athletes and equipment (ball, net-towel, laundry cart). **Design:** Cross Sectional. **Setting:** University clinic and laboratory. **Participants:** Nine collegiate Division I Volleyball players (age = 19.6 ± 1.1 years). **Interventions:** Swabs were taken from the anterior forearm of each subject, 2 random net towels, 3 random practice volleyballs, and the laundry cart. Each sample was placed in a sterile 2ml tube with four aliquots of 500 μ L. Aliquot 1 was stored at a temperature between 10-2 $^\circ$ C. Aliquots 2-4 had 125 μ L of glycerol added and was stored at -80 $^\circ$ C. A random sample from Aliquot 1 was plated onto the CAN and Oxacillin agar to test

for control and sterility of plates. A Denka Seiken MRSA Latex Test Kit for PBP2 was used to identify if the PBP2 protein in samples colony form on the Oxacillin plate. A positive control was a swab of the laboratory counter top and negative control was tested by incubating a newly made agar plate for colonization. **Outcome Measures:** Presence of PBP2 protein and subsequent levels of agglutination within the test circle (strong agglutination=3+, agglutination against slightly turbid background=2+, slight agglutination against a turbid background=1+, and no agglutination=0). **Results:** The presence of MRSA was identified in 4/9 volleyball players, net towels, volleyballs, and the laundry cart. One sample suggested a strong level and presence of agglutination (player), three samples showed a slight agglutination (player, laundry cart, and towels), and three samples showed a slight agglutination (two players and the volleyballs). Five samples from athletes tested negative. **Conclusions:** Findings indicate the presence of MRSA in a collegiate volleyball environment including the balls, net-towels, and athletes. The presence of MRSA on balls and net towels may suggest a vector for transmission of MRSA bacteria from one player to another since each player touches the ball and often towels are shared among team members. Further studies may assess the colonization rate in the nares, axilla, or groins of athletes and compare to forearm samples. In addition, demographic information and hygiene habits of athletes could be used to establish risk factors for infection and/or colonization. Once the transmission of CA-MRSA in athletes is better understood, athletic trainers, physicians, and pharmacists can improve techniques for prevention of CA-MRSA.

Knee Extension Exercises Do Not Immediately Increase Quadriceps Activation In Individuals With Anterior Knee Pain.

Park J, Grindstaff TL, Negishi N, Hertel J, Hart JM, Ingersoll CD: University of Virginia, Charlottesville, VA, and Brigham Young University, Provo, UT

Context: Individuals with anterior knee pain (AKP) may experience weakness and inhibition of the quadriceps muscles. It is not known whether weight-bearing (WB) or non-weight-bearing (NWB) exercises elicit immediate improvements in quadriceps activation. **Objective:** To determine the immediate effects of WB and NWB knee extension exercises on quadriceps force output and activation in individuals with AKP. **Design:** A single-blind randomized control

trial. **Setting:** University laboratory. **Participants:** Thirty subjects (16 female and 14 male; age=26.0±10.2y) with self-reported AKP. **Interventions:** Quadriceps force was measured using a dynamometer and quadriceps activation was measured using the superimposed burst technique. Subjects performed a maximal voluntary isometric contraction (MVIC) of the quadriceps with the knee at 90°. Once the MVIC reached a plateau, an electrical stimulation was manually delivered percutaneously and transmitted directly to the quadriceps via stimulating electrodes. Quadriceps activation was quantified using the central activation ratio (CAR; CAR=MVIC/(MVIC+superimposed burst force)) and calculated by dividing the MVIC force by total force. Subjects performed 3 trials with the mean utilized for data analysis. Following baseline testing, subjects were randomized to 1 of 3 intervention groups: WB knee extension, NWB knee extension, or control. WB knee extension exercise was performed using a sling-based exercise while NWB knee extension exercise was performed on an isotonic dynamometer. Exercises were performed using 3 sets of 5 repetitions at approximately 55% MVIC. Measurements were obtained at 4 time intervals: baseline, post-exercise-0, 15, and 30 minutes. **Main Outcome Measures:** Dependent measurements included normalized quadriceps force output, and quadriceps CAR. Two separate 3x4 repeated measures ANOVAs were performed to compare force and CAR scores between groups across time. Probability was set at $P \leq .05$ for all statistical tests. **Results:** For quadriceps force (n-m/Kg) there was not a significant group by time interaction ($F_{6,81} = 0.386, P = 0.886$), between groups main effect ($F_{2,27} = 0.592, P = 0.56$), or time main effect ($F_{3,81} = 1.857, P = 0.14$); WB: Pre=1.80±0.55, Post-0=1.72±0.69, Post-15=1.70±0.75, Post-30=1.68±0.70; NWB: Pre=1.75±0.55, Post-0=1.71±0.65, Post-15=1.62±0.49, Post-30=1.72±0.49; Control: Pre=1.56±0.51, Post-0=1.38±0.35, Post-15=1.41±0.51, Post-30=1.50±0.61). For quadriceps activation ratio (%) there was not a significant groups by time interaction ($F_{6,81} = 0.14, P = 0.99$), group main effect ($F_{2,27} = 0.069, P = 0.93$), or time main effect ($F_{3,81} = 0.895, P = 0.45$); WB: Pre=72.4±0.09, Post-0=72.8±0.12, Post-15=72.3±0.12, Post-30=73.8±0.11; NWB: Pre=71.4±0.14, Post-0=71.8±0.15, Post-15=70.9±0.14, Post-30=74.9±0.15; Control: Pre=70.3±0.17, Post-0=70.4±0.12, Post-15=70.8±0.12, Post-30=71.7±0.13. **Conclusions:** Both WB and NWB knee extension exercises do not acutely increase quadriceps force output or activation. It may be necessary to perform exercises over a number of sessions and incorporate other disinhibitory interventions

such as cryotherapy, electrical stimulation, or joint mobilization. **This study was supported by a gift from Redcord AS, Staabo, Norway.**

Lateral Ankle Ligament Anesthesia Impairs Single Limb Postural Control

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Context: Lateral ankle anesthesia has been used as a model to explore the effects of ligament deafferentation related to ankle sprain on single-limb postural control with conflicting results. Time-to-boundary (TTB) is a postural control measurement technique that has detected subtle deficits in postural control in those with chronic ankle instability. **Objective:** To determine the effects of lateral ankle ligament anesthesia on TTB measures of single limb postural control in healthy adults. **Design:** Crossover design. **Setting:** Research laboratory. **Participants:** Twenty-two healthy adults (13 males, 9 females, age:28±6.6yrs, mass:83.62±17.54kg, height:172.25±8.35cm) with no history of lower extremity injury within the past six months and no history of lower extremity surgery or balance disorders participated in the study. **Interventions:** On two separate days, subjects performed three, ten-second trials of barefoot single-limb stance on a forceplate with eyes open and eyes closed. On one day, a board certified physician injected 10 ml of lidocaine to infiltrate the lateral ankle soft tissue structures from 3 o'clock to 9 o'clock surrounding the inferior tip of the fibula on the test limb of each subject prior to testing. On the control day, subjects did not receive an injection. The order of the testing day was counterbalanced. TTB measures were calculated from the forceplate center of pressure position and velocity data in the mediolateral (ML) and anteroposterior (AP) directions. The mean of each measure for the three trials was used for analysis. **Main Outcome Measures:** The dependent variables were the mean of TTB minima(s) and standard deviation of TTB minima(s) in (ML) and (AP) directions. Separate condition (anesthesia, control) by vision (eyes open, eyes closed) ANOVAs with repeated measures were used for each TTB variable to determine the effects of lateral ankle anesthesia on postural control. Alpha level was set a priori at $p \leq 0.05$. **Results:** There were no significant condition by vision interactions for any of the TTB measures, $p > 0.05$. There was a condition main effect for the mean of TTBAP minima (Anesthesia: 3.83±1.10, Control: 4.33±1.30s, $p = 0.008$) and the standard deviation of TTBAP minima (Anesthesia: 2.48±0.74, Control: 2.78±0.95, $p = 0.04$). The anesthesia day TTBAP measures were significantly lower than the control day,

regardless of vision. There were no condition main effects found for TTBL measures. There were also vision main effects for all TTB measures ($p < 0.01$). All subjects had significantly lower TTB measures with their eyes closed compared to eyes open regardless of condition. **Conclusions:** A transient deafferentation of the lateral ankle ligamentous structures significantly reduced the magnitude and variability of TTB measures in the AP direction with eyes open and eyes closed. These findings are similar to deficits found in those with chronic ankle instability. Potentially, these postural control alterations represented a reorganization of the sensorimotor system due to the increased constraint of ligament deafferentation.

Increasing Electrical Stimulation Frequency Above Cramp Threshold Frequency Increases The Strength And Duration Of Electrically Induced Muscle Cramps

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Context: High frequency electrical stimulation of the tibial nerve is a reliable, well-tolerated model for inducing muscle cramps. Stimulation frequency begins at a frequency of 4 Hz and increases in 2 Hz increments until the flexor hallucis brevis (FHB) cramps. The minimum electrical stimulation frequency at which a cramp occurs is known as threshold frequency (TF). One limitation with this model is that cramps induced at TF are mild and usually last ~30 sec. The short cramp duration makes it difficult to study cramp treatments because it would be unclear if the cramp resolved spontaneously or because of the treatment. **Objectives:** We asked: (1) Does increasing stimulation frequency above TF increase cramp intensity or duration? (2) Are cramp intensity and duration correlated? (3) Is there a learning effect associated with FHB maximal voluntary isometric contractions (MVICs)? **Design:** Randomized, counter-balanced experimental design. **Setting:** Laboratory. **Patients or Other Participants:** Twenty healthy, rested, cramp prone subjects (Mean $\pm$ SE, male=12, female=8, age=20.7 $\pm$.6 yrs; ht =174.9 $\pm$ 1.9cm; mass=76.6 $\pm$ 2.2kg). **Interventions:** FHB cramps were induced on 5 consecutive days. Cramp TF was determined the first day. On subsequent days, subjects were randomly stimulated at 5, 10, 15, or 20 Hz above TF. FHB MVIC force was measured prior to cramp induction each day. **Main Outcome Measures:** Cramp intensity (%) was determined by normalizing the 2-sec of cramp EMG activity immediately following the conclusion of the electrical stimuli and comparing it to the 2-sec average MVIC EMG activity.

Cramp duration (sec) was defined as the difference between the start of cramp EMG activity and the point when cramp EMG activity decreased to within two standard deviations of resting EMG activity. **Results:** Increasing electrical stimulation frequency above TF resulted in more intense ($F_{4,76}=5.7$, $P<.001$) and longer lasting cramps ($F_{4,76}=8.3$, $P<.001$). Cramps induced at 20 Hz above TF were 68% more intense than cramps at TF (100.5 $\pm$ 10.5% vs. 60.0 $\pm$ 11.5%, $P<.05$). Cramp duration was 91% longer when stimulated at 15 Hz above TF (77.9 $\pm$ 8.4 sec) and 70% longer at 20 Hz above TF (69.5 $\pm$ 8.2 sec) than when stimulated at TF (40.8 $\pm$ 7.6 sec, $P<.05$). Cramp intensity and duration were highly correlated ($r=.83$). FHB MVIC force was lower on day 1 than days 3, 4, and 5 ($F_{4,76}=12.5$, $P<.001$). **Conclusions:** Cramp duration and intensity increase as electrical stimulation increases above TF in rested, cramp prone subjects. To study the effect of treatments on cramp duration, subjects should be stimulated at 15 Hz above TF as this frequency produces the longest lasting cramps. Researchers may wish to screen subjects prior to experimentation to determine if a long lasting cramp can be induced. A learning curve occurs with FHB MVIC force after 3 days; cramp researchers should include 2 familiarization days prior to collecting data on FHB force.

The Effect Of Plyometric Training On Peroneal Latency

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Context: Previous studies have found that the reaction time of the peroneal muscles is not fast enough to control and overcome the inversion moment placed on the ankle during an inversion ankle sprain. Training protocols may assist in decreasing muscle activation reaction time, and therefore help reduce the risk of ankle injuries. **Objective:** To determine the effect of a 6-week plyometric training program on reaction time of the peroneus longus muscle. **Design:** A repeated measures design. **Setting:** Controlled University Research Laboratory. **Participants:** Forty-eight healthy college students (age=20.0 $\pm$ 1.2 years, height=176.1 $\pm$ 16.9cm, weight=74.5 $\pm$ 27.9kg) from a large midwestern university volunteered to participate in this study. All subjects were physically active, participating in exercise for at least 3 days a week for 30 minutes. Subjects were excluded if they had a history of an ankle sprain in the past 12 months, or a history of ankle surgery or fracture. Each subject was randomly assigned to either the training group or the no training control group. **Interventions:** The independent variables were plyometric training group at 2 levels (training and no training)

and time at 2 levels (pretest and posttest). The dependent variable was peroneal latency, which was measured by using the BIOPAC systems MP150 with telemetry system (BIOPAC Systems Inc, Goleta, CA). Surface electromyography (EMG) data were collected through a remote amplifier at a sampling rate of 1250 Hz. EMG data were filtered through a band-pass filter of 10-350 Hz. A custom-made trapdoor device capable of inverting the ankle to 30 degrees was also used. Latency data were obtained from the time the trap door dropped until the peroneus longus muscle activated. Peroneal latency measurements occurred before and after the 6-week period. The no training group was instructed to maintain current activity level for a six-week period. The training group performed a six-week plyometric protocol 3 times weekly. Data were examined with a RMANOVA with one within subject factor (time at 2 levels) and one between subjects factor (group at 2 levels). A priori alpha level was set at $P \leq .05$. **Main Outcome Measures:** Pretest and posttest latency measurements (msec) were recorded for the peroneus longus muscle. **Results:** We found no significant group by time interaction ($F_{1,46}=.03$, $P=.87$). Additionally, we found no difference between the pretest and posttest values (pretest=61.76 $\pm$ 14.81msec, posttest = 59.24 $\pm$ 12.28msec, $P=.18$), and no difference between the training and no training groups (Training group=59.10 $\pm$ 12.18msec, No Training Group=61.79 $\pm$ 15.18msec, $P=.43$). **Conclusions:** Although latency measurements were consistent with previous literature, 6 weeks of training did not cause significant reflex adaptations in the peroneus longus muscle.

Analysis Of Lower Extremity Coordination And Variability Between Sexes During A Sidestep Cut

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Context: Although significant research has shown that males and females have different lower extremity (LE) kinematics during sidestep cutting maneuvers, there are no published studies on how the neuromuscular system organizes and coordinates LE motion. If the coordination of the segments of the LE is different between males and females, this may help explain the higher risk of non-contact anterior cruciate ligament (ACL) injuries in females who perform sidestep cutting. **Objective:** To compare the coordination and variability of the lower extremity between male and female athletes during a sidestep cutting task. **Design:** Cross-sectional. **Setting:** Research laboratory. **Patients or Other Participants:** Thirty-six healthy volunteers who have participated in soccer, basketball, lacrosse, or

volleyball at the intercollegiate, club, intramural, or high school varsity level (Males: N=18, age:21.0±2.2yrs, height:181.3±5.1cm, mass:77.5±6.8kg; Females: N=18, age:20.2±1.0yrs, height:170.0±5.1cm, mass:61.9±8.1kg). **Interventions:** Participants performed 10 repetitions of a sidestep cutting maneuver with a running approach speed between 3.5-4.5m·s⁻¹. Participants planted the foot of the dominant leg on the center of a forceplate, then cut at a 40-50° angle. Three-dimensional kinematics and vertical ground reaction force (VGRF) data were recorded with an infrared motion capture system and forceplate. Sagittal and frontal plane segment angles, referenced to a global horizontal axis, were calculated for the foot, shank, thigh, and trunk. Segment angle and angular velocity were plotted for each segment during the stance phase of the cut (defined as the period of time when VGRF>10N), then normalized to 101 datapoints. Phase angles were calculated, then continuous relative phase (CRP) portraits were created for each segment pair (foot-shank, shank-thigh, and thigh-trunk) in both planes of motion (sagittal and frontal). **Main Outcome Measures:** Mean absolute relative phase (MARF) and deviation phase (DP) were calculated using the CRP portraits to compare coordination and variability respectively. The average MARF and DP values across all 10 repetitions were compared between sexes with independent-samples t-tests ($\alpha \leq 0.05$). **Results:** Males demonstrated a lower thigh-trunk frontal plane MARF compared to females (M: 27.73±7.15, F: 38.17±9.89, $t_{34} = -3.63$, $P=0.001$). There were no other significant differences between males and females in MARF or DP in any other segment pair. **Conclusions:** Males and females generally have very similar coordination and variability patterns in the LE during an anticipated sidestep cut, indicating similar neuromuscular organization strategies. However, females have a more out-of-phase coordination pattern between the thigh and trunk in the frontal plane. This suggests that females coordinate the movement of the trunk and thigh differently than males. Although the implications of this sex-related differences on injury risk is not known, recent research does suggest the trunk influences knee joint loading forces and moments. Future research should examine the relationship between LE coordination, knee joint loading, and non-contact ACL injuries.

Sex Differences In Balance And Power Among Youth Soccer Players

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Context: Lower extremity injuries are common among adolescent athletes, especially soccer players. Balance and power are key factors related to injury risk and performance. Following puberty, females are more likely to sustain sports injuries compared to males and possess more risk factors associated with injury. Previous research has failed to address when these sex differences begin to emerge, and has not evaluated potential risk factor differences among preadolescent populations. **Objective:** To compare balance and power between male and female youth soccer athletes. **Design:** Cross-sectional. **Setting:** Research laboratory. **Participants:** Sixty-six youth soccer players volunteered to participate (38 males: height = 143.3±6.3 cm, mass= 34.2±5.2 kg, age=10±1 years; 28 females: height = 141.0±6.6 cm, mass= 33.8±5.4 kg, age=10±1 years). **Interventions:** The independent variable for this study was sex. All subjects performed three time to stabilization (TTS) trials and three vertical jump trials. During the TTS, participants jumped forward off a 30cm high box and landed with their dominant foot (foot used to kick a ball for maximum distance) on a force plate. The box was positioned a distance equal to half their height from the front of the force plate. Participants were required to maintain balance on their dominant foot for ten seconds after landing. For the vertical jumps, participants were instructed to jump as high as possible from a double leg stance with their dominant foot on a force plate. **Main Outcome Measures:** A force plate was used to collect ground reaction force (GRF) data. Antero-posterior, medio-lateral and resultant TTS values were calculated from GRF data using customized software. During vertical jump trials both vertical jump height and power were calculated using customized software. The averages of three trials for both tasks were used for statistical analyses. A Mann-Whitney *U* test was conducted to evaluate sex differences in TTS, while separate one-way ANOVAs were used to compare vertical jump height and power across sex ($\alpha \leq 0.05$). **Results:** Males (3.22±2.47s; Average rank=27.24) stabilized themselves significantly quicker than females (5.24±3.47s; Average rank=40.19) during the TTS task, ($z = -2.73$, $P=0.006$). Males (25.2±4.0 cm) jumped significantly higher than females (22.7±3.7 cm) ($F_{(1,65)} = 6.3$, $P=0.01$) and generated significantly more power (Males=973.68±269.40 Nm/s; Females=806.30±274.50 Nm/s; $F_{(1,62)} = 6.1$, $P=0.01$). **Conclusions:** Despite their young age,

sex differences existed in time to stabilization, jump height and power as males performed better than females on all tasks. These results may lend insight into the elevated risk for sport injury in girls compared to boys. Therefore, prevention programs may be more beneficial if started at an earlier age. (Funded by the Injury Prevention Research Center at the University of North Carolina at Chapel Hill and the National Academy of Sports Medicine)

Subcutaneous Fat Thickness Measurements Of The Distal Thigh Comparing Pinch Calipers To Ultrasound Imaging

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Context: Pinch calipers are typically used to determine subcutaneous fat thickness. The measurement is often difficult, especially where adiposity is not freely moveable or when the pinch calipers are not large enough to capture the full thickness. With the new technology of ultrasound, it may provide a better technique of analyzing subcutaneous fat thickness than commonly used pinch calipers. **Objective:** To compare the thickness of subcutaneous fat in the distal thigh when measured by pinch calipers to ultrasound imaging (USI) measurements of healthy volunteers. **Design:** Crossover design. **Setting:** Laboratory. **Patients and Other Participants:** 11 healthy adults (5 male, 6 female: Age 25.45 ± 4.23 years; Height 172.4 ± 7.45 cm; Mass 73.44 ± 15.05kg) participated. **Interventions:** The independent variable was measurement tool (pinch caliper and USI). Subjects sat in a chair and were marked over the distal VMO and distal rectus femoris (RF) using a template. For the pinch caliper (Lange Skinfold Caliper, Beta Technology, 2005), the assessor performed a vertical pinch with the fingers and used the calipers to measure just distal to the pinch. For USI (Philips Ultrasound GE Logiq XP, 2006), ultrasound gel was applied over the region and the transducer was placed over the gel, making firm contact but not depressing the tissue. Once a clear image was observed, it was saved and the amount of subcutaneous fat was measured using the software within the unit. For each tool, a total of 3 measurements at each of the 2 sites were taken and averaged. The same assessor measured fat thickness with the calipers and USI. **Main Outcome Measures:** Fat thickness in millimeters from pinch calipers and USI at the VMO and RF were the outcome measures. Measurements at each site were compared using Pearson's correlations and Bland-Altman plots. **Results:** At the VMO, there was a strong correlation ($r = .92$, $p < .001$) and the plot indicated a mean difference (calipers-USI) of

3.3mm±2.9 with limits of agreement from -2.6 to 9.1mm. At smaller fat thicknesses, the mean difference was close to zero, but at larger fat thicknesses there were larger mean differences with the USI having smaller fat thickness values than the calipers. For the distal RF, there was a strong correlation ($r=.97$, $p<.001$) and the plot indicated a mean difference of 2.4mm±2.5 with limits of agreements from -2.6 to 7.3mm. This site also had minimal differences at smaller fat thickness values and overestimation with the calipers at higher fat thickness values. **Conclusions:** There are significant correlations of measuring subcutaneous fat in the distal thigh with calipers and USI, however, the large limits of agreement and increasing mean differences with increasing fat thickness were concerning. When measuring subcutaneous fat thickness of the distal thigh, the pinch calipers tended to overestimate fat thickness in individuals with higher fat values.

TENS Application Does Not Alter Vibratory Sensory Threshold

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Context: Recent cross-validation supported the minimizing effects of Transcutaneous Electrical Nerve Stimulation (TENS) on sensory pressure discrimination. However, only a constant, non-moving stimulus was applied, thus targeting only one type of cutaneous mechanoreceptor such as Ruffini endings that are responsible for the detection of a sustained pressure stimulus. The effects of TENS on other types of mechanoreceptors, specifically those that sense non-constant or vibratory pressure stimuli are uncertain. **Objective:** Our purpose was to examine the effects of a TENS application on cutaneous mechanoreceptors responsible for sensing vibration. **Design:** A repeated measures experimental design was used. **Setting:** Controlled laboratory setting. **Participants:** Eighteen participants (age = 20.44 yrs ± 0.86; mass = 71.81 ± 15.68 kg; height = 169.90 ± 10.19 cm) volunteered in accordance with IRB protocol. **Interventions:** Our independent variables were a control treatment and a twenty minute high frequency TENS application applied to the dorsum of the hand. The control treatment consisted of 10 minutes of quiet sitting. The dependent variable was the vibratory sensory threshold assessed at the dorsal aspect of the hand between the third and fourth metacarpals. Vibratory sensory threshold was assessed with the Case IV Computer Aided Quantitative Sensory Evaluator (Medical Electronics Co., Stillwater, MN). The Case IV Evaluator administered a series of vibratory stimuli via a plunger-like device. The stimuli magnitudes

varied according to the computer algorithm sequence test. Participant's, prompted by a light, respond "yes" or "no" to indicate if a stimulus was felt. Testing continued until the computer determined the weakest vibratory stimulus the participant could detect. Delta scores were analyzed using a Friedman's repeated-measures analysis (control, during TENS, after TENS). Significance level was set at .05. **Main Outcomes Measures:** The minimal detectable vibratory stimulus (μm) was recorded before and after the control, and before, during, and after TENS. **Results:** Vibratory sensory threshold over the dorsal aspect of the hand was not significantly reduced during or after TENS ($\chi^2 = 0.37$, $p = 0.83$). Mean change values and standard deviations for the control, during TENS, and after TENS measurements were -0.33 μm ± 0.83, -0.42 μm ± 0.74, and -0.17 μm ± 0.84 respectively. **Conclusions:** Whereas the application of TENS increases constant pressure stimulus threshold, our results indicate that TENS does not alter sensitivity to vibratory stimulus. This suggests that although TENS appears to have an attenuating impact on cutaneous mechanoreceptors responsible for detecting a constant pressure stimulus, it does not have a similar effect on vibratory receptors such as Pacinian corpuscles. To continue to identify the pathways through which TENS may impact sensory discrimination, future investigation should focus on the effects of TENS on cutaneous thermoreceptors and nociceptors.

The Acute Effects Of A Corrective Exercise Strategy On Knee Valgus Angle And Muscle Activity During A Squat Exercise

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Context: Knee valgus is a theorized risk factor for both acute and chronic lower extremity injuries including anterior cruciate ligament injuries and patellofemoral pain. Muscle imbalances are proposed as one cause of increased knee valgus position during dynamic activities; however, it is not known if an acute intervention can correct this faulty knee valgus position and muscle activation patterns. **Objective:** To determine if a one time exercise program can alter muscles activation and decrease knee valgus during a squat exercise. **Design:** Repeated measures. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty-eight subjects (24 females, 4 males; age= 19.83±1.47yrs; ht=165.71±7.13cm; m= 63.83±8.76kg) free from lower extremity injury in the past six months volunteered for this study. All subjects presented with knee valgus during a

double leg squat that was corrected when a lift was placed under the heel. Knee valgus was defined if the midpoint of the patella passed medial to the great toe. **Interventions:** Subjects were randomly assigned to either a control (CON) or intervention (INT) group. Kinematics and EMG were recorded during five double-leg squats (DLS). The INT group completed exercises aimed at correcting muscle imbalances thought to contribute to knee valgus. These exercises included foam rolling of the gastrocnemius and peroneals (2x1minute), static stretching of the gastrocnemius and soleus (2x30seconds), trials. Separate 2 (group) x 2 (time) repeated measures analyses of variance were performed for each dependent variable ($\alpha\leq 0.05$). Tukey HSD was used for post hoc analysis. **Results:** No significant interactions were found between the CON and INT groups: peak knee valgus angle ($P=0.08$), TA ($P=0.38$), MG ($P=0.51$), and LG ($P=0.65$). A group main effect was found for peak knee valgus angle (CON: -4.89±5.74, INT: -10.29±5.33, $F_{1,24}=6.98$, $P=0.01$) as well as a time main effect (Pre: -6.09±4.93, Post: -9.09±6.94, $F_{1,24}=16.62$, $P<0.001$). **Conclusions:** A single bout of foam rolling, stretching, strengthening, and single leg balance exercises did not alter muscle activation nor improve knee valgus angle during a DLS. In fact it seems that the intervention caused knee valgus angle to worsen possibly because of fatigue. Future research should determine the effect of multiple sessions of an intervention on knee valgus angle and muscle activation during a DLS. *Funding provided by the National Academy of Sports Medicine and the National Basketball Athletic Trainers Association.*

Correlations Between Muscle Properties And Reproductive Hormones

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Context: Females have a greater non-contact ACL injury rate compared to males. Reproductive hormone fluctuations are thought to contribute to this discrepancy, with a significant amount of research focused on ligament properties. However, little research has focused on the hormonal influences on muscle properties. Given the substantial contributions of the hamstrings muscles to knee joint stability, changes in these properties may influence ACL injury risk. **Objective:** To evaluate relationships between hamstring properties and blood concentrations of estrogen, testosterone, and progesterone. **Design:** Correlational. **Setting:** Research laboratory. **Patients or Other Participants:** 15 males (age=20.9±1.7yrs, ht=180.8±7.7cm, m=78.7±10.9) and 15 females

(age=20.4±1.6yrs, ht=163.9±5.6cm, m=62.7±10.6) who were free of lower extremity injury volunteered for this study. Females were tested 3-5 days post-menses. **Interventions:** Hamstring stiffness was assessed by quantifying the damping effect imposed by the hamstrings on oscillatory knee flexion/extension induced by perturbation. Hamstring electromechanical delay (EMD), time-to-50% peak force (T50%), and rate of force production (RFP) were assessed during maximal isometric contraction. EMD was defined as the time interval between the onsets of EMG and force. T50% was calculated as the time between the onset of force and the instant at which 50% peak force was attained. This force was expressed relative to body mass (N/kg), and RFP was calculated as the ratio of this normalized force to T50%. Blood hormone levels were assessed via radioimmunoassay procedures. Pearson correlation coefficients were computed between the respective muscle properties and hormone levels with genders combined and separately ($\alpha \leq 0.05$). **Main Outcome Measures:** Hamstring stiffness (K), rate of force production (RFP), electromechanical delay (EMD), time to 50% peak force (50%F), and estrogen, testosterone, and progesterone concentrations. **Results:** For genders combined, estrogen (mean=46.0±28.2pg/ml) was negatively correlated with K (mean=12.8±2.6N/cm, $r = -.43$, $P=.02$) and RFP (mean=758.77±507.6N/kg·sec⁻¹, $r = .43$, $P=.02$). Free testosterone (mean=13.17±13.0pg/ml) was positively correlated with K ($r=.46$, $P=.01$) and RFP ($r=.56$, $P=.001$) but negatively correlated with T50% (mean=114.73±38.88ms, $r = -.43$, $P=.02$). When gender was considered separately, males displayed no significant correlations between the selected hormones and muscle properties. Females demonstrated a negative correlation between estrogen (mean=68.02±23.21pg/ml) and K (mean=11.72±1.47N/cm, $r = -.53$, $P=.05$) and free testosterone (mean=1.53±.64pg/ml) and K ($r = -.52$, $P=.05$). **Conclusions:** When both genders were considered, higher levels of estrogen were associated with lesser K and RFP. However, greater levels of free testosterone were associated with faster RFP. In females, greater amounts of estrogen were associated with lesser K. These results suggest that female muscle tissue may be more responsive to estrogen. Increased estrogen concentration during the ovulatory phase of the menstrual cycle may negatively influence hamstring muscle properties in manners which result in a decreased ability to produce force and protect the knee joint during high risk activities.

Psychometrics Of Ankle Self-Report Survey (PASS)

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Context: One challenge athletic training faces in establishing an evidence based profession is the lack of outcome instruments appropriate for physically active clientele. Although there are over 40 self-reported ankle/foot scales, none have been validated for the physically active. The Foot and Ankle Disability Index (FADI) has merit but has not been psychometrically analyzed for physically active individuals with varying levels of ability. **Objective:** Our purpose was to determine the measurement capabilities of the FADI using Rasch modeling for athletic training clientele (injured to highly physically active). **Design:** We used a non-experimental, observational design. **Setting:** Data were collected in collegiate athletic training rooms and outpatient rehabilitation clinics. **Participants:** Two-hundred-and-forty-four participants (age: 18-50 years) volunteered in accordance with university IRB. The participants (146 males, 98 females) represented four sub-groups: a) 39 healthy/elite, b) 110 healthy/physically active, c) 20 healthy/not active, and d) 75 injured. **Interventions:** Participants completed the FADI, a 34-item scale that consists of two subscales (ADL = 26 items; Sport = 8 items). We used the Rasch Rating Scale Model to examine the FADI. Additional analyses using the calibrated estimates in the form of logits were also performed. **Main Outcome Measure:** We established model-data fit using infit/outfit statistics ($>.5 < 1.5$). The item difficulties range, ability estimate range, precision (Conditional Standard Error ≤ 0.4 ; CSE), and visual inspection of the Wright Item-person map were performed. We addressed ceiling effects by examining the percentage of maximum scores, using a five percent error tolerance. **Results:** Overall, the data fit the model well with 27 of 34 items having adequate infit/outfit statistics. There were seven misfitting items: "Walking without shoes", "Squatting", "Sleeping", "Walking 10 minutes", "Home responsibilities", "Personal care", and "Low-impact activities". Whereas item difficulty ranged from -2.80 to 2.20 logits, ability estimates ranged from -1.91 to 8.07 logits. Based on the accepted CSE (≤ 0.4), the instrument precisely measured ability estimates that ranged from -1.91 to 4.35 logits. Eighty-four participants had a CSE ≤ 0.4 , indicating that only 34.4% of the participants were measured precisely and over 65% were not. Of the 84 participants that had scores less than 0.4, only two (5.1%) were healthy/elite and 64 (85.3%) were injured. Furthermore, 120 of the 244 participants (49.2%) obtained the maximum FADI score, indicating a severe ceiling effect. **Conclusions:**

The FADI-Total can precisely measure individuals with low ability levels, such as those with ankle/foot injuries. However, it is severely limited in its measurement capabilities and lacks items difficult enough to measure healthy active individuals. Once an individual's ability approaches anything beyond what is considered low, the FADI becomes useless. For the FADI to be applicable in athletic training, more difficult items must be developed. Funded by a Master's Research Program Grant from the NATA Research and Education Foundation.

The Effect Of Oral Contraceptive Use On Muscle Properties Across The Menstrual Cycle

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Context: Fluctuations in reproductive hormone concentrations across the menstrual cycle potentially influence female non-contact ACL injury risk. Hormone receptors also exist on skeletal muscle, and changes in mechanical muscle properties have been noted across the menstrual cycle. Given the substantial contributions of the hamstrings muscles to knee joint stability, such property changes may influence ACL injury risk. Oral contraception (OC) minimizes hormonal fluctuations across the menstrual cycle and thus may subsequently minimize the associated changes in muscle properties and injury risk. **Objective:** To investigate the effects of OC use on mechanical properties of the hamstrings. **Design:** Cross-sectional quasi-experimental. **Setting:** Research laboratory. **Participants:** Twelve females using monophasic OC (age=19.87±1.13yrs, height=1.65±0.08m, mass=61.54±13.12kg) and 12 females not using OC (age=20.40±1.59yrs, height=1.69±0.05m, mass=62.75±10.61kg) with normal menstrual cycles and no lower extremity injuries. **Interventions:** Active hamstring stiffness (K_A) and vertical leg stiffness (K_{vert}) were assessed at time points corresponding with low (Menses) and high (Ovulation) estrogen (E) concentrations. The Menses testing session occurred 3-5 days post menses for the non-OC group and pill number 3-5 for the OC group. Subjects in the non-OC group were tested 2-4 days after Ovulation (identified via commercial ovulation kit) and OC pill number 15-17 in the OC group. K_{vert} was calculated as the ratio of the change in vertical ground reaction force to the vertical displacement of the total body center of mass (DForce/DLength of Leg Spring) during double-leg hopping on a force plate at a controlled rate. K_A was assessed by evaluating the damping effect imposed by the hamstrings on oscillatory knee flexion/extension induced by perturbation. Blood

E concentration was assessed with radioimmunoassay procedures. 2 (Group) x 2 (Time) repeated measures ANOVA were used to compare K_A , K_{vert} , and E between OC and Non-OC users across the menstrual cycle ($\alpha \leq 0.05$). Tukey HSD was used for post hoc analysis. **Main Outcome Measures:** K_A and K_{vert} in N/cm and E in pg/ml. **Results:** E increased (interaction: $F_{(1,22)} = 16.08$, $P = .001$) at ovulation in the non-OC group (Menses: 71.22 ± 8.12 pg/ml; Ovulation: 100.95 ± 7.89 pg/ml) but not in the OC group (Menses: 57.84 ± 8.12 pg/ml; Ovulation: 53.09 ± 7.89 pg/ml). The Group x Time

interaction effects for K_A ($P = .15$) and K_{vert} ($P = .23$) were non-significant. Similarly, the group main effects for K_A (OC: 10.97 ± 2.00 N/cm, Non-OC: 11.41 ± 1.76 N/cm, $P = .51$) and K_{vert} (OC: 193.88 ± 34.68 N/cm, Non-OC: 219.25 ± 68.38 N/cm, $P = .17$) and the time main effects for K_A (Menses: 11.23 ± 1.77 N/cm; Ovulation: 11.15 ± 2.02 N/cm, $P = .76$) and K_{vert} (Menses: 204.15 ± 50.18 N/cm; Ovulation: 208.99 ± 60.68 N/cm, $P = .57$) were non-significant. **Conclusions:** These results indicate that while OC use minimized the increase in E at ovulation, it did not alter muscle properties.

OC use may have little-to-no prophylactic value for injury prevention as related to muscle stiffness. Future research is necessary to determine the magnitude of changes in muscle properties across the menstrual cycle and the influence that these changes impart on non-contact ACL injury risk. Funded by a Master's Research Program Grant from the NATA Research and Education Foundation.

Free Communications, Poster Presentations: Shoulder

Thursday, June 18, 2009, 8:00AM-12:00PM, Park View Lobby, Concourse Level; authors present 11:00AM-12:00PM

The Responsiveness Of Selected Patient-Report Outcomes In An Upper Extremity Injury Model

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Context: Common outcomes measured in experimental studies using a delayed onset muscle soreness (DOMS) injury model include patient-reported pain, function and disability. Beyond validity and reliability a viable outcomes variable should be responsive in order to detect when clinically meaningful change occurs in a study. **Objective:** The purpose of this project was to determine the responsiveness of four outcomes instruments measuring patient-reported pain, function and disability between baseline and two days post DOMS inducement. **Design:** double blind, prospective cohort study **Setting:** Athletic Training Research Lab **Participants:** A convenience sample of 25 physically active sham subjects (14 males, 11 females, weight $73.35 \text{ kg} \pm 12.18$, height $173.76 \text{ in} \pm 7.52$) from a larger study participated in this project. **Interventions:** Subjects completed patient-report baseline measures for pain, function and disability. Induction of DOMS occurred on a randomly selected arm with an isokinetic, eccentric elbow protocol (10 sets of 6 repetitions at 90° per second). No treatment was provided and follow-up was completed two days later. Subjects completed baseline instruments and a global rating of change scale (GRC) during follow-up. **Main Outcomes Measures:** The outcomes measured included pain using a graphic pain rating scale (GPRS) at rest and during passive elbow extension, function using a global functioning scale (GF), disability using a region specific instrument named the Quick Disabilities of the Arm, Shoulder, and Hand Scale (QDASH) and a generic disability scale named the Disablement in the Physically Active (DPA) scale. The psychometric values for the GF ($r = 0.69-0.77$), DPA ($\text{ICC} = 0.94$, $r = -0.75$) and

QDASH ($\text{ICC} = 0.94$, $r = 0.70-0.80$) have been established. The GRC was used to categorize subjects as stable ($\text{GRC} > -4$) or having experienced a clinically significant deterioration ($\text{GRC} < -4$). We calculated the responsiveness of the various outcomes by creating a receiver operating characteristic (ROC) curve to measure the area under the curve (AUC). **Results:** The AUC for the GPRS at rest was .465 ($p = .765$, $95\% \text{ CI} = .227$ to .703) while during extension was .920 ($p < .001$, $95\% \text{ CI} = .813$ to 1.027). The AUCs for the GF = .753 ($p = 0.03$, $95\% \text{ CI} = .544$ to .962), QDASH = .978 ($p < .001$, $95\% \text{ CI} = .932$ to 1.023) and DPA = .907 ($p = .001$, $95\% \text{ CI} = .770$ to 1.044) were all significant. **Conclusions:** All patient-report instruments were deemed responsive except the GPRS completed at rest. The GPRS completed during passive extension is the more useful pain measure in detecting change. All other instruments performed well with the region specific QDASH performing the best when compared to the DPA and GF. This concurs with the literature which shows that region specific instruments are more responsive than generic instruments like the GF and DPA. Nonetheless, all three instruments can be used in experimental studies using a DOMS injury model and can provide insight into clinically significant change.

Comparison Of Tri-Planar Scapulohumeral Rhythm In Healthy Shoulders During Shoulder Elevation In Three Planes

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Context: Scapulohumeral rhythm is a cornerstone of shoulder function. While the assessment of tri-planar scapular motion is possible, little has been done to investigate tri-planar scapulohumeral rhythm. **Objective:** The purpose of this study was to test the hypothesis that there would be differences in tri-planar

scapulohumeral rhythm (SHR) during humeral elevation in three planes of motion. **Design:** One-way study design. **Setting:** Study was performed in a controlled laboratory environment. **Patients or Other Participants:** Six volunteers (22 ± 1.41 years; 1.78 ± 0.12 meters; 77.64 ± 25.68 kg; 3 males, 3 females), free from any previously diagnosed upper extremity, neck and/or back injury, agreed to participate. All subjects underwent an evaluation to ensure a healthy, dominant shoulder. **Intervention:** Shoulder kinematic data were collected using The MotionMonitor™ system and software (Innovative Sports Training, Chicago, IL). All data collection involved the dominant shoulder. Plane of elevation was the independent variable while SHR was the dependent variable. For kinematic data collection, subjects performed three trials of humeral elevation in the frontal, sagittal, and scapular planes, randomized by plane. **Main Outcome Measures:** Anatomic coordinate systems and Euler angles sequences were used to calculate SHR (glenohumeral elevation/scapular rotation). Scapulohumeral rhythm was calculated with respect to scapular anterior-posterior tilt ($\text{SHR}_{\text{APtilt}}$), upward/downward rotation (SHR_{ROT}), and medial-lateral tilt ($\text{SHR}_{\text{MLtilt}}$). One-way ANOVA's were used to identify differences in SHR between planes of humeral elevation at 30° , 60° , 90° and 120° of elevation. Gabriel's pair-wise test was used to address multiple comparisons between planes of elevation. An $\alpha = 0.05$ was set *a priori*. **Results:** Significant differences were identified for $\text{SHR}_{\text{APtilt}}$ at 60° of elevation (frontal: -2.97 ± 1.75 ; sagittal: -5.58 ± 2.78 ; scapular: -3.16 ± 1.93); ($F_{(2,50)} = 7.54$, $p = .002$, $95\% \text{ CI} = -4.55$ to -3.19) and 90° of elevation (frontal: $-2.96 \pm .93$; sagittal: -4.85 ± 3.60 ; scapular: -3.04 ± 1.51); ($F_{(2,51)} = 3.79$, $p = .036$, $95\% \text{ CI} = -4.28$ to -2.95). Significant differences were noted for SHR_{ROT} at 90° of elevation (frontal: $3.04 \pm .294$; sagittal: $1.43 \pm .66$; scapular: $1.46 \pm .83$); ($F_{(2,51)} = 4.68$, $p = .020$, $95\% \text{ CI} = 1.45$ to 2.50). The tests for multiple comparisons revealed differences between sagittal vs. frontal

($\mu_d = 2.61$) and sagittal vs. scapular ($\mu_d = 2.42$) planes of elevation for SHR_{APilt} at 60° of elevation. Similar differences were identified between frontal vs. sagittal ($\mu_d = 1.61$) and frontal vs. scapular ($\mu_d = 1.58$) planes at 90° of elevation for SHR_{ROT} . **Conclusions:** Humeral elevation occurring in the frontal, sagittal and scapular planes requires significant variations in SHR. These differences appear most notable when considering SHR_{APilt} and SHR_{ROT} . Our findings provide evidence of compensatory shifts in triplanar scapulohumeral rhythm to adjust for planes of humeral elevation in healthy shoulders.

Comparison Of Electromyographical Analysis Techniques In Indwelling EMG Data Of Rotator Cuff Musculature

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Context: Few studies have used an injured or post-surgical patient population when studying electromyography (EMG) during shoulder rehabilitation exercises. Previous studies typically use a maximal voluntary contraction to normalize EMG data however this method could harm a patient with a shoulder injury.

Objective: To compare two methods of analyzing EMG data: a reference voluntary contraction (RVC) and a percent change from resting baseline (%CHG) to determine their relationship. **Design:** A single session, cross sectional cohort design. **Setting:** Testing was conducted in a musculoskeletal laboratory.

Patients: 20 subjects volunteered to participate in this study. 10 subjects were 4-6 weeks post-superior labral anteroposterior (SLAP) repair (28 ± 9 yrs, 1.8 ± 0.1 m, 90 ± 19.6 Kg) and 10 subjects were healthy normal patients (28 ± 6 yrs, 1.8 ± 0.1 m, 84 ± 19.1 Kg). One injured subject's data was compromised due to technical issues and was not used in the analysis. **Interventions:** Subjects performed 10 typical early rehabilitation shoulder exercises in random order to gain active elevation while EMG and two-dimensional kinematic data was collected synchronously. Two indwelling electrodes were inserted into the dominant or involved supraspinatus and infraspinatus muscles of each subject. Sub-maximal RVC for infraspinatus was holding a 5lb weight in external rotation at 45° of abduction for 5 seconds. The supraspinatus RVC was performed with arm at 90° abduction with elbow fully extended with no weight for 5 seconds. The resting EMG data was collected for 5 seconds with the subjects standing in resting posture with arms at the side. Data analysis using a band pass filter of 20-500Hz and the maximal root mean squared (RMS) amplitude of 500ms window during the RVC was used to normalize the exercise data for RVC (EX_{RVC}).

The RMS amplitude of the mean 500ms resting amplitude was used to calculate the percentage change during the exercise activity from resting ($EX_{\%CHG}$). The $EX_{\%CHG}$ was determined by subtracting the RMS EMG amplitude during rest from the RMS amplitude during exercise and dividing the difference by the resting amplitude, a negative number would indicate that exercise amplitude was lower than the resting amplitude. **Main Outcome Measures:** The EMG data from the 10 exercises for all 19 subjects was determined with both EX_{RVC} and the $EX_{\%CHG}$ methods and the mean EMG data for were compared using a bivariate Pearson correlation.

Results: The correlation between the two methods for supraspinatus was $r=0.85$, ($p=0.002$) and the correlation for the infraspinatus was $r=0.920$, ($p=0.0001$).

Conclusions: Both methods of data analysis yield comparable results when attempting to evaluate muscular demand of an exercise and may be useful when testing an injured population. The %CHG method of data analysis may be a useful way to compare EMG data between patients who are not able to perform maximal or submaximal voluntary contractions due to risk of reinjury. Funded by University of Kentucky Orthopedics Department Educational Grant

Upper Quadrant Posture Effects On Subacromial Space In Subjects With And Without Rotator Cuff Disease Using Ultrasonography

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Context: Poor upper quadrant posture is associated with altered scapular kinematics and rotator cuff disease (RCD) of the shoulder. Mechanistically, alterations in upper quadrant posture may contribute to RCD by reducing the subacromial (SA) space and compressing the contents of the SA outlet. **Objective:** To examine the effects of 3 posture positions, neutral, upright, and slouched posture on SA space at various positions of arm elevation. We hypothesize when compared to neutral posture, upright posture will increase the SA space, and slouched posture will decrease SA space. **Design:** Two-group repeated measures. **Setting:** Laboratory setting. **Patients or Other Participants:** Patients free from shoulder pain (HTHY, $n=29$, 31.9 ± 10.7 yrs) and patients with RCD ($n=31$, 53.5 ± 13.7 yrs) confirmed with magnetic resonance imaging. **Interventions:** An ultrasound (US) unit (Pyramid 764) with a 7.5 MHz frequency linear array transducer was used to obtain images of the SA space of each subject's painful shoulder (RCD) or a randomly selected shoulder (HTHY) by placing the US probe at the posterolateral aspect of the shoulder. An US image was collected, and the SA space was

measured via the acromiohumeral distance (AHD), defined as the shortest distance between inferior acromion and the superior humerus. The AHD was measured using on screen calipers in mm. The reliability of this measurement is excellent [$ICC_{(3,1)} = 0.83-0.92$]. Two trials were collected and averaged with arm at rest (0° elevation), 45° abduction, and 90° flexion with the subject in normal resting posture, slouched posture, and upright posture. Posture positions were standardized across subjects. Two trials at each arm position were averaged for data analysis. **Main Outcome Measures:** The AHD measurements. **Results:** Two-way repeated-measures ANOVAs were used to compare AHD across postures and groups at each arm position. There was no interaction between group and posture and no significant main effect of group for AHD at each shoulder position. There was a significant main effect of posture on AHD in both groups at the 45° abduction ($p < 0.001$). Specifically, with the arm at 45° abduction, AHD was greater in the upright posture (AHD = 9.76mm, SE = 0.27) as compared to neutral posture position (AHD = 8.63mm, SE = 0.26). No other significant differences were found between postures at the three arm angles.

Conclusions: Upright posture demonstrated a greater AHD measurement as compared to the neutral posture position when the arm was elevated to 45 degrees of abduction. Posture can influence SA space, however the effect is limited, as there were no difference between postures when the arm was at rest or 90 degrees of flexion. Moreover, the slumped posture did not demonstrate an effect on SA space. Disease state does not appear to mitigate the effects of posture, as SA space did not differ between RCD and healthy subjects. Funded by a General Research Program Grant from the NATA Research and Education Foundation.

Free Communications, Poster Presentations: Physiological Response to Physical Activity

Thursday, June 18, 2009, 8:00 AM-12:00PM, Park View Lobby, Concourse Level; authors present 11:00AM-12:00PM

A Comparison Between Bone Density Of The Distal Tibia In Swimmers With And Without Medial Tibial Stress Syndrome (MTSS) Following Dry-Land, Weight Bearing Training

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Context: Previously, a limited number of investigations have compared bone mineral density (BMD;g/cm²) measures in individuals with and without medial tibial stress syndrome (MTSS). Similarly, initiation of weight bearing "land training" exercises in swimmers provides a unique investigative model as they are unaccustomed to this type of training. **Objective:** To determine differences in distal tibial BMD measures in swimmers who are symptomatic (S-MTSS) versus asymptomatic (A-MTSS) for MTSS following 8-weeks of dry land, weight-bearing training. **Design:** A cross-sectional descriptive design was employed. **Setting:** Dual-energy x-ray absorptiometry (DXA) scans and questionnaires were completed in the University of Kentucky Body Composition Core Laboratory. **Patients or Other Participants:** Sixty-six (34 men and 32 women) varsity Division I swimmers participating in 8 weeks of dry land, weight bearing training. Thirty-five swimmers had symptoms of MTSS (S-MTSS) and 31 swimmers reported no pain or soreness related to MTSS (A-MTSS). **Interventions:** Symptom questionnaires and physical examination of the lower leg performed by a certified athletic trainer were used to categorize the subjects into the S-MTSS and the A-MTSS groups at any time during the 8 weeks dry land training. Total body DXA scans were used to manually create right and left distal one-third tibial regions and analyzed using a Lunar DPX-IQ (GE Lunar Inc., Madison, WI) bone densitometer at the conclusion of the 8-week dry land training. All scans were analyzed by a single trained investigator using software version 4.3. **Main Outcome Measures:** The distal regional tibial BMD measures were the main outcome measures. Repeated measures analysis of variance was used to determine differences in the distal tibial BMD measures between the S-MTSS and N-MTSS groups. **Results:** The right and left distal tibial third BMD was significantly lower (1.04 ± 0.11 vs 1.11 ± 0.14 g/cm², $P = .029$; and 1.03 ± 0.11 g/cm² vs 1.10 ± 0.13 g/cm², $P = .019$; respectively) in the S-MTSS versus N-MTSS groups. **Conclusions:** These findings suggest that lower BMD measures in swimmers may increase the likelihood of

developing MTSS during dry land training, and subsequently weight bearing activities should be appropriately introduced in this group of athletes to minimize the development of MTSS.

The Effect Of Delayed Puberty On The Growth Plate

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Context: Female athletes, involved in intense training, are at an increased risk of developing the female athlete triad (disordered eating, amenorrhea, and osteoporosis) which can cause acute and long term skeletal injury such as stress fracture and osteoporosis. Primary amenorrhea (delayed puberty), suppresses estrogen levels during puberty. An increase in estrogen is responsible for maturation of the growth plate where as a decrease in estrogen could lead to the prolonged opening of the growth plate and potentially exacerbate the window of vulnerability to fracture in young athletes. **Objective:** The purpose of this investigation was to determine whether a delay in puberty will cause an increase in growth plate width and how an increase translates to the maturity. **Design:** Randomized control comparison group. **Setting:** Study conducted in Research laboratory. **Patients or Other Participants:** Forty-eight female Sprague-Dawley rats (23 days-of-age). All procedures were approved by (IACUC) at Brooklyn College. **Interventions:** Independent variables were age (short term or long term) and group (delayed puberty or normal puberty). The animals were randomly assigned to one of four groups ($n=12$); short-term control (C-ST), long-term control (C-LT), short-term GnRH antagonist (G-ST) and long-term GnRH antagonist (G-LT). At 25 days-of-age, daily injections of gonadotropin-releasing hormone antagonist (GnRH-a; Cetrotide™, Serono, Inc.) were used to delay the onset of puberty. All animals were monitored daily for vaginal opening, an indicator of pubertal onset. The left tibia were removed, cleaned of soft-tissue, and processed for histomorphometric analysis. Von Kossa stained frontal slices of proximal tibia (5 μ m thick) were analyzed using a bioquantification system (Bioquant). System consists of a fluorescent microscope (Nikon 800) attached to a digital camera where the image is captured and analyzed in the Bioquant system. **Main Outcome Measures:** Widths of the entire growth plate from the hypertrophic to resting zone were measured and an average value was calculated. **Results:** Short-term control

values for growth plate width were 21.16% wider in the delayed puberty group ($p<0.05$). Growth plate width between long-term control and experimental groups showed a narrowing of the width gap but the experimental growth plates were 34.15% wider than the control group ($p<0.05$). **Conclusions:** Our findings revealed that a delay of puberty in the short term will lead to a prolonged widening of the growth plate. Growth plate recovery is prevalent but does not bring the growth plate back to a normal width range. The window of increase risk to fracture is open longer and could lead to short term and long term problem such as stress fracture and osteoporosis due to the prolonged weakened state of the growth plate.

Dietary Sodium Intake and Sweat Sodium Losses in Professional Football Players during Pre-season Training Camp

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Context: Calculated sweat sodium losses in NFL players during pre-season likely requires sodium replacement beyond some players' typical diet. Researchers, particularly those outside of the USA, contend that large American football players do consume adequate sodium in the diet. **Purpose:** To analyzed dietary sodium intake and sweat sodium losses in NFL players during a day of pre-season practices. We hypothesized that differences would exist in sodium intake versus losses. **Design:** Observational cohort. **Setting:** Data was collected in FB players during a day of preseason practices in August. **Patients or Other Participants:** Thirteen players, randomly selected from one NFL team, agreed to participate. They were: age = 26 ± 2.4 y, height = 186.6 ± 7 cm, mass = 109 ± 18 kg, BSA = 2.33 ± 0.2 m². **Interventions:** Before practices the upper right forearm was prepped with alcohol and de-ionized water and a sterile sweat patch was secured to the skin. Sweat rate was calculated using change in mass adjusted for fluids consumed and urine excreted divided by practice time in h following standard procedures. A comprehensive diet record for each subject was completed by the researchers' by recording foods, food preparation and taking pictures of what was eaten at each meal. Comparisons were made using correlated and

independent t-tests with a Bonferroni correction when indicated. **Main Outcome Measures:** Daily dietary sodium intake and calculated sweat Na⁺ losses for practices lasting 2.25 and 4.5h/d. **Results:** Sodium intake was greater than sodium loss when players practiced 2.25 h/d, $P = .03$, but no different when they practiced 4.5 h/d (intake = 7.7 ± 2.3 g, loss = 9.97 ± 7.3 g). When players who under-replaced ($n=7$) during 4.5 h days they did so significantly such that intake was 7.3 ± 2.1 g and loss was 14.9 ± 5.9 g, $P = .02$. Players' with relatively low sweat sodium losses

($n=6$) over-replaced significantly by consuming 8.2 ± 2.6 g while only losing 4.3 ± 3.6 g. When the two groups were compared, those who over replaced sodium (over-replacers) had the same dietary sodium intake as those that under replaced (under-replacers), (8.2 ± 2.6 versus 7.3 ± 2.1 g) but had lower daily sweat sodium losses $4.3 \pm .6$ g versus 14.9 ± 5.9 g, $P = .005$. Coincidentally, there were no physical differences (height, mass, BSA) between over-replacers and under-replacers. **Conclusions:** Although overall the

13 NFL players replaced sweat sodium losses during pre-season when they practice 4.5h/d, there was large individual variability in daily sodium losses. Only one of the 13 players was within 500 mg of sodium balance (intake versus losses) and the other 12 were split evenly as over-replacers or under-replacers. Notably, players who are heavy, salty sweaters do not consume adequate sodium in their diet and likely require additional sodium replacement.

Free Communications, Poster Presentations: Case Report Posters

Thursday, June 18, 2009, 8:00AM-12:00PM, Park View Lobby, Concourse Level; authors present 11:00AM-12:00PM

Hyperextended Knee In A Collegiate Football Quarterback

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Background: Athlete is a 19 year-old male college football quarterback. The athlete was preparing to pass when his trail leg (right leg) was struck by an opposing tackler. The athlete's leg was in a closed chain position with the playing surface when he received a force inferior to the patella causing his knee to hyperextend. The athlete removed himself from the game and was evaluated by the Certified Athletic Trainer (ATC). Physical exam revealed no obvious deformities. Athlete was point tender over the tibial tuberosity and within the popliteal fossa. Obvious weakness and pain were noted in active and resistive knee flexion and extension. Orthopedic special tests revealed (-) Lachman's, (-) Anterior Drawer, (-) Valgus, and (-) Varus stress tests. Athlete did present with a Posterior Sag and (+) Posterior Drawer. **Differential Diagnosis:** Hamstring Strain, Anterior Leg Contusion, Anterior Cruciate Ligament (ACL) Sprain, Femoral Condyle Contusion, Tibial Plateau Contusion, Posterior Cruciate Ligament (PCL) Sprain. **Treatment:** Initial treatment consisted of pain and swelling control through ice and a compression bandage. The athlete was then referred to the team orthopedic physician. Diagnostic imaging consisted of an X-ray and MRI two days post injury which confirmed the on-the-field diagnosis of a third degree Posterior Cruciate Ligament sprain. Once the initial inflammation was controlled, the athlete began rehabilitation exercises. It was decided by the team orthopedic surgeon in collaboration with the ATC, that a conservative treatment plan would be instituted. Specific focus was given to strengthening the quadriceps and enhancing the athlete's proprioception. The athlete was able to return fully to competition 3 weeks post injury. The athlete was placed in a Don Joy functional knee brace for sport participation and

functional rehabilitation and the athlete reported no problems while participating. There was no bracing required for activities of daily living. The athlete continued with rehabilitation exercises after returning to full competition. **Uniqueness:** Third degree sprains of the PCL are usually caused by the athlete falling on the knee and forcing the knee into hyperflexion when the ankle is plantar flexed or receiving an anterior force while the knee is bent to at least 90 degrees. The PCL can also be injured by a rotational force. Most often, the mechanism of injury that is presented in this case typically results in an ACL sprain with the possibility of an associated medial collateral ligament sprain; therefore, the resulting PCL injury demonstrated in this case is a rarity among the physically active. **Conclusion:** This case highlights the diagnosis of a third degree Posterior Cruciate Ligament sprain in a college football player. The athlete has made a full recovery through conservative treatment. This case highlights the need for the certified athletic trainer to remain to engage in a thorough differential diagnosis process to account for the causes of unusual injuries. This case demonstrates a highly unlikely mechanism of injury that resulted in a third degree PCL sprain.

A Division I Football Player With Recurrent Debilitating Hip Pain

Branam B, Booi MJ, Butterfield TA, Medina McKeon JM: University of Kentucky, Lexington, KY

Background: A 19 year-old Division I defensive tackle injured his right hip with a hyperextension mechanism during a game. Past medical history included markedly decreased hip range of motion (ROM), especially into flexion, which was discovered during his freshman year pre-participation exam. Subsequent MRI revealed a labral tear in his right hip and an arthroscopic debridement was scheduled. Following labral debridement, he continued to participate relatively pain free, but had persistently limited

ROM. The following season, he sustained a severe hip trauma during a game. On the field, the athlete complained of excruciating pain and was unable to bear weight. Off-field examination revealed marked pain with passive hip adduction and flexion. The athlete was transported to the emergency department. **Differential Diagnosis:** Labral tear, hip fracture or dislocation, avulsion fracture, and hip flexor strain. **Treatment:** X-rays revealed a small heterotopic exostosis extending proximally off his lesser trochanter. CT scan revealed a fracture through the base of the lesser trochanter. MRI revealed edema around the lesser trochanter and the fracture site. He was initially treated nonoperatively due to the propensity to develop new HO with surgical intervention. He was placed on crutches with toe-touch weight-bearing (TTWB). One week post-injury, the fracture site was injected with cortisone, which significantly alleviated his pain. He then began aquatic therapy with goals of increasing hip strength and ROM while progressing to weight-bearing with crutches. Three weeks post-injury, X-rays were repeated with no change in the exostosis or the fracture site. Subsequent clinical exam revealed a significant decrease in pain and nearly normal ROM when compared bilaterally. Once able to perform a straight leg raise, he was cleared to full weight-bearing and began jogging at 4 weeks post-injury. He returned to baseline conditioning levels, and with aggressive rehabilitation to increase hip ROM and strength, he returned to full activity 5 weeks post-injury. However, nine weeks after the initial injury he re-aggravated his right hip. He continued to experience pain throughout the remainder of the season and into spring conditioning. After exhausting all conservative treatment options with no pronounced symptom relief, he was referred to a bone specialist for surgical consultation. X-rays and CT scan taken 49 weeks post-injury revealed that the heterotopic exostosis had increased in size to 7-cm. Three-fifths of the exostosis were excised arthroscopically, however due to the increased risks of injury to the femoral nerve and for developing further HO, the

remainder of the lesion was removed a week later through an open anterior approach. He was placed on crutches TTWB for two weeks postoperatively, and allowed to return to walking as tolerated. Gentle hip ROM and strengthening exercises were performed initially and increased in intensity as tolerated. He was cleared to begin impact running after 6 weeks postoperatively. X-rays taken 21 weeks post-surgery were unremarkable and revealed no new heterotrophic bone growth. He was able to return to play at a level equal to or above baseline. **Uniqueness:** Large heterotrophic exostoses can be debilitating, especially in high-intensity athletes. This athlete was able to participate even with a large exostosis present in his right thigh. It was not until it fractured, that he was truly limited from participation. In addition, a non-displaced fracture through strong cortical bone with no joint dislocation is very unusual, and had not been previously observed by any of the involved physicians. **Conclusions:** Surgical intervention of HO is generally avoided due the risk of recurrent excessive bone growth. After failure with conservative treatment, the surgical removal of a large heterotrophic ossification in a Division I football player was not career ending and the athlete was able to return to full participation.

A Knee Fracture With A MCL, ACL, And Lateral Meniscus Tear With Intracondular Displacement Of The Medial Meniscus

Campbell EE, Long BC, Hunt R, Pascale M, O'Brien M: Oklahoma State University, Stillwater, OK

Background: A 23 year old NCAA Division I male athlete with no history of knee pathologies was participating in a football game. During a live play the athlete ran, stopped and planted his left foot and was hit above the waist resulting in a valgus force to the knee. The athlete subsequently collapsed on the field. During the evaluation, the athlete stated that he heard and felt a pop in his knee. There was no obvious deformity or swelling immediately following the injury. There was pain with palpation at the joint line and medial side of the knee. Active and passive range of motion and strength were significantly limited. The Head Athletic Trainer and Head Team Physician agreed that the athlete had a positive Lachman's test and a valgus stress test at 0° and at 20°–30° of flexion. Radiographic images revealed an impact fracture of the medial femoral condyle and medial tibial plateau. A medial collateral ligament, anterior cruciate ligament and lateral meniscus tear with irregular intracondular displacement of the medial meniscus was also present. **Differential Diagnosis:** Possible injuries included a ruptured: anterior cruciate ligament, posterior cruciate ligament, medial collateral ligament,

semitendinosus or semimembranous. Additionally lesions of the lateral meniscus and medial meniscus or tibiofemoral dislocation were possible. **Treatment:** The athlete received cryotherapy immediately following the injury, was placed in a knee immobilizer at 0°, and educated on crutch walking non-weight bearing. Surgical repair of the anterior cruciate ligament was performed 12 days following the injury using the semitendinosus tendon graft reconstruction. Additionally the medial and lateral menisci were reattached to the tibial plateau. The day after surgical repair, rehabilitation involving cold treatments, non-weight bearing towel stretches, and clinician assisted PROM exercises consisting of dorsiflexion/plantarflexion exercises were performed. Approximately 1 week following surgery, additional exercises involving knee flexion/extension PROM and daily-adjusted progressive resisted exercises were incorporated into the rehabilitation. **Uniqueness:** The injury is unique because of the mechanism. It is suggested that O'Donahue's "unhappy triad" occurs when a valgus stress applied to the knee causes damage to the MCL, ACL, and medial meniscus. However, a direct hit above the waist resulting in a valgus stress to the knee with the foot in a planted position results in damage to the MCL, ACL, lateral meniscus, medial meniscus and an impact fracture of the lateral femoral condyle and tibial plateau. **Conclusion:** The diagnosis of this injury was difficult because of each anatomical structure involved. As a result, this case report should make athletic trainers aware that although a valgus stress may cause damage to the anteriomedial region of the knee; all structures are susceptible to injury regardless of the mechanism.

Knee Pain In A High School Football Player

Jacobs D, Milbrandt T: University of Kentucky, Lexington, KY

Background: A 14-year-old male reports to the sports medicine clinic due to an injury that occurred during a football game. He states he twisted his left knee while being tackled and was landed on by another player. Upon examination, he had point tenderness along the medial joint line with mild effusion on the medial aspect of his left knee. He was unable to weight bear or straighten his left leg. His knee was stable in varus and valgus stress. He was guarding on Lachman's and McMurray's exams. Apprehension of his patella was negative. **Differential Diagnosis:** Possible injuries to the left knee include a medial collateral ligament sprain, anterior cruciate sprain, medial meniscus tear, or a Salter-Harris fracture. **Diagnostic Imaging:** Radiographs and MRI revealed a Salter Harris III fracture with fracture line passing through the

medial part of the lower epiphysis and the distal metaphysis of the femur. No other abnormalities were seen on the MRI. He was then referred to a pediatric orthopedic surgeon and a CT scan was ordered to check the extent of growth plate damage. The CT revealed the fracture ran completely through the epiphysis and separated the epiphysis and growth plate from the metaphysis with a two-centimeter gap. This area was also angulated and rotated posteriorly. The results of the CT scan along with the benefits, complications, and risks of surgery were discussed with the patient and his parents. **Treatment:** Due to his age, and continuing bone growth, a right femoral epiphysodesis was planned to create bone growth arrest. This procedure was done to reduce the possibility of leg length discrepancy. An open reduction and internal fixation of the left distal femur, by reducing the fracture with two screws was the preferred procedure. Next a left hemi-epiphysodesis and a right femoral epiphysodesis were done. After the surgery, the left leg was placed in a long leg cast. The right leg was placed in a knee immobilizer and he was instructed to bear weight as tolerated. He reported to the clinic two weeks later to have his cast removed and replaced, wound checked, and staples removed. He was allowed to weight bear and began range of motion as tolerated on his right knee. On his one month post-operative clinic visit, his cast was removed and AP/Lat x-rays were taken and there were no signs of screw migration. His left knee was then placed in an ELS brace, which was locked at zero degrees except when doing passive and active range of motion exercises. Quad sets and straight leg raises in four directions were begun on his left knee. Exercises were progressed on the right knee. Eight weeks after surgery, his ELS brace was unlocked to 0-90 degrees, and he continued to be non-weight bearing on his left leg. His was able to progress activity as tolerated on his right knee. Leg strengthening progression continued on both legs. Three months after surgery he was weight bearing with no signs of leg length discrepancy. He decided not to return to sports after six months. **Uniqueness:** Salter Harris fractures are unique to pediatric patients and rarely occur. This case presents a unique situation where surgical treatment of the uninvolved side may be necessary to prevent future limb asymmetries. Rehabilitation on each leg varied and progressed at different rates which added to the uniqueness. **Conclusion:** Knowing of the classification of this fracture is important because it provides proper treatment for the injury. Possible long-term complications of this type of injury are bone growth disruption leading to leg length discrepancy, angular deformity, joint stiffness and degenerative arthritis.

Radiographic Error When Diagnosing ACL Deficient Knee 1 Year Post Acute Trauma

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Background: A 20-year-old male presented to the Emergency Department with a chief complaint of right knee pain. Two days prior, he fell while jumping off a trampoline. Upon landing, he reported that his right knee popped and gave way. Pain was 8/10 at rest and increased with motion, it was non-radiating. Physical findings consisted of diffuse tenderness without swelling or effusions. X-rays taken were negative for bony deformity. Treatment included crutches, knee immobilizer and Lortab for pain relief. Eight days later, the patient was seen at the UK Orthopaedic Surgery and Sports Medicine Clinic with complaints of 10/10 pain, instability, decreased ROM, and moderate effusion. Clinical evaluation presented with negative patellar apprehension, stable valgus/varus stress testing at zero and thirty degrees, guarding with Lachman's, and anterior and posterior drawer. McMurray's test produced pain over the medial joint line. Good strength and 2+ posterior tibial pulse was assessed. An MRI was ordered and patient was told to continue to use brace, crutches, ice and follow up in one week. **Differential diagnosis:** Possible injuries include patellar dislocation, ACL rupture, MCL sprain, and medial meniscus tear. **Treatment:** Initial MRI impression: complete disruption of ACL mid-substance, grade I MCL sprain, extensive bone contusion pattern consistent with pivot shift mechanism, no definite meniscal tear, and large hemarthrosis was present. The patient was educated about treatment options but decided not to have ACL reconstructive surgery. The patient was given a home exercise program and restrictions. One year post initial injury, patient felt symptoms of right knee instability, pain and swelling. He was seen by his primary care provider and a second MRI was ordered. The second MRI was read as having normal findings of the right knee. Patient was then seen by a second orthopaedic surgeon who diagnosed a grade I MCL sprain. However, patient felt this was unsatisfactory since symptoms of instability were not resolved. The patient then returned to UK Sports Medicine and his clinical exam revealed a positive, grade I-II Lachman's with endpoint, positive but mild pivot shift, and mild opening of the MCL at thirty degrees during valgus load. Diagnostic arthroscopy and ACL reconstruction was scheduled. Diagnostic arthroscopy revealed a lateral posterior horn meniscus tear, medial meniscal capsule avulsion on posterior horn of the medial meniscus, and ACL disruption. A successful surgical fixation of medial meniscus and ACL reconstruction using hamstring

autograph was completed. Post-surgical physical therapy ensued with no further complications.

Uniqueness: The initial MRI and second MRI images show changes from an acute ACL tear to a chronically ACL-deficient knee. Without the proper knowledge of the patient's history and clinical exam, an ACL-deficient knee was misdiagnosed by a primary care provider, radiologist and an orthopaedic surgeon due to the healing response shown on the second MRI.

Conclusion: Typically, the ACL has a smooth, well-defined, low-signal-intensity contour seen on sagittal images within the intercondylar notch. Although the ACL appeared to be intact and there wasn't acute trauma commonly associated with ACL tear, there were signs of tissue abnormality within the ACL in the second MRI image. Without a thorough clinical exam and history of pathology, a chronically deficient ACL cannot be ruled out based on MRI findings alone.

Anterior Cruciate Ligament Rupture And Displaced Bucket Handle Tear Of The Lateral Meniscus In A Male Collegiate Lacrosse Player

Liberty JM, Sparrow SL: Boston University, Boston, MA

Background: A 19-year-old male collegiate club lacrosse player sustained an acute non-contact injury to his left knee during practice on a turf field in mid-February. The patient received a pass, planted his left foot, twisted, and fell on his left knee. Patient was assisted off the field and upon examination he presented with non-descript left knee pain of 8/10 severity on a verbal scale. Palpation revealed tenderness over the lateral tibial plateau, fibular head, and posteriorly over the hamstring tendons. Stress testing of PCL and MCL did not indicate an injury to those structures. Varus stress test was positive for pain but negative for laxity. No definitive end-feel was noted for the ACL with Lachman's and Anterior Drawer tests. McMurray's and Apley's meniscal tests were both negative. Approximately 30 min post injury there was a small pocket of inflammation present over the fibular head. The Patient has a history of traumatic injury to his right shoulder including 3 dislocations and multiple subluxations suggesting general ligamentous laxity. **Differential Diagnosis:** ACL sprain, PCL sprain, LCL sprain, biceps femoris strain, meniscal tear, fibular head fracture. **Treatment:** Patient was unable to WB following injury and was fitted with crutches and an elastic wrap after a 20-minute application of ice. Re-evaluation the following morning noted significant effusion and ecchymosis around the patella and lateral knee. Patient was referred to orthopedic surgeon for diagnostic imaging and diagnosis. X-ray imaging was obtained and fibular head fracture was ruled

out. Physician examination identified grade 3+ effusion, and ruled out MCL, LCL, and PCL injury. MRI revealed evidence of an ACL tear and a bucket handle tear of the lateral meniscus displaced into the center of the joint. Patient was unable to achieve full passive extension secondary to the displacement of the meniscus; therefore surgical intervention was scheduled for the following week. Examination under anesthesia revealed a positive lateral pivot shift, a positive anterior drawer, and an inability to achieve full passive extension. Surgical intervention consisted of arthroscopic ACL reconstruction with posterior tibialis tendon allograft and lateral meniscal repair. Postoperative diagnosis was left knee 3° ACL sprain and a bucket handle lateral meniscal tear. The patient was cleared to begin a rehabilitation protocol during the second week post surgical intervention. One month post-op patient was cleared to start progressive WB. At two months post-op patient had no lateral joint pain or instability, and was FWB. However, he still lacked 2° of extension at this time. The patient achieved full extension and flexion to 140° at 3 months post-op. ACL stability was established at this time by the physician through Lachman's and anterior drawer tests. At the end of 3 months of rehabilitation, his gait pattern was normal and pain free. The physician advised 2 additional months of rehabilitation for strengthening and functional exercises.

Uniqueness: The amount of trauma that occurred in his knee is atypical of a non-contact, twisting mechanism of injury. The most common mechanism for lateral meniscal injury in a young adult population is direct impact. The medial meniscus, not the lateral, is typically prone to injury with concurrent ACL sprains due to shared attachments. Additionally, the displacement of the lateral meniscus into the center of the joint is uncommon. **Conclusions:** Although the mechanism of injury may be typical for an ACL tear, this case demonstrates that one must not approach an evaluation with pre-conceived notions regarding specific pathologies. In this case, it was imperative to consider differential diagnoses during physical evaluation. Additionally, this case highlights the importance of on-going evaluation methods to make an accurate diagnosis.

Lateral Knee Pain In A Collegiate Soccer Goalkeeper

Shaya E, Simich A, Laursen RM: Boston University, Boston, MA

Background: A 20-year-old female Division I soccer goalkeeper presented with sharp pain over the lateral left knee. The injury occurred in October 2008 while making a save during a game. The patient jumped off her left foot and landed with her left ankle forced into dorsiflexion causing

the knee to slightly buckle laterally. The patient reported an inability to generate power or push off the left leg. The fibular head and lateral joint line were tender to palpation. Full active range of motion both knee flexion and ankle dorsiflexion were painful. The patient reported her knee would lock when in full extension. Pain was present with anterior drawer, McMurry's, Thessley's, varus, and Appley compression, but there was no laxity, instability, clicking or catching. The patient's medical history revealed left hip inflammation, left IT band fraying/left tensor fascia lata strain, left gluteus maximus contusion, and right hip dysplasia as an infant which was treated with a Pavlik harness.

Differential Diagnosis: Lateral meniscus tear, lateral collateral ligament sprain, proximal fibula subluxation, patella subluxation. **Treatment:**

The team physician found specific lateral joint pain with no medial joint pain. The patient had positive meniscal compression and positive squat tests without instability to varus or valgus stress. Anterior drawer and Lachman were negative. The team physician diagnosed a possible lateral meniscus tear. An MRI was obtained, which revealed a partial tear involving the origin of the left extensor digitorum longus muscle from the upper aspect of the medial fibular head. Both menisci were intact. All other bony and soft tissue structures were unremarkable. Thus, the injury was treated as a muscle strain focusing on reducing pain in the left knee with ice massage (10 mins), bipolar electrical stimulation (15 mins), non-thermal ultrasound (3Mhz, 5 mins, 25%), ibuprofen (800mg 3x's day), and ankle taping to limit dorsiflexion. However, the patient continued to have pain with activities of daily living, preventing her from beginning functional rehabilitation until the end of the season. The team physician prescribed a tall walking boot when not participating in soccer, discontinuation of lower body weight lifting, modification of activity during practices, and a night splint to keep the ankle in dorsiflexion while sleeping. The patient was able to complete the remainder of the season with these limitations. The team physician's post-season follow-up examination revealed full knee range of motion, pain to palpation directly over the proximal portion of the extensor digitorum longus, no specific lateral joint line pain, and no subluxation of the proximal fibula. Post-season treatment is in progress and consists of two weeks of rest in the walking boot followed by range of motion, proprioceptive, and strengthening exercises.

Uniqueness: This injury presented as a lateral meniscus tear due to the mechanism of injury, lateral joint line pain, and positive clinical meniscal tests. It seemed unlikely the patient would partially tear an extensor tendon, especially at the origin, based on the details of this case. In addition, it seemed inconsistent that the patient would have lateral joint line pain when the proximal attachment of the extensor digitorum

longus muscle is on the medial fibular head. Similar cases do not appear to be prevalent within collegiate athletes. **Conclusions:** This is an example of a case with an unexpected diagnosis. A thorough evaluation of lower extremity muscle strength may have provided more insight into the underlying problem prior to diagnostic testing. Interestingly, the patient's pain corresponded to the origin of the extensor digitorum longus on the fibula head. The MRI proved to be a valuable tool in the management of this patient.

Athletic Pubalgia Resulting From Recurrent Groin Strains, Muscular Imbalances, And An Anatomical Leg Length Discrepancy In A Male Collegiate Soccer Athlete

Holsinger R, Webb J, Ramshaw B, Tomchuk D: Missouri Valley College, Marshall, MO, and Missouri Health Institute, University of Missouri Health Care, Columbia, MO

Background: A 22-year-old male collegiate soccer athlete with a history of groin strains and a 1-cm anatomical leg length discrepancy experienced right abdominal and groin discomfort during a summer league soccer match. The athlete self-treated with rest and ice for approximately two weeks; with no alleviation of his symptoms which were an inability to sit-up without pain, a pulling sensation in his right medial thigh, and discomfort when his abdominals were tightened. The athlete consulted his family physician, who ruled out internal medical issues (appendicitis, kidney stones, and an inguinal hernia) diagnosed him with athletic pubalgia. The athlete subsequently reported to his college soccer team and was evaluated by the Athletic Training staff. The examination revealed pain during resisted sit-ups with trunk rotation and a positive Valsalva. Manual muscle testing determined the hip adductor strength to be 3/5 and 4/5 on the athletes' right and left. The Athletic Training staff determined that athletic pubalgia was a likely diagnosis; treating the athlete with rest, NSAIDs, moist heat, stretching, ultrasound, and ice daily. After 2 weeks, no significant changes in the athletes' symptoms were noted and the athlete was referred to an area physician who has substantial experience in treating athletic pubalgia.

Differential Diagnosis: Osteitis pubis, rectus abdominis strain, inguinal hernia, femoral hernia, pelvic stress fracture, and hip adductor strain.

Treatment: An MRI revealed small bilateral subchondral cysts and mild degenerative changes at the pubic symphysis, consistent with osteitis pubis. A small posterior disc bulge at L4-5 was also noted. A laparoscopic bilateral inguinal hernia repair with polyester mesh was recommended and subsequently performed. Initial rehabilitation protocol consisted of ice, wound

management, and restriction from heavy lifting for 2 weeks; allowing for wound and tissue healing. Since the athlete has a history of groin strains a conservative rehabilitation program was implemented. After 2 weeks, the athlete was relative pain-free and progressed to moist heat, ultrasound, and stretching treatments combined with basic pelvic stabilization exercises. The athlete began to include light jogging activities 3 weeks post-surgery. After 4 weeks, the Athletic Training staff tested the athletes' bilateral hip abductor/adductor strength. This revealed a 3:1 hip abductor/adductor strength ratio on the right and a near 1:1 ratio on the left. The Athletic Training staff subsequently implemented basic slideboard, eccentric hip adduction, gluteal, and dynamic stabilization exercises to address these muscular imbalances and active release techniques to reduce scar tissue formation. At 6 weeks the athlete began general cardiovascular conditioning and increased the difficulty of his running and exercise program. The athlete progressed to dynamic abdominal and pelvic exercises by the 8th week followed by basic agility, jumping, and footwork exercises during the 10th week. After 12 weeks the athlete will begin soccer specific conditioning exercises gradually progressing to full-participation while maintaining a variety of exercises to prevent future muscular imbalances.

Uniqueness: The L4 nerve root innervates many of the gluteal, lateral rotator, and hip adductor group muscles. This athletes' muscular imbalances may have been created by his slight L4-5 bulge which were exacerbated by his anatomical leg length discrepancy and previous groin strains. Athletic pubalgia may have resulted from these combined abnormal stresses placed on the pelvic region. A case report on athletic pubalgia with this history has not been presented in Athletic Training literature. **Conclusions:** A thorough evaluation of the kinetic chain should be performed on athletes suffering from athletic pubalgia. Predisposing factors (previous muscular strains, muscular imbalances, and leg length discrepancies) may cause abnormal forces on the hip and pelvic region resulting in the development of athletic pubalgia. Athletic Trainers should evaluate the kinetic chain and address any abnormalities noted.

Insidious Onset Of An Avulsion Injury At The Hamstrings Origin In A Collegiate Softball Player

Vitale SR, Smith KJ, Gribble PA; University of Toledo, Toledo, OH

Background: This case report details a hamstring injury sustained by a 19 year old Division I collegiate softball player while running the bases. The athlete denied feeling a pop or snap and upon initial evaluation, the proximal posterior thigh was point tender, however no ecchymosis or edema was noted. The athlete

demonstrated very minimal loss in strength and function and therefore the injury was classified as a grade I hamstring strain. The athlete was allowed to participate as pain permitted and was able to finish the season. Despite ongoing conservative treatment the symptoms continued over the next 5 months; at that time, her participation was discontinued. Following one month of complete rest and several failed treatment plans, her symptoms were unresolved and she was sent for surgical consultation. She had no history of hamstring injury to either leg; however she reported a history of ipsilateral MCL and an L4-L5 stress fracture during high school. **Differential Diagnosis:** Chronic Proximal Biceps Femoris strain, Proximal hamstring avulsion and soft tissue abnormality were considered as possible injuries. **Treatment:** Following the initial injury, traditional hamstring strain treatment and rehabilitation were performed including ice, electrical stimulation, pain-free stretching and strengthening, and manual therapy techniques. At 6 months post-injury, radiographs were unremarkable for bony

injury. A significant leg length discrepancy and associated sacroiliac dysfunction was discovered and treated, but hamstring pain persisted. An MRI taken 10 months post-initial injury revealed a partial avulsion from the ischial tuberosity as well as a small tear in the conjoining tendon of the biceps femoris and semitendinosus. Following MRI results, surgical intervention was performed to repair the avulsion and tendon disruption. Surgical procedures included reattachment of the proximal conjoining tendon to the ischial tuberosity and repair of the disrupted tendon. The athlete rested for 6 weeks following surgery and has since nearly completed a rehabilitation program. The athlete is currently performing sport-specific functional drills without symptoms. A full recovery and return to competition is expected. **Uniqueness:** This injury represents an insidious onset avulsion that resulted from accumulated microdamage despite the progression through a traditional conservative rehabilitation program. The treating ATC used a program that had been successful in other athletes with similar pathology. This case presented

unique challenges as the common hamstrings pathology was confounded by the gradual build up of microtearing at the hamstrings origin. **Conclusions:** While strain to the hamstrings is a common pathology treated by Athletic Trainers, not all hamstring injuries will resolve themselves in a usual timeline. This case study represents an injury that worsened even though the athlete was progressed through an appropriate rehabilitation timeline by a certified Athletic Trainer. Due to unknown microtrauma, the structural integrity of the tissue may become compromised and may require surgical intervention. **Clinical Application:** Given their biarticular action, the hamstrings are placed under high demand during the gait cycle and must withstand constant tension during all phases of running and walking. Continued pain at the origin of the hamstrings may indicate unresolved healing and/or avulsion injury, and while treatment methods are limited, special attention should be paid to continued symptoms even if certain levels of function are restored.

Free Communications, Poster Presentations: Protective Equipment

Thursday, June 18, 2009, 1:00PM-5:00PM, Park View Lobby, Concourse Level; authors present 4:00PM-5:00PM

Face Mask Removal In Newly-Designed Football Helmets

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Context: Newly-designed football face mask (FM) attachment systems may impact the effectiveness of emergency FM removal by athletic trainers. **Objective:** To compare the effectiveness of FM removal on newly-designed and traditional football helmets. **Design:** Repeated measures. **Setting:** Controlled laboratory. **Participants:** Twenty-five subjects (13 male, 12 female, age=31.79±10.14) were recruited from among local certified athletic trainers (9.24±7.18 years certified). Subjects were free from significant upper extremity or central nervous system injury and provided informed consent. **Interventions:** Subjects removed FMs from 3 styles of helmets in two conditions (unaltered hardware, altered hardware). The approach to FM removal varied according to helmet style with subjects using the combined-tool technique (screwdriver first, cutting tool as necessary) for Traditional and Riddell Quick Release (QR) helmets, and using a cutting-tool-only approach for the Schutt Ion helmet whose FM cannot be removed with a screwdriver. Hardware (screws or QR mechanisms) was altered to unexpectedly challenge subjects during removal. Independent variables were helmet-FM

attachment system (Traditional, QR, Ion) and hardware status (unaltered, altered) for a total of five conditions: 1) traditional unaltered (Trad), 2) traditional altered (TradAlt), 3) QR unaltered (QR), 4) QR altered (QRAlt), and 5) Ion. An investigator reviewed, and subjects practiced, pertinent FM removal techniques before data collection. Subjects encountered each condition twice in random order and were blinded to hardware condition. A stopwatch measured time and a three-dimensional motion capture system recorded helmet motion. If the FM remained attached at 3 minutes, the trial was considered a failure. Repeated measures ANOVAs ($\alpha=.05$) with follow-up pairwise comparisons were performed to test for differences between conditions for time and motion. **Main Outcome Measures:** Dependent variables included: removal success, removal time and combined 3-D head motion. **Results:** Successful FM removal frequency was 100% (50/50) for Trad and QR, 96% (48/50) for Ion, 94% (47/50) for TradAlt, 72% (36/50) for QRAlt. Significant effects were detected for time ($F=50.88_{4,21}$, $P=.001$) and head motion ($F=13.58_{4,21}$, $P=.001$). Pairwise comparisons revealed significant differences in removal time between all conditions except between TradAlt (84.41 ± 15.60 s) and Ion (89.96 ± 33.26 s; $P=.278$). The fastest condition-mean removal time was 34.63 ± 14.24 (QR); the slowest was 101.35 ± 22.74 (QRAlt). Pairwise comparisons for motion revealed QR ($10.15\pm3.02^\circ$) and Trad ($12.07\pm3.90^\circ$) to be significantly different from

QRAlt ($16.13\pm5.00^\circ$), TradAlt ($17.78\pm6.72^\circ$), and Ion ($15.02\pm3.29^\circ$; $P<.05$). **Conclusions:** The unaltered QR resulted in the fastest FM removal times with less head motion than the other helmets. When loop strap cutting was required (altered QR, altered traditional, Ion), there were significantly longer removal times, more motion and lower success rates. These results suggest that the functional QR is ideal for FM removal, but our alteration-induced failure of the QR mechanism significantly challenged our subjects' ability to remove the FM.

Success Rate In Removal Of A New Football Helmet Face Mask Attachment System After One Season Of Use

Gatti JM, Scibek JS, McKenzie JJ: Duquesne University, Pittsburgh, PA, and University of Pittsburgh, Pittsburgh, PA

Context: Technological advancements in football helmet design and construction have led to many changes in traditional football helmets, including facemask attachment systems. Unpublished data suggests favorable removal success rates of Riddell's Quick Release™ (QR) Face Guard System (Elyria, OH), but only in new, unused helmets. **Objective:** The purpose of this study was to examine the success rate in removing Riddell QR clips after one season of use at the Football Championship Subdivision

level in the western Pennsylvania climate.

Design: Single-factor study design. **Setting:** Study was performed in a controlled laboratory setting. **Patients or Other Participants:** Riddell Revolution® football helmets retrofitted with the QR System during reconditioning prior to the 2008 football season were used. The QR replaced traditional side loop straps for face mask attachment. We used 63 helmets, totaling 126 clips (63 left, 63 right). Three certified athletic trainers (31.3 ± 3.06 years, 9.42 ± 2.65 years certified, 2 males, 1 female) performed all testing. **Interventions:** Each athletic trainer attempted to remove the QR clips from each of the 63 helmets using the Riddell insertion tool (part #27515). All helmets had 2 QR clips, providing a total sample size of 378 clips (189 left and 189 right). Successful clip removal was considered to be the ability to remove one QR clip within 15 seconds. Helmet testing order was randomized. Athletic trainer order and starting side (left vs right) was also randomized. After an athletic trainer attempted removal of the QR's, the helmet was reassembled and the next athletic trainer attempted removal. **Main Outcome Measures:** Dependent variables included total clips removed (TCR), total right clips removed (TCR-R), total left clips removed (TCR-L), and success rate of clip removal (SRCR). SRCR was defined as the ability to successfully remove both clips within the allotted time. Clip removal and success rate percentages were calculated. A paired *t*-test was used to compare differences in removal rate for TCR-R and TCR-L. Using a one-way ANOVA differences in SRCR relative to testing order was assessed. An $\alpha=0.05$ was set *a priori*. **Results:** Percentages for TCR, TCR-R and TCR-L were 98.15% (371/378), 96.30% (182/189), and 100% (189/189), respectively. The percentage for SRCR was 96.30% (182/189) while SRCR percentages for trials one, two, and three were 95.24% (60/63), 98.41% (62/63), and 95.24% (60/63), respectively. The paired *t*-test revealed a significant differences between TCR-R and TCR-L ($t_{(188)} = -2.689$, $p = 0.008$, $\mu_d = 0.037$, 95% CI = -0.064 to -0.010). No statistically significant difference was identified for SRCR with respect to trials ($F_{(2,186)} = .588$, $p = .557$, 95% CI = 0.94 to 0.99). **Conclusions:** The results of this study indicate that Riddell's QR system performed favorably after one season of use.

The Presence Of Methicillin Resistant Staphylococcus Aureus (MRSA) In Collegiate Volleyball Players And Volleyball Equipment

Wolfe E, Torres-McGehee T, Carson J, Cairns M, Steinberg J, Stacy J, Mensch J: University of South Carolina, Columbia, SC

Context: Community Acquired methicillin-resistant Staphylococcus aureus (CA-MRSA) is an emerging pathogen found to be carried in the anterior nares, groins, and axillas of people, and these carriers have been shown to have increased rates of infection. Research has shown an increase in colonization during the season, thought to be due to increased contact. To date, no research studies have calculated the prevalence of CA-MRSA on the skin of multiple team members and/or their shared equipment. **Objective:** To calculate the prevalence of CA-MRSA in volleyball athletes and equipment (ball, net-towel, laundry cart). **Design:** Cross Sectional. **Setting:** University clinic and laboratory. **Participants:** Nine collegiate Division I Volleyball players (age= 19.6 ± 1.1 years). **Interventions:** Swabs were taken from the anterior forearm of each subject, 2 random net towels, 3 random practice volleyballs, and the laundry cart. Each sample was placed in a sterile 2ml tube with four aliquots of 500 μ L. Aliquot 1 was stored at a temperature between 10-2°C. Aliquots 2-4 had 125 μ L of glycerol added and was stored at -80°C. A random sample from Aliquot 1 was plated onto the CAN and Oxacillin agar to test for control and sterility of plates. A Denka Seiken MRSA Latex Test Kit for PBP2 was used to identify if the PBP2 protein in samples colony form on the Oxacillin plate. A positive control was a swab of the laboratory counter top and negative control was tested by incubating a newly made agar plate for colonization. **Outcome Measures:** Presence of PBP2 protein and subsequent levels of agglutination within the test circle (strong agglutination=3+, agglutination against slightly turbid background=2+, slight agglutination against a turbid background=1+, and no agglutination=0). **Results:** The presence of MRSA was identified in 4/9 volleyball players, net towels, volleyballs, and the laundry cart. One sample suggested a strong level and presence of agglutination (player), three samples showed a slight agglutination (player, laundry cart, and towels), and three samples showed a slight agglutination (two players and the volleyballs). Five samples from athletes tested negative. **Conclusions:** Findings indicate the presence of MRSA in a collegiate volleyball environment including the balls, net-towels, and athletes. The presence of MRSA on balls and net towels may suggest a vector for transmission of MRSA bacteria from one player to another since each player touches the ball and often towels are shared among team members. Further studies may

assess the colonization rate in the nares, axilla, or groins of athletes and compare to forearm samples. In addition, demographic information and hygiene habits of athletes could be used to establish risk factors for infection and/or colonization. Once the transmission of CA-MRSA in athletes is better understood, athletic trainers, physicians, and pharmacists can improve techniques for prevention of CA-MRSA.

Multi-Drug Resistant Staphylococcus And Micrococcus Species Isolated From Protective Athletic Mouth-Guards

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Context: Microbial analyses of 124 protective athletic mouth-guards (PAM) retrieved from a Division 1 football team (FMG = 84) and a junior league hockey team (HMG = 40) yielded a total of 443 bacterial isolates (FMG = 274; HMG = 169). Of these isolates, 253 were gram positive cocci (FMG = 157; HMG = 96). **Objective:** The objective of this study was to evaluate the susceptibility/resistance of Staphylococcus and Micrococcus species (*spp.*) found in PAM to commonly used antibiotics and the antimicrobial triclosan. **Design:** The PAM were retrieved and replaced from a cross-section of football and hockey players at various times during their respective seasons. **Setting:** This study was performed in controlled field and laboratory settings. **Patients or Other Participants:** After signing an informed consent, 62 football and 18 hockey players volunteered to be a part of the study. **Interventions:** After retrieval of the PAM from the field, they were immediately transported to the Infectious Disease Laboratory at Oklahoma State University Center for Health Sciences for processing. Each PAM was cut aseptically and their surfaces and depths were touched to blood agar plates. These plates were incubated at 37°C for 24 hours. Standard laboratory techniques were used to differentiate and identify gram positive cocci. **Main Outcome Measures:** Antibiotic susceptibilities of all isolates were determined using the Kirby-Bauer procedure. **Results:** Of the 253 total gram positive cocci isolates, the most common were Staphylococcus spp. (182) and Micrococcus spp. (54), with the remaining 17 isolates being various Streptococcus spp. Only 14 of the Staphylococcus isolates were Staphylococcus aureus. Of the 165 non-

aureus *Staphylococcus spp.*: 53% were methicillin-resistant; 73% were penicillin-resistant; 11% were vancomycin-resistant; 46% were methicillin/penicillin-resistant; 8% were methicillin/penicillin/vancomycin-resistant; and 42% were triclosan-resistant. Of the *Micrococcus spp.*: 76% were methicillin-resistant; 72% were penicillin-resistant; 4% were vancomycin-resistant; 65% were methicillin/penicillin-resistant; 2% were methicillin/penicillin/vancomycin-resistant; and 83% were triclosan-resistant. Of the 14 *Staphylococcus aureus* isolates, only 2 were methicillin-resistant *Staphylococcus aureus* (MRSA); 10 were penicillin-resistant; 2 were vancomycin-resistant; 1 was methicillin/penicillin-resistant; no isolates were methicillin/penicillin/vancomycin-resistant; and 2 were triclosan-resistant. **Conclusions:** The results of this study confirm that PAM are contaminated with a variety of gram positive cocci which have a wide range of antibiotic/antimicrobial resistance patterns. Therefore, if a PAM-related oral or systemic infection occurs, microorganism identification and antibiotic susceptibilities are clinical necessities so that proper treatment can be rendered.

Helmet Design Affects Time And Movement During Lacrosse Helmet Facemask Removal

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Context: Efficient emergency management of the cervical spine injured men's lacrosse athlete is critical for certified athletic trainers. Helmet design may affect time and head/neck movement associated with removal of the facemask. Knowledge of helmet differences may help the certified athletic trainer during emergency management of a suspected spine injury. **Objective:** The purpose of this study is to assess the effects of helmet design on time and head/neck movement during the facemask removal process. **Design:** A single factor repeated-measures design was used to assess the effects of the independent variable [helmet: (Brine Triumph, Cascade CPRO, Cascade CPX, Riddell XR, Warrior Viking)] on time and maximal head/neck movement in 3 planes. **Setting:** Biomechanics lab. **Patients or Other Participants:** Ten (4 males, 6 females) certified athletic trainers (age 33.9 ± 7.70). **Interventions:** Subjects removed the facemasks of the 5 different helmets worn by a human model. Three-dimensional kinematic data with regards to time were collected using a motion analysis system to track a marker set. Subjects stabilized the head of the human model with their knees while using an electric screwdriver to remove the facemask. Helmet testing order was randomized to control for ordering effect. Within-subject

differences for time and maximal head/neck movement in 3 planes were examined with repeated measures ANOVA followed by Tukey's HSD. **Main Outcome Measures:** The dependent variables were removal success and failure rate, removal time (sec), and maximal head/neck movement (deg) in relationship to the thorax measured in three planes (sagittal, frontal, axial). **Results:** Overall removal success/failure rates were (90.22% / 9.8%) respectively. The Brine and Warrior helmets each had 100% removal rate. Failure was due to either human error (CPro, 17%; Riddell 9%), or helmet t-nut spin (CPX, 23%). Successful mean removal times ranged from 22.93 – 48.36 sec. Four helmets (Brine, Cascade CPro/ CPX, Riddell) took significantly less time to remove than the Warrior helmet ($P < .05$). Significant differences existed between maximal movement in the sagittal and coronal planes ($P > .05$). Maximal sagittal plane movement in the Brine helmet (8.27 ± 2.77) was significantly less than the Cascade CPro (12.39 ± 2.98) and the Warrior (13.21 ± 4.28). Maximal coronal plane movement in the Brine helmet (3.11 ± 2.26) was significantly less than the Warrior (6.23 ± 3.19) and the Cascade CPX (4.79 ± 2.81). There were no significant differences between helmets for maximal axial plane movement. **Conclusion:** Helmet designs affected removal failure rate, time and maximal head/neck movement.

Comparison Of The Physical And Mechanical Properties Of Commercialized Mouthguard Materials To Established Standards

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Context: The American National Standards Institute (ANSI) is the only U.S. standards organization that specifically sets the physical and mechanical properties requirements for mouthguard materials manufacturers at their intended end-use temperature ($\approx 37^\circ\text{C}$). **Objective:** To characterize a popular set of commercialized mouthguard materials' properties at intra-oral temperature and compare the mean results to ANSI standards. **Design:** A benchtop dynamic mechanical analysis study. **Setting:** Sport and high performance materials laboratory. **Patients or Other Participants:** As this is a materials experiment, no human subjects were utilized and no demographics are necessitated. Five commercial thermoplastic mouthguard materials (ER, EF, PR, PL, PS) were stamped into test specimens with of 22mm X 22mm X 4mm dimensions. **Interventions:** The durometer hardness, water absorption, tear strength, and impact absorption of the mouthguard materials were measured according to ASTM D2240-05, D570-98 (2005), D624-

00, and ASTM D6110-06f guidelines. All tests were conducted on $n=5$ specimens conditioned at intra-oral ($37 \pm 2^\circ\text{C}$) temperature. Data was entered into the Statistical Package for Social Sciences (SPSS v. 15.0, SPSS Inc., Chicago, Ill.). **Main Outcome Measures:** One sample independent t-tests ($\alpha = 0.05$) were implemented to test for differences between the observed mean physical and mechanical properties' values and the established ANSI standards. **Results:** The mean Shore A hardness values for each of the materials was significantly higher than the proposed minimum standard of 55, ER ($t(4) = 92.26, p < .05$), EF ($t(4) = 111.01, p < .05$), PR ($t(4) = 81.41, p < .05$), PL ($t(4) = 116.44, p < .05$), and PS ($t(4) = 67.61, p < .05$). The mean water absorption values for each of the materials was significantly lower than the proposed maximum standard of 0.5 wt%, ER ($t(4) = -47.31, p < .05$), EF ($t(4) = -114.71, p < .05$), PR ($t(4) = -33.23, p < .05$), PL ($t(4) = -157.53, p < .05$), except for PS which absorbed significantly more than the proposed standard ($t(4) = 42.74, p < .05$). The mean tear strength values for each of the materials was significantly higher than the proposed minimum standard of 20 kN-m, ER ($t(4) = 116.76, p < .05$), EF ($t(4) = 60.14, p < .05$), PR ($t(4) = 16.57, p < .05$), PL ($t(4) = -143.36, p < .05$), and PS ($t(4) = 4.38, p < .05$). The mean impact absorption values for each of the materials was significantly lower than the proposed minimum standard of 65%, ER ($t(4) = -103.88, p < .05$), EF ($t(4) = -40.99, p < .05$), PR ($t(4) = -34.53, p < .05$), PL ($t(4) = -157.53, p < .05$), except for PS which significantly surpassed the minimum impact standard ($t(4) = 6.38, p < .05$) with an average impact absorption value of 66%. **Conclusions:** Our findings revealed that only a single mouthguard material passed the ANSI minimum impact absorption standard. The failure of 4 commonly utilized commercial mouthguard materials illuminates the current state of standards adherence.

Free Communications, Poster Presentations: Therapeutic Modalities

Thursday, June 18, 2009, 1:00pm-5:00pm, Park View Lobby, Concourse Level; authors present 4:00pm-5:00pm

No Difference In Skin Anaesthesia With Lidocaine Delivered With High Or Standard Doses Of Iontophoresis

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Context: Iontophoresis is a method of administering medications in solution transcutaneously using galvanic current. Dosage is the product of current amplitude and treatment duration. It is assumed that a higher dose of iontophoresis is more effective in delivering medication, yet research supporting this claim is lacking. **Objective:** To compare a high dose iontophoresis treatment (80mA*min) to a standard dose of iontophoresis (40mA*min). The anaesthetic effect of lidocaine delivered via galvanic current can be measured using Semmes-Weinstein monofilaments and is a model to determine the iontophoretic effect. Two sham treatments (saline with 2.0 mA current and lidocaine without current) were used as controls. **Design:** Double blinded, cross over study. **Setting:** Research laboratory. **Patients or**

Other Participants: Fifteen healthy volunteer subjects (10 females; 5 males: age: 24.06±2yrs, height 169.7±8.3cm, weight 72.5±14.2 kg). **Interventions:** The independent variables were treatment group and time. Four treatments: two true interventions (40mA*min and 80mA*min) and two sham treatments (saline and lidocaine sham) were counterbalanced and applied to the anterior forearm. Each treatment was separated by at least 24 hours. The true intervention dosages were applied at a current of 2mA with 2.5mL 2% lidocaine HCL for 20 and 40-minutes respectively. The sham treatments were: 1) 2.5mL of lidocaine without galvanic current (intensity = 0mA; 40-minutes), and 2) 2.5mL of saline solution (galvanic current of 2mA for 40-minutes). **Main Outcome Measures:** Semmes-Weinstein monofilament scores were taken pre-intervention and post-intervention (0, 20, 40 and 60-mins) to measure skin anaesthesia. A blinded examiner performed all outcome measures. A 4x5 ANOVA with repeated measures on time was used to determine group differences over time for Semmes-Weinstein monofilament scores (logarithmic measure with no units). **Results:** A significant interaction between treatment and time ($F=4.137$, $p<.01$, $\eta_p^2=.228$) was identified. There was no significant difference between either treatment condition: 40mA*min (mean ± SD; 3.64±.1, 95%CI 3.4-3.9) and 80mA*min (3.49±.1, 95%CI 3.3-3.7) at any post-treatment time. There was no difference between either of the sham treatments: lidocaine sham (3.2±.1, 95%CI 3.0-3.4) and saline sham (3.02±.081, 95%CI 2.848-3.195) at any time. The

40mA*min resulted in greater anaesthesia over both shams at all times ($P\leq.02$ saline sham; $P\leq.01$ lidocaine sham) while the 80mA*min resulted in greater anaesthesia over the saline sham at all times ($P\leq.004$) and the lidocaine sham only at post intervention 0 and 60 min ($P\leq.02$). **Conclusions:** There was no difference in the iontophoretic effect a 40mA*min and an 80mA*min treatment. Both treatments were significantly more effective than sham iontophoresis. A standard dose of iontophoresis resulted in similar effects in a shorter period of time, suggesting that the higher dose is not beneficial.

Effects Of Neuromuscular Electrical Stimulation After Anterior Cruciate Ligament Reconstruction On Quadriceps Strength, Function, And Patient Oriented Outcomes: A Systematic Review

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Context: Deficits in quadriceps strength following anterior cruciate ligament reconstruction (ACL-R) have been reported and are considered a risk factor to chronic joint pathologies. Two modes of strengthening, voluntary exercise and neuromuscular electrical stimulation (NMES), have been commonly utilized to restore quadriceps weakness, however, inconsistencies exist in the literature on the effectiveness of NMES versus exercise. **Objective:** To perform a systematic review of randomized controlled trials (RCT) assessing the effects of NMES on quadriceps strength (QS), functional performance (FP), and self-reported function (SRF) compared to therapeutic exercise alone in patients after ACL-R. **Data Sources:** Exhaustive searches were performed for RCTs using the PubMed, CINAHL, Sports Discus, Cochrane Collaboration, and Web of Science databases from 1966 through 2008, with search terms "NMES AND ACL-R" OR "quadriceps rehabilitation" OR "FP" OR "SRF". **Study Selection:** RCTs were included if they evaluated the effectiveness of NMES versus exercise on QS, FP, or SRF in ACL-R patients. RCTs that presented means and standard deviations for NMES groups and control groups were used to calculate the Cohen's d effect sizes (ES) and associated 95% confidence interval (CI) on those outcomes. Six studies met were included. **Data Extraction:** Two independent investigators reviewed the included RCTs and assessed their methodological quality using the Physiological Evidence Database (PEDro) scale. The following outcome measures were collected to calculate

ES between NMES groups and control groups post intervention: QS (isometric or isokinetic knee extension torque); FP (unilateral squat, lateral step-up test, or anterior reach test); and SRF (Activity of Daily Living Scale). **Data Synthesis:** The average PEDro score was 4.3 with the range from 3 to 6 and the mode of 4. The mean ES for QS from 5 studies was 1.65 with a mean 95% CI ranging from 0.50 to 2.79. The ES for FP from one study was 0.36 with a 95% CI ranging from -0.53 to 1.24. The ES for SRF from one study was 0.66 with a 95% CI ranging from 0.05 to 1.28. **Conclusions:** NMES may help to improve quadriceps strength and patient oriented outcomes whereas its effect on functional performance tests is inconclusive. Inconsistencies were noted in the parameter selection and application of NMES. A recommendation to utilize NMES in ACL-R rehabilitation to restore quadriceps strength deficits and improve self-reported function can be made based on a Strength of Recommendation Taxonomy level of evidence 2 with a grade B strength recommendation.

Effect Of Continuous Circulating Water And Cyclical Compression On Intramuscular Temperature And Cardiovascular Strain

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Context: Despite the widespread use of cryotherapy for treatment of injury, the effect of different application methods (e.g., traditional ice bags vs commercially available cooling devices) on the magnitude of intramuscular cooling is not fully understood. In addition, the effect of different cryotherapy treatments on cardiovascular parameters has yet to be identified. **Objective:** To investigate the effects of continuous circulating water and cyclical compression on intramuscular cooling and cardiovascular parameters (e.g., mean arterial pressure, heart rate (HR), and rate pressure product). **Design:** 4 x 12 (treatment x time) crossover repeated measure design. **Setting:** Physiology Research Laboratory. **Patients or other Participants:** Five males and one female (n=6) volunteered (age 21±1 yr, mass 70±11 kg, ht 173±10 cm, thigh skinfold 11±4 mm). **Interventions:** Four counterbalanced treatments included two ice bags and compression and three Game Ready™ protocols [no (GR_{NO}), medium (GR_{MED}) and high (GR_{HIGH}) compression] and time (0.5, 1.5, 3, 5, 10, 15, 20, 25, 30, 45, 50, 60 minutes). All treatments included 30-minutes cooling and 30-minutes passive recovery. A

thermocouple inserted 1.5cm below the subject's subcutaneous adipose layer sampled intramuscular temperature (T_{IM}) and a skin thermocouple sampled surface temperature. Thermocouples were interfaced to a desktop computer through an Isothermex®. Each ice bag had 1-kg of crushed ice and each Game Ready™ cooler was filled with 2-kg of ice and 2-L of water. Velcro secured Game Ready™ knee sleeves. Six-inch double elastic wraps secured the ice bags. Heart rate (HR) was collected continuously using a 3-lead ECG. Blood pressure was collected at each of the time points using an automated blood pressure device. Data were analyzed using separate repeated measure ANOVAs. Alpha = 0.05. **Main Outcome Measures:** T_{IM} (°C), HR (bpm), mean arterial pressure (MAP; mmHg), and rate pressure product (RPP; mmHg*bpm). MAP equals diastolic blood pressure + (pulse pressure)/3. RPP equals systolic blood pressure x HR. **Results:** All values are reported as mean±SE. There were no significant changes in HR ($p>0.05$). For MAP and RPP there was no Condition main effect ($p>0.05$), but there was a Time main effect ($p<0.05$). After 5 minutes of cooling, both MAP (87 ± 1 mmHg) and RPP (7354 ± 107 mmHg*bpm) were different from their respective baselines (81 ± 1 mmHg and 6639 ± 107 mmHg*bpm). The T_{IM} after 30-minutes cooling were $19.4\pm 2.8^{\circ}\text{C}$ (ice bag), $28.3\pm 1.5^{\circ}\text{C}$ (GRNO), $22.7\pm 1.4^{\circ}\text{C}$ (GRMED), $20.6\pm 2.0^{\circ}\text{C}$ (GRHIGH). GRNO did not cool to the same extent as the ice bags, GRMED and GRHIGH ($p<0.05$). The T_{IM} after 30-minutes of passive recovery were $25.8\pm 1.5^{\circ}\text{C}$ (ice bag), $29.5\pm 1.0^{\circ}\text{C}$ (GRNO), $27.3\pm 0.7^{\circ}\text{C}$ (GRMED), $25.9\pm 0.9^{\circ}\text{C}$ (GRHIGH). Ice bags, GRHIGH and GRMED remained significantly cooler than GRNO ($p<0.05$). **Conclusion:** Cyclical compression enhanced tissue cooling. Cryotherapy increased MAP and RPP indicating an increase in myocardial oxygen demand (i.e., increase cardiovascular strain). Therefore, consideration of pre-existing vascular disease may be necessary before the application of cryotherapy.

TENS Application Alters Constant Pressure Sensory Threshold

Meyer RB, Lawson NE, Niemann AJ, Goerdt KL, Snyder KR, Evans TA: University of Northern Iowa, Cedar Falls, IA

Context: Previous research from our laboratory indicated that ice immersion diminished sensory pressure threshold when assessed with a constant (non-moving) pressure stimulus. However, it is uncertain if this effect exists with the application of other modalities such as high frequency

Transcutaneous Electrical Nerve Stimulation (TENS). **Objective:** Our purpose was to examine the effects of a twenty-minute TENS application on sensory discrimination of the hand using a constant pressure stimulus. **Design:** We used a repeated measure experimental design. **Setting:** The study was performed in a controlled laboratory setting. **Participants:** Nineteen volunteers (age = $20.53 \text{ yrs} \pm .905$; mass = $71.44 \pm 15.33 \text{ kg}$; height = $169.11 \pm 10.48 \text{ cm}$) participated in accordance with IRB protocol. **Interventions:** Each participant underwent a control treatment and a twenty-minute TENS application to the dominant hand. The control treatment consisted of quiet sitting for ten minutes. Sensory pressure threshold was assessed at the dorsal aspect between the third and fourth metacarpal bones of the hand with the Von Frey Touch-Test Evaluator (North Coast Medical, Inc.). The Von Frey hairs are 20 monofilaments similar to paintbrush hairs, ranging from very fine to thick. The fiber tip was pressed against the skin at right angles until the fiber bent at the calibrated pressure. The examiner continued touching/bending with fibers of increasing thickness until the participant felt a fiber touch and responded "yes". Independent variables were the twenty-minute TENS application to the hand and the control treatment. The dependent variable was pressure sensory threshold measured before and after the control, and before, during, and after the TENS application. Delta scores (change between two measurements) were calculated for the control (pre-post), TENS-during (pre-during), and TENS-post (pre-post) and analyzed using a Friedman's repeated-measures analysis ($p<.05$). **Main Outcomes Measures:** The main outcome was sensory pressure threshold, measured in grams. **Results:** Sensory pressure threshold at the dorsum of the hand was significantly reduced during TENS application ($\chi^2 = 14.54$, $p = .001$). When comparing mean change values, the TENS-during ($= -1.56\text{g} \pm 2.15$) demonstrated the greatest pressure threshold increase compared to the control ($= 0.05\text{g} \pm 0.22$) and the TENS-post ($= -0.39\text{g} \pm 0.69$). **Conclusions:** TENS application increased the sensory pressure threshold at the dorsum of the hand when measured during and after the application. This supports previous research from our laboratory indicating that sensory discrimination, assessed with constant pressure from the Von Frey filaments, is reduced through modality application. However, high frequency TENS is often indicated for the facilitation of movement through pain reduction. Therefore, future research should examine the impact of high frequency TENS on pain and the ability to sense a moving pressure sensory stimulus such as vibration.

Torque-Based Triggering Improves Stimulus Timing Precision In Activation Tests

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Context: Voluntary muscle activation is commonly assessed by superimposing an electrical stimulus during a maximal voluntary isometric contraction (MVIC). Electrical stimuli during activation testing are conventionally delivered either 1) manually by visually inspecting the torque curve and triggering the stimulator at the point perceived to be peak torque/force, or 2) automatically at a set time-point following the onset of volitional contraction. It is rare, however, for the stimulus to be delivered at peak torque with these approaches. Hence, some measurement error is introduced to the estimation of voluntary activation. **Objective:** The aim of this study was to compare the stimulus delivery precision of a novel automated torque-based triggering to a conventional automated time-based stimulator triggering approach. **Design:** A single group test design. **Setting:** Controlled laboratory setting. **Subjects:** Eleven (6M, 5F) active young subjects (23.5 ± 4.5 yrs, 1.76 ± 0.11 m, 76.1 ± 13.6 kg) with no history of serious lower extremity injury volunteered for this study. **Interventions:** Isometric knee extensor strength testing was performed at 90° of knee and hip flexion using an isokinetic dynamometer. During testing, two lines (torque threshold & target torque) were displayed on a LCD monitor placed in front of the subjects. The torque threshold line represented the torque required to initiate the automated stimulator triggering process and the target torque line established a target that the subjects were instructed to attempt to achieve/surpass during their MVIC trials. Custom software was used to automatically trigger the stimulator when the torque exerted by the subject exceeded the torque threshold and subsequently dropped by 1 N·m (torque-based triggering). With the conventional time-based triggering method the stimulator was triggered approximately 3 seconds after the onset of contraction. An output TTL signal from the triggering significantly improves the precision of stimulus delivery when compared to the conventional time-based triggering approach. The results of this study will be meaningful to scientists and clinicians who use voluntary activation tests when assessing the effects of knee injury, disease, and the outcomes related treatment.

Increasing Electrical Stimulation Frequency Above Cramp Threshold Frequency Increases The Strength And Duration Of Electrically Induced Muscle Cramps

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Context: High frequency electrical stimulation of the tibial nerve is a reliable, well-tolerated model for inducing muscle cramps. Stimulation frequency begins at a frequency of 4 Hz and increases in 2 Hz increments until the flexor hallucis brevis (FHB) cramps. The minimum electrical stimulation frequency at which a cramp occurs is known as threshold frequency (TF). One limitation with this model is that cramps induced at TF are mild and usually last ~30 sec. The short cramp duration makes it difficult to study cramp treatments because it would be unclear if the cramp resolved spontaneously or because of the treatment. **Objectives:** We asked: (1) Does increasing stimulation frequency above TF increase cramp intensity or duration? (2) Are cramp intensity and duration correlated? (3) Is there a learning effect associated with FHB maximal voluntary isometric contractions (MVICs)? **Design:** Randomized, counterbalanced experimental design. **Setting:** Laboratory. **Patients or Other Participants:** Twenty healthy, rested, cramp prone subjects (Mean±SE, male=12, female=8, age=20.7±.6yrs; ht =174.9±1.9cm; mass=76.6±2.2kg). **Interventions:** FHB cramps were induced on 5 consecutive days. Cramp TF was determined the first day. On subsequent days, subjects were randomly stimulated at 5, 10, 15, or 20 Hz above TF. FHB MVIC force was measured prior to cramp induction each day. **Main Outcome Measures:** Cramp intensity (%) was determined by normalizing the 2-sec of cramp EMG activity immediately following the conclusion of the electrical stimuli and comparing it to the 2-sec average MVIC EMG activity. Cramp duration (sec) was defined as the difference between the start of cramp EMG activity and the point when cramp EMG activity decreased to within two standard deviations of resting EMG activity. **Results:** Increasing electrical stimulation frequency above TF resulted in more intense ($F_{4,76}=5.7, P<.001$) and longer lasting cramps ($F_{4,76}=8.3, P<.001$). Cramps induced at 20 Hz above TF were 68% more intense than cramps at TF ($100.5\pm10.5\%$ vs. $60.0\pm11.5\%$, $P<.05$). Cramp duration was 91% longer when stimulated at 15 Hz above TF (77.9 ± 8.4 sec) and 70% longer at 20 Hz above TF (69.5 ± 8.2 sec) than when stimulated at TF (40.8 ± 7.6 sec, $P<.05$). Cramp intensity and duration were highly correlated ($r=.83$). FHB MVIC force was lower on day 1 than days 3, 4, and 5

($F_{4,76}=12.5, P<.001$). **Conclusions:** Cramp duration and intensity increase as electrical stimulation increases above TF in rested, cramp prone subjects. To study the effect of treatments on cramp duration, subjects should be stimulated at 15 Hz above TF as this frequency produces the longest lasting cramps. Researchers may wish to screen subjects prior to experimentation to determine if a long lasting cramp can be induced. A learning curve occurs with FHB MVIC force after 3 days; cramp researchers should include 2 familiarization days prior to collecting data on FHB force.

The Relationship Between The Beginning Electrical Stimulation Frequency And A Person's "True" Cramp Threshold Frequency

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Context: To study cramping, the tibial nerve is electrically stimulated at a frequency of 4 Hz and increased in 2 Hz increments until the flexor hallucis brevis (FHB) cramps. The minimum stimulation frequency at which a cramp occurs, termed threshold frequency (TF), varies from 14-26 Hz and is indicative of an individual's cramp propensity. Since few individuals cramp at 4 Hz, one potential limitation is that the multiple subthreshold stimulations may cause neuromuscular fatigue thereby "priming" the muscle to cramp prematurely and biasing the TF measurement. **Objectives:** We asked: (1) Is an individual's "true" cramp TF similar when initially stimulated at 4 Hz or 14 Hz? (2) Is maximum voluntary isometric contraction (MVIC) force different between stimulation frequencies? (3) Is FHB MVIC force reliable? (4) What is the intensity of cramps induced at TF? **Design:** Randomized, counterbalanced design. **Setting:** Laboratory. **Patients or Other Participants:** Twenty cramp prone, healthy subjects (13 male, 7 female, age = $20.6\pm.7$ yrs; height = 178.2 ± 2.3 cm; mass = 71.4 ± 2.3 kg). **Interventions:** Subjects performed 20 practice MVICs with each contraction separated by 1 min of rest. Subjects rested for 5 min and three, 2-sec consecutive MVICs were recorded and averaged. Following 30 additional min of rest, subjects' tibial nerves were stimulated beginning at either 4 Hz or 14 Hz. Stimulation frequency was increased by 2 Hz from each starting frequency until the FHB cramped. Force was reevaluated at 1 and 5 min postcramp. **Main Outcome Measures:** (1) FHB cramp intensity (%) was determined by normalizing the 2-sec of cramp EMG immediately following conclusion of the electrical stimulation to the mean 2-sec MVIC EMG. (2) FHB MVIC force (N) was measured precramp induction and 1 and 5 min postcramp induction. (3) Cramp TF (Hz).

Results: Starting electrical stimulation frequency had no effect on cramp TF (Mean±SE; 4 Hz = $16.2\pm.86$ Hz, 14 Hz = 17.1 ± 1.1 Hz; $t_{19}=1.21, P=.242$). FHB MVIC force was not different between starting frequencies over time ($F_{2,38}=2.3, P=.11$) and was highly reliable ($r=.78$). Despite no difference in EMG activity between starting frequencies over time ($F_{3,57}=2.33, P=.08$), FHB force was lower 1 min postcramp induction compared to baseline (25.1 ± 1.6 N vs. 28.7 ± 1.2 N, respectively, $P<.05$). Cramp intensity was ~59% of precramp MVIC force ($.36/.62V$). **Conclusions:** A starting frequency of 4 Hz will not induce significant amounts of fatigue nor change an individual's cramp TF. However, some neuromuscular fatigue occurs 1 min postcramp induction. Subjects should rest at least 5 min postcramp induction if repeated tests are performed the same day. Cramps induced at TF are moderately intense, but it is unclear if this intensity is sufficient to study cramp treatments.

Transcutaneous Electrical Nerve Stimulation (TENS) Does Not Alter Cold Sensory Detection Threshold

Snyder KR, Meyer RB, Niemann AJ, Lawson NE, Goerdt KL, Evans TA: University of Northern Iowa, Cedar Falls, IA

Context: Previous research from our laboratory suggests that TENS reduces constant pressure sensory threshold, but has no effect on vibratory sensory threshold. However, these findings are limited to the effect of TENS on mechanoreceptors. It is uncertain how TENS affects thermoreceptors. **Objective:** The purpose of this study was to examine the impact of TENS on thermal sensory detection threshold. **Design:** We used a repeated measures experimental design. **Setting:** A controlled laboratory setting was used. **Participants:** Seventeen participants (age = 20.41 yrs ± 0.87 ; weight = 72.97 kg ± 15.36 ; height = 170.18 cm ± 10.43) volunteered for this study in accordance with IRB protocol. **Interventions:** The independent variables were a control treatment consisting of quiet resting and a twenty minute high frequency TENS application to the dorsum of the hand. Cold sensory threshold represented the dependent variable and was assessed using the Case IV Computer Aided Quantitative Sensory Evaluator (Medical Electronics Co., Stillwater, MN). The Case IV Evaluator delivered cold stimuli by means of the thermal stimulator, which was placed on the dorsum of the hand. The intensity of the cold stimuli varied based on the computer-generated algorithm. When a stimulus was delivered, the participant indicated either "yes" if a stimulus was felt, or "no" if no stimulus was felt. The test ended when the computer determined the cold sensory threshold by

identifying the mildest cold sensation that the participant could detect. Delta scores were calculated and analyzed using a Friedman's repeated-measures analysis (Control pre-post, TENS pre-during, TENS pre-post). Significance level was set at .05. **Main Outcome Measures:** The minimum detectable cold stimulus (degrees Celsius) was recorded before and after the control and before, during, and after the TENS application. **Results:** Cold sensory threshold over the dorsal side of the hand was not significantly reduced during or following the TENS treatment ($\chi^2 = 0.68$, $p = 0.71$). Mean change values for the control, during-treatment, and post-treatments were $-0.85^\circ\text{C} \pm 1.36$, $-0.05^\circ\text{C} \pm 1.61$, and $-0.01^\circ\text{C} \pm 1.59$, respectively. **Conclusions:** Our results indicate that a TENS treatment does not alter the thermal sensory threshold. Participants were able to sense the changing cold intensities delivered by the neurodiagnostic equipment during and immediately following the high frequency TENS treatment. However, the thermal sensory threshold was determined via the application of pain free cold stimuli of varying intensities. The standard clinical indication for TENS application is pain control. Future research should examine the impact of TENS on the ability to perceive varying intensities of painful thermal stimuli.

Subcutaneous Fat Thickness Measurements Of The Distal Thigh Comparing Pinch Calipers To Ultrasound Imaging

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Context: Pinch calipers are typically used to determine subcutaneous fat thickness. The measurement is often difficult, especially where adiposity is not freely moveable or when the pinch calipers are not large enough to capture the full thickness. With the new technology of ultrasound, it may provide a better technique of analyzing subcutaneous fat thickness than commonly used pinch calipers. **Objective:** To compare the thickness of subcutaneous fat in the distal thigh when measured by pinch calipers to ultrasound imaging (USI) measurements of healthy volunteers. **Design:** Crossover design. **Setting:** Laboratory. **Patients and Other Participants:** 11 healthy adults (5 male, 6 female: Age 25.45 ± 4.23 years; Height 172.4 ± 7.45 cm; Mass 73.44 ± 15.05 kg) participated. **Interventions:** The independent variable was measurement tool (pinch caliper and USI). Subjects sat in a chair and were marked over the distal VMO and distal rectus femoris (RF) using a template. For the pinch caliper (Lange Skinfold Caliper, Beta Technology, 2005), the assessor performed a vertical pinch with the fingers and

used the calipers to measure just distal to the pinch. For USI (Philips Ultrasound GE Logiq XP, 2006), ultrasound gel was applied over the region and the transducer was placed over the gel, making firm contact but not depressing the tissue. Once a clear image was observed, it was saved and the amount of subcutaneous fat was measured using the software within the unit. For each tool, a total of 3 measurements at each of the 2 sites were taken and averaged. The same assessor measured fat thickness with the calipers and USI. **Main Outcome Measures:** Fat thickness in millimeters from pinch calipers and USI at the VMO and RF were the outcome measures. Measurements at each site were compared using Pearson's correlations and Bland-Altman plots. **Results:** At the VMO, there was a strong correlation ($r = .92$, $p < .001$) and the plot indicated a mean difference (calipers-USI) of $3.3\text{mm} \pm 2.9$ with limits of agreement from -2.6 to 9.1mm . At smaller fat thicknesses, the mean difference was close to zero, but at larger fat thicknesses there were larger mean differences with the USI having smaller fat thickness values than the calipers. For the distal RF, there was a strong correlation ($r = .97$, $p < .001$) and the plot indicated a mean difference of $2.4\text{mm} \pm 2.5$ with limits of agreements from -2.6 to 7.3mm . This site also had minimal differences at smaller fat thickness values and overestimation with the calipers at higher fat thickness values. **Conclusions:** There are significant correlations of measuring subcutaneous fat in the distal thigh with calipers and USI, however, the large limits of agreement and increasing mean differences with increasing fat thickness were concerning. When measuring subcutaneous fat thickness of the distal thigh, the pinch calipers tended to overestimate fat thickness in individuals with higher fat values.

TENS Application Does Not Alter Vibratory Sensory Threshold

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Context: Recent cross-validation supported the minimizing effects of Transcutaneous Electrical Nerve Stimulation (TENS) on sensory pressure discrimination. However, only a constant, non-moving stimulus was applied, thus targeting only one type of cutaneous mechanoreceptor such as Ruffini endings that are responsible for the detection of a sustained pressure stimulus. The effects of TENS on other types of mechanoreceptors, specifically those that sense non-constant or vibratory pressure stimuli are uncertain. **Objective:** Our purpose was to examine the effects of a TENS application on cutaneous mechanoreceptors responsible for

sensing vibration. **Design:** A repeated measures experimental design was used. **Setting:** Controlled laboratory setting. **Participants:** Eighteen participants (age = $20.44 \text{ yrs} \pm 0.86$; mass = $71.81 \pm 15.68 \text{ kg}$; height = $169.90 \pm 10.19 \text{ cm}$) volunteered in accordance with IRB protocol. **Interventions:** Our independent variables were a control treatment and a twenty minute high frequency TENS application applied to the dorsum of the hand. The control treatment consisted of 10 minutes of quiet sitting. The dependent variable was the vibratory sensory threshold assessed at the dorsal aspect of the hand between the third and fourth metacarpals. Vibratory sensory threshold was assessed with the Case IV Computer Aided Quantitative Sensory Evaluator (Medical Electronics Co., Stillwater, MN). The Case IV Evaluator administered a series of vibratory stimuli via a plunger-like device. The stimuli magnitudes varied according to the computer algorithm sequence test. Participant's, prompted by a light, respond "yes" or "no" to indicate if a stimulus was felt. Testing continued until the computer determined the weakest vibratory stimulus the participant could detect. Delta scores were analyzed using a Friedman's repeated-measures analysis (control, during TENS, after TENS). Significance level was set at .05. **Main Outcomes Measures:** The minimal detectable vibratory stimulus (μm) was recorded before and after the control, and before, during, and after TENS. **Results:** Vibratory sensory threshold over the dorsal aspect of the hand was not significantly reduced during or after TENS ($\chi^2 = 0.37$, $p = 0.83$). Mean change values and standard deviations for the control, during TENS, and after TENS measurements were $-0.33\mu\text{m} \pm 0.83$, $-0.42\mu\text{m} \pm 0.74$, and $-0.17\mu\text{m} \pm 0.84$ respectively. **Conclusions:** Whereas the application of TENS increases constant pressure stimulus threshold, our results indicate that TENS does not alter sensitivity to vibratory stimulus. This suggests that although TENS appears to have an attenuating impact on cutaneous mechanoreceptors responsible for detecting a constant pressure stimulus, it does not have a similar effect on vibratory receptors such as Pacinian corpuscles. To continue to identify the pathways through which TENS may impact sensory discrimination, future investigation should focus on the effects of TENS on cutaneous thermoreceptors and nociceptors.

Intramuscular Temperature Changes In Response To Post-Exercise Application Of Two Cold Modalities

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Context: Sports injuries occur when the musculature is warm; however, most research examining the effect of cold modalities has been conducted on resting, non-warmed tissues. Therefore, determining which cold modality decreases intramuscular tissue temperature of warmed tissue will contribute to the athletic trainer's knowledge on how to best treat an injured athlete and allow them to return to play quicker. **Objective:** To determine changes in post-exercise intramuscular temperature in response to ice bag or ice massage therapy. **Design:** Randomized, control trial with a repeated measures crossover design. **Setting:** Research laboratory. **Participants:** Eighteen healthy volunteers (age = 23.06±0.45 yrs, height = 171.49±1.69 cm, mass = 73.06±2.21 kg). **Inter-**

ventions: The independent variables were treatment (control, 1.0 kg crushed ice pack, or 12 oz ice massage) and time (30 second intervals). Intramuscular temperature was measured during a 5-minute pre-exercise condition, a 2-minute post-exercise baseline condition, and 20 minutes of modality treatment. Exercise was a 10-minute bout of aerobic treadmill exercise. During the treatment phase, an ice pack or massage ice cup was applied to the posterior aspect of the left triceps surae. Additionally, intramuscular temperature was recorded during a 30-minute re-warming period without treatment. Lastly, intramuscular temperature was recorded for 50 minutes during a non-cold modality, control trial.

Main Outcome Measures: Left triceps surae intramuscular temperature measured 1 cm below the subcutaneous adipose layer. A repeated measures ANOVA was used to compare the three treatments across multiple times for each subject with paired t-tests and pairwise comparisons used for post hoc analysis. **Results:** Both cold modalities decreased intramuscular temperature when compared to the control condition. Ice massage reduced intramuscular temperature from 36.76 ± 0.22°C to 26.40 ± 1.43 °C ($p < 0.001$)

and crushed iced from 37.06 ± 0.22°C to 29.79 ± 1.18°C. During re-warming, intramuscular temperature continued to decline for 7 and 3 minutes for the crushed ice pack and ice massage conditions, respectively. This was followed by a significant increase in temperature that remained lower than the resting intramuscular temperature for ice massage (35.07 ± 0.12 vs. 30.45 ± 0.48°C, $p < 0.001$) and crushed ice (35.13 ± 0.20 vs. 30.62 ± 0.47°C, $p < 0.001$). Intramuscular temperature during the control trial was lower than ice massage and crushed iced (35.06 ± 0.15 vs 30.45 ± 0.48 and 30.62 ± 0.47°C, respectively, $p < 0.001$ both). Ice massage showed a greater rate of re-warming when compared to the ice pack trial. **Conclusions:** After 20 minutes of cold modality, both conditions decreased intramuscular temperature when compared to the control condition. However, the ice massage showed a greater rate of cooling, a lower intramuscular temperature, and a greater rate of re-warming when compared to the ice bag.

Free Communications, Poster Presentations: Mild Traumatic Brain Injury

Thursday, June 18, 2009, 1:00PM-5:00PM, Park View Lobby, Concourse Level; authors present 4:00PM-5:00PM

The Cumulative Effects Of Subconcussive Head Impacts On Clinical Measures Of Concussion In Youth Ice Hockey Players

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Context: Sport-related concussions are among the most difficult injuries to manage in athletics. There is very little known about the effects of repeated head trauma in this young population. As novel methods of measuring biomechanical characteristics of head impacts emerge, we are able to better understand the potential cumulative effects of subconcussive forces in this age group.

Objective: To study the effects of subconcussive head impacts on neurocognitive function, postural stability, and symptomatology in youth ice hockey players. We hypothesized that there would be no measurable declines in clinical measures of concussion as a result of player participation. **Design:** Prospective repeated measures design. **Setting:** Research laboratory and field. **Patients or Other Participants:** A convenient sample of 34 male ice hockey players (age=13.57±0.59 years; height=165.03±9.01 cm; mass=55.32±11.49 kg; experience=6.71±2.28 years) selected from two ice hockey teams. **Interventions:** All clinical measures of concussion were evaluated prior to the start of the season and repeated following the completion of the season. The Immediate Postconcussion

Assessment and Cognitive Test (ImPACT), Balance Error Scoring System (BESS), and 22-item Postconcussion Symptom Scale (PCSS), were used to evaluate neurocognitive function, postural stability, and symptomatology. Head impact data were collected during all games and practices over the course of the hockey season from six single-axis accelerometers embedded in Reebok RBK helmets using the Head Impact Telemetry System. The clinical measures of concussion have all been previously shown to be reliable and valid. Separate analyses of covariance (ANCOVA) were employed to investigate the differences in postseason testing (POST) relative to preseason baseline testing (PRE). The number of head impacts sustained by each player over the course of the season, and the number of head impacts greater than 60g, were used as covariates for these analyses.

Main Outcome Measures: Neurocognitive scores from ImPACT included composite indices of verbal memory, visual memory, visuomotor processing speed, and reaction time. Total number of errors on the BESS and PCSS total symptom severity score were also measured. **Results:** There were no significant differences in verbal memory (PRE=79.82±15.22; POST=82.76±12.01; $P=0.352$), visual memory (PRE=74.61±13.97; POST=71.72±13.93; $P=0.451$), or any of the other neurocognitive outcomes ($P>0.05$). Postural stability (PRE=15.31±4.43; POST=15.50±4.75; $P=$

0.771) and total symptom severity score (PRE=4.32±6.43; POST=4.32±8.70; $P=0.916$) did not differ across the playing season. The total number of head impacts (median=371) and the total number of severe head impacts greater than 60g (median=8) sustained over the course of the season were not statistically significant covariates in any of our analyses. **Conclusions:** Repeated subconcussive head impacts sustained over the course of a season do not appear to affect neurocognitive function, postural stability, or symptomatology in youth ice hockey players. Certified athletic trainers should continue to manage reported injuries using objective clinical measures of concussion.

Sex Differences In Balance Performance Prior To And Acutely Following Sports-Related Concussion

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Context: Ambiguity exists concerning true sex differences on clinical measures of concussion at baseline and following injury. Balance assessment is a commonly used clinical measure and little evidence exists on sex differences related to this clinical measure of concussion. **Objective:** The purpose of this study was to examine differences in balance performance between males and

females prior to and acutely following sports-related concussion in collegiate athletes using dynamic posturography. **Design:** A prospective experimental study design was used. **Setting:** Sports Medicine Research Laboratory **Patients or Other Participants:** Collegiate athletes who completed a pre-season and an acute post-injury balance assessment (N=108; males=75; females=33) participated in the study (age =18.83±1.27 years, height=180.95±10.01 cm, mass=83.29±19.63 kg). Only athletes assessed at pre-season baseline and within 3 days of injury were included in the study (1.52±0.96 days to post-injury evaluation). **Interventions:** Athletes were stratified as either male or female based on self-report on a pre-season baseline questionnaire. A separate mixed model, repeated measures analysis of variance was used to examine each outcome measure. **Main Outcome Measures:** Sensory Organization Test (NeuroCom International) Composite Score, which represents overall balance performance and the Vestibular (VEST), Somatosensory (SOM), and Visual (VIS) Ratio scores served as outcome measures. **Results:** There was no difference ($F_{106,1}=0.010$; $P=0.920$) in overall composite balance performance between males (77.63±0.96) and females (77.80±1.45). No significant interaction was found between sex and test-time ($F_{106,1}=0.029$; $P=0.865$) for overall balance performance. A significant main effect of test-time was observed ($F_{106,1}=17.42$; $P<0.001$) on the composite score; whereby, composite balance performance for both males and females was significantly lower during the initial post-injury test time (74.92±13.45) than at pre-season baseline (77.63±0.96). No significant group effect (males vs. females) was observed for the VEST ($F_{106,1}=0.5$; $P=0.481$; males=0.704±0.164; females=0.722±0.140), the SOM ($F_{106,1}=0.007$; $P=0.931$; males=0.96±0.04; females=0.96±0.04), or the VIS ($F_{106,1}=0.105$; $P=0.746$; males=0.87±0.12; females=0.87±0.01). There was also no interaction effect for the VEST ($F_{106,1}=0.508$; $P=0.478$); the SOM ($F_{106,1}=0.038$; $P=0.846$); or the VIS ($F_{106,1}=0.008$; $P=0.929$). There was a significant main effect of test-time for the VEST ($F_{106,1}=12.56$; $P=0.001$); the SOM ($F_{106,1}=13.26$; $P<0.001$); and the VIS ($F_{106,1}=9.83$; $P=0.002$) with the post-injury scores being decreased indicating impaired sensory integration in both males and females. **Conclusions:** Our results suggest that female post-concussion balance data should be interpreted in the same way as male data, with similar deficits expected. Males and females display similar balance performance both prior to and following a concussive injury. Post-injury sensory integration impairments are also similar between males and females. Clinicians should use similar strategies and evaluation techniques for balance across sexes. More attention should be placed on overall prevention, evaluation, and management of

concussions with less emphasis on differences between males and females.

Concussive Signs And Symptoms Following Head Impacts In Collegiate Athletes With A Previous Concussion

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Context: Individuals may vary in their response to head impacts and susceptibility to concussion. This could manifest itself in previously concussed athletes that experience a greater number and more pronounced concussive signs and symptoms (s/s) following head impacts versus their counterparts. **Objective:** To evaluate the association between having a previous documented concussion and experiencing concussive s/s following head impacts in collegiate athletes. **Design:** Retrospective case control. **Setting:** University athletic facilities.

Participants: Two hundred and one college male (n = 168) and female (n = 33) athletes (age = 19.68 ± 1.48yrs, height = 180.51 ± 14.67cm, body mass = 92.26 ± 22.86kg,) who participated in football or women's soccer. Institutional Review Board approval and participant written informed consent was obtained prior to data collection. **Interventions:** During pre-season, athletes completed a questionnaire and reported 1) if they had been diagnosed with a concussion documented by an ATC or physician; 2) if they experienced concussive s/s following a head impact during a game or practice in the previous year; and 3) the number of times they experienced individual concussive s/s following a head impact during a game or practice in the previous year. Based on questionnaire response athlete's were placed in the concussion (cases, n=49) or no concussion (controls, n=152) group. An odds ratio was calculated to analyze if those with a previous concussion were more likely to experience concussive s/s following a head impact. Group differences in the sum of s/s experienced were analyzed using descriptive statistics and an independent samples t-test using SPSS 15.0 ($p \leq .05$). **Main Outcome Measures:** The main outcome measures were if an athlete reported a documented concussion (yes, no), if an athlete reported experiencing concussive s/s (yes, no), and the sum of individual concussive s/s experienced following head impacts in a game or practice during the previous year. **Results:** The odds ratio (2.98) indicated that those with a previously documented concussion were approximately 3 times more likely to have experienced concussive s/s. Sixty percent (91 of 152) of athletes who did not have a documented concussion reported experiencing s/s following head impacts in the previous year compared to 82% (40 of 49) of previously concussed athletes. The concussion group (14.67 ± 20.96) reported

experiencing significantly more concussive s/s (t (199) = -2.673, $p = .008$, $d = -0.439$) following a head impact versus the no concussion group (6.65 ± 17.33). **Conclusion:** Previously documented concussed athletes are more likely to report experiencing s/s and also report a greater number of concussive s/s after head impacts than their non concussed counterparts. Reporting of s/s could be a function of experiencing a previous concussion or due to some athletes being more susceptible to brain injury.

Comparison Of Concussion Assessment Tools: Standardized Assessment Of Concussion (SAC) And Immediate Post Concussion Assessment And Cognitive Test (IMPACT™)

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Context: Several concussion assessment tools are available for use by clinicians, ranging from standard paper-and-pencil tests to more novel computerized neurocognitive assessments. In a position statement released by the NATA, experts state that using multiple instruments provides clinicians with a comprehensive picture of an individual's cognitive function. When multiple tools are used, it is important that they provide insight to different aspects of cognitive processing. **Objective:** To identify if a relationship between scores on the Standardized Assessment of Concussion (SAC) and the Immediate Post-concussion Assessment and Cognitive Testing (ImPACT™) exists in collegiate athletes who had no prior exposure to either test. **Design:** A single group correlational study. **Setting:** Controlled laboratory setting. **Participants:** Thirty-two Division III Collegiate Men's Lacrosse players (age=21±2 years) with no previous exposure to the SAC or ImPACT™ tests. **Intervention:** Subjects reported to the Athletic Training Room and completed the SAC test in a quiet office. Prior to data collection, test administrators underwent training to standardize procedures. After completion of all SAC testing, the subjects reported to a computer laboratory to take the ImPACT™ test. Subjects were given instructions before the test and were monitored throughout the test by a certified athletic trainer. **Main Outcome Measures:** The SAC is an oral test that includes questions dealing with orientation (S-OR), immediate memory (S-IM), concentration (S-C) and delayed recall (S-DR). The individual is given a score for each of the sections, as well as a SAC total score. The ImPACT™ is a computerized neurocognitive test for the assessment of concussion. The ImPACT™ software develops results for the test, including composite scores for verbal memory (I-VER), visual memory (I-VIS), visual

motor speed (I-VMS), reaction time (I-RT), impulse control (I-IC), and total symptoms (I-TS). After completion of both tests, the subjects' scores were entered into SPSS 15.0 and analyzed using the significance level of 0.05. Pearson correlations were conducted between the SAC components and the ImPACT™ composite scores. In addition, multiple linear regressions were performed to evaluate how well the collection of the SAC components predicted each of the ImPACT™ composite scores. **Results:** Pearson correlations revealed three significant relationships between SAC components and ImPACT™ composite scores; S-DR and I-VER [$r(32)=0.362$, $p=0.042$], S-C and I-VMS [$r(32)=0.563$, $p=0.001$], S-C and I-RT [$r(32)=-0.377$, $p=0.034$]. According to multiple linear regression output, combinations of SAC components did not have the ability to predict ImPACT™ composite scores, $p>0.05$. **Conclusions:** Other than subtle similarities between the tests, this data suggests that the SAC and ImPACT™ provide unique contributions to the understanding of cognitive processes. Therefore, athletic trainers should consider using both the SAC and ImPACT™ tests.

The Prevalence Of Concussions And Musculoskeletal Injuries And Access To Appropriate Medical Care At Elite Taekwondo Tournaments In The Republic Of Korea

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Context: In the Olympic sport of taekwondo, high velocity kicks to the head are integral aspects of tournament competition. Little is known about the number of concussions sustained by participants, the type and availability of sports medicine care, and the assessment and management protocols used to evaluate the severity of concussions reported to medical personnel. **Objectives:** To determine the number and severity of concussions and other musculoskeletal injuries sustained while participating in full contact taekwondo sparring tournaments and to evaluate athletes' access to and perceptions of the medical services provided at these elite tournaments. **Design:** Cross-sectional survey. **Setting:** Questionnaires were administered to participants in elite taekwondo tournaments in South Korea, specifically, the 41st Taekwondo National President's Cup in 2006 and the 30th Korean National Collegiate Taekwondo Championships in 2007. **Patients or Other Participants:** 256 World Taekwondo Federation certified black belt athletes (183 males, 73 females) of Korean nationality [age (mean $\pm$ SD) = 19.2 ± 2.5 yrs, years of experience = 8.8 ± 3.4 yrs, number of taekwondo tournaments

entered in last 5 years = 23.7 ± 13.9]. **Interventions:** This investigation used a 28-question, paper-and-pencil Korean language questionnaire. Responses included dichotomous "yes" or "no" answers with follow-up questions soliciting the number of concussions experienced, the duration of time lost following injury, and concussion evaluation methods employed by attending medical personnel. Four Likert-scale questions were included to gauge athletes' perceptions concerning the medical services provided. **Main Outcome Measures:** We used nonparametric frequency analysis and descriptive statistics to identify a medical history of concussion and/or concussion symptoms. Taekwondo athletes were also asked to indicate whether they had sustained any of 7 different categories of musculoskeletal injury during tournament competition, e.g., fracture, dislocation, sprain. **Results:** 14 of 256 athletes surveyed (5.5%) reported that they had sustained a concussion during a taekwondo tournament, with 6 subjects (2.3%) indicating that they were disqualified from further tournament participation due to concussion. In contrast, 100 of these black belt competitors (39.1%) indicated that they experienced concussion symptoms after a blow to the head or a fall during tournament competition. With regard to musculoskeletal injuries, 154 athletes (60.2%) sustained 4 or more categories of injury, with 80 (51.9%) of these injuries being so severe as to warrant tournament disqualification. Only 34.8% of taekwondo tournament participants surveyed agreed or strongly agreed that medical stations were accessible at tournaments, while 32.8% thought that medical personnel were readily available. **Conclusions:** While only 5.5% of taekwondo athletes surveyed had sustained a concussion, nearly 40% experienced concussion symptoms as a result of tournament participation. None of the competitors who sustained concussions underwent formal post-concussion assessment of symptoms to grade the severity of their brain injury. This study funded by an Undergraduate Research Innovation, Scholarship and Creativity grant.

Cognitive And Balance Performance During A Single Task And A Dual Task In Physically Active Young Adults

Ross LM, Register-Mihalik JK, Mihalik JP, Shields EW, Prentice WE, Guskiewicz KM: University of North Carolina, Chapel Hill, NC

Context: Recent evidence suggests deficiencies in the ability to split attention following concussion. Few studies have examined the role of splitting attention in the concussion assessment paradigm. **Objective:** To examine the effects of a dual task paradigm on procedural

reaction time and balance performance in healthy college-aged participants. **Design:** Two dual-task paradigms were performed in a counterbalanced, repeated-measures design. Each paradigm included a balance and a cognitive task. **Setting:** Sports medicine research laboratory. **Patients or Other Participants:** Thirty healthy, recreationally active college students including 14 males and 16 females (age= 20.43 ± 1.33 years; height= 173.44 ± 9.28 cm; mass= 79.03 ± 19.28 kg). **Interventions:** Subjects performed balance and cognitive tasks under a single task and a dual task condition during two separate counterbalanced test sessions conducted 14 days apart. A validated shortened version of the procedural reaction time test (PRT) from the Automated Neuropsychological Assessment Metrics, and an adapted auditory procedural reaction time task (APRT), was used to assess cognition. The NeuroCom Sensory Organization Test (SOT) and the Balance Error Scoring System (BESS) assessed balance performance. For the dual tasks, the PRT was used during eyes open conditions on the SOT, and the APRT was used for eyes closed conditions of the SOT and during the BESS. **Main Outcome Measures:** The SOT equilibrium score, the BESS total error score, the average accuracy on the APRT, and the throughput score from the PRT served as the main outcome measures for the study. **Results:** On the SOT, overall balance performance significantly improved between the first (80.33 ± 4.96) and second (84.98 ± 4.52) sessions ($F_{1,29}=35.695$, $P<0.001$), and from the single task (81.72 ± 4.89) to the dual task (83.59 ± 4.61) conditions ($F_{1,29}=9.604$, $P=0.004$). On the PRT test, overall performance significantly improved in test session two (132.45 ± 13.96) compared to the first test session (123.98 ± 9.07) ($F_{1,29}=57.252$, $P<0.001$), and from the single task (123.98 ± 10.76) to the dual task (127.11 ± 12.09) condition ($F_{1,29}=7.673$, $P=0.010$). No differences across test sessions or tasks were seen on the BESS or the APRT test ($P>0.05$). **Conclusions:** The SOT and the PRT scores indicated practice effects across session. Consistent with current literature, balance performance appears to improve under the dual task condition, indicating differences in demands and performance across tasks. There appears to be a role for both the BESS and the SOT for utilization in a dual task methodology. Future research should examine the influence of more difficult cognitive tasks in conjunction with balance and the sensitivity of the dual task in concussed athletes.

Post-Concussive Self-Report Symptoms In College Students

Piland SG, Gould TE: University of Southern Mississippi, Hattiesburg, MS

Context: Baseline assessments of concussion measures are recommended practice within the athletic population. This method allows direct comparisons to post-injury data and serves to facilitate safer return-to-play (RTP) decisions. However, the constellation of self-report symptoms (SRS) associated with concussion can be experienced independent of brain injury. Thus, it must not be assumed that pre-injury responses to concussion-related symptom scales should approximate a null score, nor should overly elevated response scores be ignored. To this end, thorough characterization and understanding of potentially influential conditions to baseline symptom scores across a wide range of active populations should be obtained to provide clinicians the best possible information towards making RTP decisions. **Objective:** The purpose of this study was to

characterize SRS post-concussive symptoms (PCS) in a sample (N=500) of healthy college-aged individuals. **Design:** A prospective, cross-sectional design involving a single testing session. **Setting:** Data was collected in a laboratory located at a southeastern Division I institution. **Patients or Other Participants:** The group was comprised of healthy, physically active volunteer students (male n=267, age=21.81±2.77, females n=233, age=21.40±2.51) majoring in a human performance discipline. **Interventions:** Test subjects were provided informed consent in accordance with requirements from the involved institution. Each subject completed a health history questionnaire and the duration and severity components of the Head Injury Scale-revised (HIS-r). **Main Outcome Measures:** Frequency and descriptive reports along with two Mann-Whitney U tests to evaluate influences of previous history of concussion (yes/no) on mean composite HIS-r (duration and severity) scores were performed. **Results:** Over 70% of the sample reported experiencing at least 1 PCS and 31.4% reported experiencing 3 or more PCS over the evaluated

24-hour period. The most common PCS reported was drowsiness followed by fatigue, headache, sleeping difficulty, difficulty concentrating, feeling "slowed down", nausea, difficulty balancing and feeling "in a fog". Twenty three percent of the sample (n=115) reported having a prior history of concussion. Composite scores describing the duration (length experienced over a 24-hour period) and severity of PCS were significantly higher in the group reporting a history of concussion compared to those with no history (U=18688, $p \geq .05$, U=18363, $p \geq .05$, respectively). **Conclusions:** Obtaining and interpreting baseline and post-injury (follow-up) responses to summative self-report symptom scales is a recommended and vital part of the multi-faceted approach to injury assessment. Therefore it is necessary to characterize PCS base-rates and explore potential influencing variables. Our findings, similar to those found in athletes, suggest that both sport and non-sporting populations report a constellation of PCS at baseline and a previous history of concussion increases SRS reporting.

Free Communications, Poster Presentations: Sex Differences

Thursday, June 18, 2009, 1:00PM-5:00PM, Park View Lobby, Concourse Level; authors present 4:00PM-5:00PM

Sex Differences In Frontal-Plane Kinematics And Kinetics Of The Knee And Hip During Running And Rapid Change-Of-Direction Tasks

Golden GM, Pavol MJ, Hoffman MA: Oregon State University, Corvallis, OR, and University of California, Los Angeles, CA

Context: The disproportionate incidence of non-contact anterior cruciate ligament (ACL) injuries in females remains perplexing. Frontal-plane knee kinematics and kinetics have been implicated in ACL injury risk and, while corresponding sex differences exist for sidestep cutting (SSC), the SSC may not be entirely representative of the rapid change-of-direction tasks associated with ACL injury. **Objective:** To identify differences in frontal-plane knee and hip kinematics and kinetics between sexes and tasks for variations of the SSC maneuver. **Design:** Mixed-factor, sex-by-task design, with repeated-measures for task. **Setting:** A biomechanics laboratory. **Patients or Other Participants:** Twenty-one healthy collegiate basketball and soccer players participated in a single testing session (females n=11: 19.8±1.5yrs; males n=10: 20.7±2.5yrs). **Interventions:** Participants performed 10 trials each of straight-ahead running (RUN), right lateral false step (LFS, 30% body height), left SSC (45° from the path of travel), and LFS and SSC in combination (LFS+SSC), all at 3.5±0.2 m·s⁻¹. Three-

dimensional knee and hip angles and internal moments were obtained for the right lower extremity. A body-fixed flexion-abduction-external rotation sequence by the distal segment was assumed. Peak values were determined between foot contact and 30° of knee flexion during stance and averaged across trials. **Main Outcome Measures:** Sex- and task-differences in peak knee abduction angle (KABDa), hip adduction angle (HADDa), knee adduction moment (KADDm), and hip abduction moment (HABDm) were identified using ANOVA with post hoc Tukey's HSD analysis ($\alpha=0.05$). **Results:** There was a main effect of condition ($p < 0.001$) on peak KABDa (RUN 3.6°±0.5, LFS 5.6°±0.5, SSC 6.1°±0.5, LFS+SSC 7.1°±0.53), KADDm (RUN: 0.1±0.1, LFS: 1.2±0.2, SSC: 2.0±0.2, LFS+SSC: 3.9±0.1 %bw·bh), HADDa (RUN: 7.3°±0.5, LFS -7.9°±0.8, SSC -5.7°±0.9, LFS+SSC -16.6°±0.8), and HABDm (RUN: 5.5±0.5, LFS: 5.8±0.8, SSC: 4.3±0.8, LFS+SSC: 2.7±0.8 %bw·bh). Peak KABDa and KADDm were greater for all three change-of-direction tasks than for RUN ($p < 0.05$) and greater for LFS+SSC than LFS or SSC ($p < 0.05$). Peak HADDa were smaller (more abducted) for the change-of-direction tasks than for RUN and smaller for LFS+SSC than LFS or SSC ($p < 0.05$). Peak HABDm were smaller for LFS+SSC than RUN or LFS ($p < 0.05$). Females demonstrated 4.0° greater peak HADDa ($p=0.04$). There were no significant interactions between sex and task. **Conclusions:** Each variation of SSC was associated with increased

abduction angles and adduction moments at the knee during early stance, accompanied by decreased hip adduction angles, a pattern consistent with increased ACL loading. A LFS appears to produce effects similar to a SSC on frontal-plane knee and hip kinematics and kinetics, whereas prefacing a SSC by an opposing LFS amplifies the effects of a SSC. The more adducted stance hip in the females across tasks suggests differences in proximal control at the hip, which may help explain why females are more susceptible to ACL injury.

Analysis Of Lower Extremity Coordination And Variability Between Sexes During A Sidestep Cut

McGrath ML, Padua DA, Thigpen CA: University of North Carolina, Chapel Hill, NC, and Proaxis Physical Therapy, Greenville, SC

Context: Although significant research has shown that males and females have different lower extremity (LE) kinematics during sidestep cutting maneuvers, there are no published studies on how the neuromuscular system organizes and coordinates LE motion. If the coordination of the segments of the LE is different between males and females, this may help explain the higher risk of non-contact anterior cruciate ligament (ACL) injuries in females who perform sidestep cutting. **Objective:** To compare the coordination

and variability of the lower extremity between male and female athletes during a sidestep cutting task. **Design:** Cross-sectional. **Setting:** Research laboratory. **Patients or Other Participants:** Thirty-six healthy volunteers who have participated in soccer, basketball, lacrosse, or volleyball at the intercollegiate, club, intramural, or high school varsity level (Males: N=18, age:21.0±2.2yrs, height:181.3±5.1cm, mass:77.5±6.8kg; Females: N=18, age:20.2±1.0yrs, height:170.0±5.1cm, mass:61.9±8.1kg). **Interventions:** each segment during the stance phase of the cut (defined as the period of time when VGRF>10N), then normalized to 101 datapoints. Phase angles were calculated, then continuous relative phase (CRP) portraits were created for each segment pair (foot-shank, shank-thigh, and thigh-trunk) in both planes of motion (sagittal and frontal). **Main Outcome Measures:** Mean absolute relative phase (MARP) and deviation phase (DP) were calculated using the CRP portraits to compare coordination and variability respectively. The average MARP and DP values across all 10 repetitions were compared between sexes with independent-samples t-tests ($\alpha \leq 0.05$). **Results:** Males demonstrated a lower thigh-trunk frontal plane MARP compared to females (M: 27.73±7.15, F: 38.17±9.89, $t_{34} = -3.63$, $P=0.001$). There were no other significant differences between males and females in MARP or DP in any other segment pair. **Conclusions:** Males and females generally have very similar coordination and variability patterns in the LE during an anticipated sidestep cut, indicating similar neuromuscular organization strategies. However, females have a more out-of-phase coordination pattern between the thigh and trunk in the frontal plane. This suggests that females coordinate the movement of the trunk and thigh differently than males. Although the implications of this sex-related differences on injury risk is not known, recent research does suggest the trunk influences knee joint loading forces and moments. Future research should examine the relationship between LE coordination, knee joint loading, and non-contact ACL injuries.

Sex Differences In Balance And Power Among Youth Soccer Players

Graf JE, Dameron EA, DiStefano LJ, Register-Mihalik JK, Kaiser KA, Canonge DM, Blackburn JT, Ross SE, Padua DA: University of North Carolina, Chapel Hill, NC

Context: Lower extremity injuries are common among adolescent athletes, especially soccer players. Balance and power are key factors related to injury risk and performance. Following puberty, females are more likely to sustain sports

injuries compared to males and possess more risk factors associated with injury. Previous research has failed to address when these sex differences begin to emerge, and has not evaluated potential risk factor differences among preadolescent populations. **Objective:** To compare balance and power between male and female youth soccer athletes. **Design:** Cross-sectional. **Setting:** Research laboratory. **Participants:** Sixty-six youth soccer players volunteered to participate (38 males: height = 143.3±6.3 cm, mass= 34.2±5.2 kg, age=10±1 years; 28 females: height = 141.0±6.6 cm, mass= 33.8±5.4 kg, age=10±1 years). **Interventions:** The independent variable for this study was sex. All subjects performed three time to stabilization (TTS) trials and three vertical jump trials. During the TTS, participants jumped forward off a 30cm high box and landed with their dominant foot (foot used to kick a ball for maximum distance) on a force plate. The box was positioned a distance equal to half their height from the front of the force plate. Participants were required to maintain balance on their dominant foot for ten seconds after landing. For the vertical jumps, participants were instructed to jump as high as possible from a double leg stance with their dominant foot on a force plate. **Main Outcome Measures:** A force plate was used to collect ground reaction force (GRF) data. Antero-posterior, medio-lateral and resultant TTS values were calculated from GRF data using customized software. During vertical jump trials both vertical jump height and power were calculated using customized software. The averages of three trials for both tasks were used for statistical analyses. A Mann-Whitney U test was conducted to evaluate sex differences in TTS, while separate one-way ANOVAs were used to compare vertical jump height and power across sex ($\alpha \leq 0.05$). **Results:** Males (3.22±2.47s; Average rank=27.24) stabilized themselves significantly quicker than females (5.24±3.47s; Average rank=40.19) during the TTS task, ($z = -2.73$, $P=0.006$). Males (25.2±4.0 cm) jumped significantly higher than females (22.7±3.7 cm) ($F_{(1,65)} = 6.3$, $P=0.01$) and generated significantly more power (Males=973.68±269.40 Nm/s; Females=806.30±274.50 Nm/s; $F_{(1,62)} = 6.1$, $P=0.01$). **Conclusions:** Despite their young age, sex differences existed in time to stabilization, jump height and power as males performed better than females on all tasks. These results may lend insight into the elevated risk for sport

injury in girls compared to boys. Therefore, prevention programs may be more beneficial if started at an earlier age. (Funded by the Injury Prevention Research Center at the University of North Carolina at Chapel Hill and the National Academy of Sports Medicine)

Correlations Between Muscle Properties And Reproductive Hormones

Bell DR, Blackburn JT, Norcross MF, Ondrak KS, Hudson JD, Hackney AC, Padua DA: University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Females have a greater non-contact ACL injury rate compared to males. Reproductive hormone fluctuations are thought to contribute to this discrepancy, with a significant amount of research focused on ligament properties. However, little research has focused on the hormonal influences on muscle properties. Given the substantial contributions of the hamstrings muscles to knee joint stability, changes in these properties may influence ACL injury risk. **Objective:** To evaluate relationships between hamstring properties and blood concentrations of estrogen, testosterone, and progesterone. **Design:** Correlational. **Setting:** Research laboratory. **Patients or Other Participants:** 15 males (age=20.9±1.7yrs, ht=180.8±7.7cm, m=78.7±10.9) and 15 females (age=20.4±1.6yrs, ht=163.9±5.6cm, m=62.7±10.6) who were free of lower extremity injury volunteered for this study. Females were tested 3-5 days post-menses. **Interventions:** Hamstring stiffness was assessed by quantifying the damping effect imposed by the hamstrings on oscillatory knee flexion/extension induced by perturbation. Hamstring electromechanical delay (EMD), time-to-50% peak force (T50%), and rate of force production (RFP) were assessed during maximal isometric contraction. EMD was defined as the time interval between the onsets of EMG and force. T50% was calculated as the time between the onset of force and the instant at which 50% peak force was attained. This force was expressed relative to body mass (N/kg), and RFP was calculated as the ratio of this normalized force to T50%. Blood hormone levels were assessed via radioimmunoassay procedures. Pearson correlation coefficients were computed between the respective muscle properties and hormone levels with genders combined and separately ($\alpha \leq 0.05$). **Main Outcome Measures:** Hamstring stiffness (K), rate of force production (RFP), electromechanical delay (EMD), time to 50% peak force (50%F), and estrogen, testosterone, and

progesterone concentrations. **Results:** For genders combined, estrogen (mean = 46.0 ± 28.2 pg/ml) was negatively correlated with K (mean = 12.8 ± 2.6 N/cm, $r = -.43$, $P = .02$) and RFP (mean = 758.77 ± 507.6 N/kg-sec⁻¹, $r = -.43$, $P = .02$). Free testosterone (mean = 13.17 ± 13.0 pg/ml) was positively correlated with K ($r = .46$, $P = .01$) and RFP ($r = .56$, $P = .001$) but negatively correlated with T50% (mean = 114.73 ± 38.88 ms, $r = -.43$, $P = .02$). When gender was considered separately, males displayed no significant correlations between the selected hormones and muscle properties. Females demonstrated a negative correlation between estrogen (mean = 68.02 ± 23.21 pg/ml) and K (mean = 11.72 ± 1.47 N/cm, $r = -.53$, $P = .05$) and free testosterone (mean = $1.53 \pm .64$ pg/ml) and K ($r = -.52$, $P = .05$). **Conclusions:** When both genders were considered, higher levels of estrogen were associated with lesser K and RFP. However, greater levels of free testosterone were associated with faster RFP. In females, greater amounts of estrogen were associated with lesser K. These results suggest that female muscle tissue may be more responsive to estrogen. Increased estrogen concentration during the ovulatory phase of the menstrual cycle may negatively influence hamstring muscle properties in manners which result in a decreased ability to produce force and protect the knee joint during high risk activities.

The Effect Of Oral Contraceptive Use On Muscle Properties Across The Menstrual Cycle

Hudson JH, Blackburn JT, Bell DR, Ondrak KS, Norcross MF, Padua DA, Hackney AC: University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Fluctuations in reproductive hormone concentrations across the menstrual cycle potentially influence female non-contact ACL injury risk. Hormone receptors also exist on skeletal muscle, and changes in mechanical muscle properties have been noted across the menstrual cycle. Given the substantial contributions of the hamstrings muscles to knee joint stability, such property changes may influence ACL injury risk. Oral contraception (OC) minimizes hormonal fluctuations across the menstrual cycle and thus may subsequently minimize the associated changes in muscle properties and injury risk.

Objective: To investigate the effects of OC use on mechanical properties of the hamstrings.

Design: Cross-sectional quasi-experimental.

Setting: Research laboratory. **Participants:** Twelve females using monophasic OC (age = 19.87 ± 1.13 yrs, height = 1.65 ± 0.08 m, mass = 61.54 ± 13.12 kg) and 12 females not using OC (age = 20.40 ± 1.59 yrs, height = 1.69 ± 0.05 m, mass = 62.75 ± 10.61 kg) with normal menstrual cycles and no lower extremity injuries.

Interventions: Active hamstring stiffness (K_A)

and vertical leg stiffness (K_{vert}) were assessed at time points corresponding with low (Menses) and high (Ovulation) estrogen (E) concentrations. The Menses testing session occurred 3-5 days post menses for the non-OC group and pill number 3-5 for the OC group. Subjects in the non-OC group were tested 2-4 days after Ovulation (identified via commercial ovulation kit) and OC pill number 15-17 in the OC group. K_{vert} was calculated as the ratio of the change in vertical ground reaction force to the vertical displacement of the total body center of mass (DForce/DLength of Leg Spring) during double-leg hopping on a force plate at a controlled rate. K_A was assessed by evaluating the damping effect imposed by the hamstrings on oscillatory knee flexion/extension induced by perturbation. Blood E concentration was assessed with radioimmunoassay procedures. 2 (Group) x 2 (Time) repeated measures ANOVA were used to compare K_A , K_{vert} , and E between OC and Non-OC users across the menstrual cycle ($\alpha \leq 0.05$). Tukey HSD was used for post hoc analysis. **Main Outcome Measures:** K_A and K_{vert} in N/cm and E in pg/ml. **Results:** E increased (interaction: $F_{(1,22)} = 16.08$, $P = .001$) at ovulation in the non-OC group (Menses: 71.22 ± 8.12 pg/ml; Ovulation: 100.95 ± 7.89 pg/ml) but not in the OC group (Menses: 57.84 ± 8.12 pg/ml; Ovulation: 53.09 ± 7.89 pg/ml). The Group x Time interaction effects for K_A ($P = .15$) and K_{vert} ($P = .23$) were non-significant. Similarly, the group main effects for K_A (OC: 10.97 ± 2.00 N/cm, Non-OC: 11.41 ± 1.76 N/cm, $P = .51$) and K_{vert} (OC: 193.88 ± 34.68 N/cm, Non-OC: 219.25 ± 68.38 N/cm, $P = .17$) and the time main effects for K_A (Menses: 11.23 ± 1.77 N/cm; Ovulation: 11.15 ± 2.02 N/cm, $P = .76$) and K_{vert} (Menses: 204.15 ± 50.18 N/cm; Ovulation: 208.99 ± 60.68 N/cm, $P = .57$) were non-significant. **Conclusions:** These results indicate that while OC use minimized the increase in E at ovulation, it did not alter muscle properties. OC use may have little-to-no prophylactic value for injury prevention as related to muscle stiffness. Future research is necessary to determine the magnitude of changes in muscle properties across the menstrual cycle and the influence that these changes impart on non-contact ACL injury risk. *Funded by a Master's Research Program Grant from the NATA Research and Education Foundation.*

Spinal Control Differences Between The Sexes

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

Context: The sexes differ in the performance of functional tasks, such as, landing and cutting. However, the underlying control mechanisms responsible for these differences remain unidentified. **Objective:** To evaluate spinal

control mechanisms and functional neuromuscular variables in males and females. **Design:** Cross-sectional. **Setting:** Research Laboratory. **Participants:** Volunteer sample of 19 males (23.0 ± 4.3 yrs, 177.45 ± 5.44 cm, 77.52 ± 13.18 kg) and 18 females (24.7 ± 2.9 yrs, 165.31 ± 5.85 cm, 62.44 ± 8.76 kg). **Interventions:** While seated on an isokinetic dynamometer with the ankle of the dominant leg secured at 90° the following recruitment curves were collected at the soleus: H-reflex, intrinsic pre-synaptic inhibition (IPI), and extrinsic pre-synaptic inhibition (EPI). The first derivative of each of the recruitment curves was then determined. Additionally, percent of recurrent inhibition (RI), V-wave ($V_{max} \cdot M_{max}$), rate of torque development (RTD), and electromechanical delay (EMD) of the soleus were assessed. IPI testing used the paired pulse conditioning protocol (interstimulus interval = 100ms). EPI was measured through common peroneal nerve conditioning (100ms conditioning interval). RI was assessed by setting stimulus 1 to 25% of M_{max} and stimulus 2 to M_{max} . V-waves were tested via Mmax stimulation to the tibial nerve during an isometric maximum voluntary contraction (iMVC). Additionally, three trials of iMVC with the instruction to contract as hard and fast as possible were collected to assess RTD. EMD, the time lag between EMG and torque activity, was measured during the RTD trials. A 2 (sex) x 7 (neural variable) MANOVA was used to compare means of the dependent variables. **Results:** The Wilks Lambda multivariate test of overall differences among groups was statistically significant ($p = 0.001$). Univariate between-subjects tests revealed males had significantly greater RI (males = 0.86 ± 0.21 , females = 0.68 ± 0.30 ; $p = 0.042$). Males also had greater RTD (males = 387.93 ± 180.90 n-m-s⁻¹, females RTD = 263.89 ± 85.15 n-m-s⁻¹; $p = 0.033$). The sexes did not differ on first derivative of the following: H-reflex (males = 9.80 ± 3.71 , females = 10.38 ± 4.58 , $p = 0.773$), IPI (males = 2.23 ± 2.27 , females = 2.14 ± 2.23 , $p = 0.778$), or EPI (males = 8.39 ± 4.15 , females = 9.79 ± 6.15 , $p = 0.668$). V-waves (males = 0.22 ± 0.21 , females = 0.27 ± 0.17 , $p = 0.526$) and EMD (males = 46.35 ± 29.76 ms, females = 58.50 ± 23.47 ms, $p = 0.278$) were not different. **Conclusions:** The sexes differ on modulation of spinal control of movement and activation of the neuromuscular system. Males were able to produce maximal torque more quickly than females. Additionally, RI, a post-synaptic regulator of torque output, was greater in males. Based on these findings, males and females clearly utilize neural control mechanisms differently. *Funded by a Doctoral Research Program Grant from the NATA Research and Education Foundation.*

Free Communications, Poster Presentations: Professional Issues

Friday, June 19, 2009, 8:00AM-11:30AM, Park View Lobby, Concourse Level; authors present 10:30AM-11:30AM

Nutrition Competency Of Certified Athletic Trainers

Marinero LM, Fiala KA: University of Akron, Akron, OH; Woodbridge High School, Bridgeville, DE; Salisbury University, Salisbury, MD

Context: Since certified athletic trainers (ATCs) have been shown to be a key source of nutrition information for athletes, it is essential that they have an adequate amount of nutrition competency in order to appropriately answer questions and make referrals. **Objective:** To assess the nutrition competency of ATCs. **Design:** Nutrition competency questionnaire. **Setting:** National, web-based distribution. **Patients or Other Participants:** The target population was ATCs employed in the high school or university setting. A random sample of 1000 ATCs who were current members of the National Athletic Trainers' Association, provided an email address, and opted-in to email surveys were contacted requesting their anonymous participation. Two hundred eighty participated (28% response rate). The majority of participants were female (169, 60.4%) aged 26-35 years (141, 50.4%), Caucasian (264, 94.3%), had practiced for less than 6 years (90, 32.1%), graduated from a curriculum program (165, 58.9%), held Master's degrees (191, 68.2%), and did not have additional certifications (176, 62.9%). The respondents had taken an average of 2.1±3.2 college-level nutrition courses. **Interventions:** Potential participants were contacted twice, one week apart, with a link to the instrument which was hosted online. Participants completed an instrument consisting of 9 demographic and 24 nutrition competency questions. It covered a variety of topics (macronutrients, micronutrients, injury-related nutrition, pre-event nutrition, hydration, eating disorders, ergogenic aids, body composition) and was developed and reviewed by a panel of registered dietitians and certified athletic trainers for face and content validity. **Main Outcome Measures:** Each participant was given a score representing the percentage of questions that were answered correctly. Descriptive statistics explored general competency while ANOVAs and *t* tests investigated potential group differences based on demographics and self-rated level of nutrition competency. All statistics were run using SPSS 15.0 for Mac; tests were considered significant at the $p < 0.05$ level. **Results:** For 280 participants, the average score on the nutrition competency questions was 76.2±12.8. Sub-topics in order from highest to lowest average score were injury-related nutrition (86.4±24.6), micronutrients (86.0±15.2), hydration (83.4±27.8), body composition (76.3±29.9),

74.1±22.6 (macronutrients), ergogenic aids (70.5±32.2), eating disorders (60.5±21.7), and pre-event nutrition (56.6±39.3). Limited differences based on demographics were found: ATCs with PhDs (84.2±13.8) scored significantly higher than those with a BA/BS (74.0±12.6); ATCs with athletic performance certifications (81.3±9.2) scored significantly higher than those without (75.0±13.2), $p < 0.05$. Differences also existed based on self-rated level of nutrition competency. Those who rated their competency as very low, low, moderate, high, and very high scored 61.7±9.9, 69.7±16.1, 75.8±11.7, 82.1±11.3, and 87.5±9.5, respectively. **Conclusions:** The findings of this investigation have positive implications for athletes who bring their nutrition concerns to athletic trainers. Minor competency limitations identified may be addressed through athletic training education programs as well as continuing education opportunities.

The ATEP Certified Athletic Trainer: Educational Satisfaction And Technique Use Within The Psychosocial Intervention And Referral Content Area

Stiller-Ostrowski JL, Hamson-Utley JJ: Lasell College, Newton, MA, and Weber State University, Ogden, UT

Context: Today's certified athletic trainer (ATC) must address both physical and mental aspects of athletic injury in a holistic rehabilitation program. **Objective:** To assess ATCs' satisfaction with their athletic training educational preparation within the Psychosocial Intervention and Referral (PIR) content area, confidence in using related techniques, and frequency of technique use within clinical settings. **Design:** Cross-sectional survey. **Setting:** Internet survey methods were used to gather information from ATCs who had been certified for ≤ 7 years. **Patients or Other Participants:** All ATCs who met inclusion criteria and who had provided their email address to the NATA were invited to participate. 1701 ATCs participated (31.9% response rate). Average years experience $M = 3.13 (\pm 1.96)$. 74% graduated from accredited undergraduate programs, 22% from internship programs, 4% from entry-level Masters programs. 36.1% worked at college/university, 30.7% in private clinic setting, 23.1% at secondary schools. **Interventions:** Independent variables: route to AT certification (undergraduate, internship, entry-level), edition of educational competencies (Third: 2000-2005, Fourth: 2006-2007), current clinical setting. Survey was administered online; essential

components included satisfaction with educational preparation within PIR, confidence in using techniques, and frequency of technique use. Survey questions were adopted from the 3rd and 4th editions of the AT educational competencies. **Main Outcome Measure(s):** 10 questions pertaining to satisfaction/confidence with educational experience; 15 questions pertaining to frequency of technique use in clinical setting. Technique use, satisfaction, and confidence were rated on a 9-point Likert scale (technique anchors: *always* (1) and *never* (9); satisfaction/confidence anchors: *completely satisfied/confident* (1) and *completely dissatisfied/unconfident* (9)). Descriptive statistics and MANOVAs were reported. **Results:** Average technique use was 3.58 (± 1.92) for motivation, 6.19 (± 2.16) for self-talk, 6.2 (± 2.06) for relaxation, and 6.53 (± 2.0) for imagery. Significant group difference for edition of educational competencies ($F(45, 2969) = 1.848$, $p < 0.001$, $\eta^2 = 0.027$) with ATCs educated under 4th edition reporting more frequent technique use. Significant group difference for route to AT certification ($F(30, 2464) = 1.477$, $p = 0.046$, $\eta^2 = 0.018$) with internship-graduate ATCs reporting the most infrequent use of techniques. No significant group difference for clinical setting ($F(30, 2514) = 0.975$, $p = 0.501$). Average satisfaction/confidence within motivation was 3.36 (± 2.03), for self-talk was 3.94 (± 2.18), for relaxation was 3.76 (± 2.17), and for imagery was 3.82 (± 2.15). Non-significant group differences were found for all independent variables on satisfaction/confidence: educational competency editions ($F(90, 2924) = 1.065$, $p = 0.320$, $\eta^2 = 0.025$); route to AT certification ($F(60, 2374) = 1.102$, $p = 0.277$, $\eta^2 = 0.027$), clinical settings ($F(60, 2514) = 0.834$, $p = 0.814$). **Conclusions:** ATEPs are providing education in most PIR competencies; however, ATCs are not implementing educated techniques in clinical practice. It should be of utmost priority for researchers to investigate and educators to learn how to instruct PIR competencies to promote implementation within clinical settings.

Standards And Criteria For Selection Training Evaluation Of Approved Clinical Instructors Not Reflected In Evaluation Tools

Zona LA, Eberman LE, Tripp BL, Doherty-Restrepo JL: Florida International University, Miami, FL; Indiana State University, Terre Haute, IN; University of Florida, Gainesville, FL

Context: The quality of the supervision and guidance provided by Approved Clinical

Instructors (ACI) is critical in the development of competent and clinically proficient entry-level Athletic Trainers. The Commission on Accreditation of Athletic Training Education (CAATE) accreditation standards requires athletic training students (ATS) to evaluate the quality and effectiveness of instruction provided by ACIs. Experts in the field of athletic training developed a set of 7 standards and 50 associated criteria on which to base the selection, training, and evaluation of effective ACIs. **Objective:** To identify the degree to which Athletic Training Education Programs' (ATEP) assessment tools reflect the standards and criteria that guide the selection, training and evaluation of effective ACIs. **Design:** Document review of ATS evaluation forms collected from CAATE-accredited ATEPs. **Setting:** CAATE-accredited ATEPs were solicited and responded via electronic mail. **Patients or Other Participants:** We contacted program directors or clinical coordinators at the 364 CAATE-accredited ATEPs. We received 61 ATS evaluation of the ACI forms from 61 (17%) different CAATE-accredited ATEPs. **Data Collection and Analysis:** We identified 1-10 keywords that reflected evaluation of each of the 7 standards and 50 associated criteria as described in the literature. We entered Microsoft® Word versions of each assessment tool into a text data mining (NVivo version 8). The software quantified the frequency in which each key word appeared and subsequently, the specific standards criteria being evaluated in each assessment tool. **Results:** Frequency analysis indicated 92% [56/61] of forms evaluated the 'supervisory and administrative skills' standard; 70% [43/61] evaluated the 'instructional skills' standard; 67% [41/61] evaluated the 'interpersonal relationships' standard; 49% [30/61] evaluated the 'student performance evaluation' standard and; 11% [7/61] evaluated the 'communication skills' standard. Only 10% [6/61] of forms evaluated the 'legal and ethical behavior' standard and even fewer (8% [5/61]) evaluated the 'clinical skills and knowledge' standard. Only 2 forms (3%) evaluated components of all 7 standards, while most forms addressed only 2 (14/61, 23%), 3 (16/61, 26%) and 4 (19/61, 31%) of the standards. **Conclusions:** The ACI evaluation forms used by participating ATEPs poorly reflect the seven standards. A large majority of the ACI evaluation forms did not adequately assess ACIs based on the standards and criteria of effective ACIs. Future research should focus on developing a standard evaluation form that ATEP program directors can employ. Such a standard tool would facilitate comparisons among ACIs at various institutions and help program directors identify areas of strengths and weaknesses. Additional training can then be provided in

the areas requiring improvement, thus creating a well-rounded, effective ACI to enhance the clinical education of ATSS.

Approved Clinical Instructor Accurately Estimate Athletic Training Student Learning Style

Ristori CA, Eberman LE, Tripp BL, Kaminski TW, Doherty-Restrepo JL: Florida International University, Miami, FL; Indiana State University, Terre Haute, IN; University of Florida, Gainesville, FL; University of Delaware, Newark, DE

Context: Researchers have suggested program directors and clinical coordinators administer learning style (LS) assessments early in a student's academic experience. Identifying each student's preferred LS may facilitate teaching and learning to enhance their educational experiences. While formal identification of athletic training students' (ATS) LSs is not an established practice, if approved clinical instructors (ACI) are inherently able to identify the LS of their ATS, formal identification may not be required. **Objective:** To identify a relationship between the actual ATS LS and ACI estimates of ATS LS. **Design:** We used a blinded, matched-pairs correlational research design to identify the relationship between ACI estimation of ATS LS and actual ATS LS. **Setting:** Participants, both ACIs and ATSS, were solicited via electronic mail and completed the investigation using an on-line LS assessment (www.surveymonkey.com). **Patients or Other Participants:** We solicited ACI contact information from Program Directors of Commission on Accreditation of Athletic Training Education (CAATE) accredited Athletic Training Education Program institutions. Within the target population (n=200), we used a table of random numbers to randomly sample ACIs (n=100). ACIs (n=13, response rate=1.3%; age=30±5y; 3.6±2.7y of ACI experience) subsequently elicited participation from ATSS (n=23, response rate= 5.3% [23/38]) assigned to them during the current clinical rotation. **Interventions:** We contacted ACIs via electronic mail with a brief introduction of the investigation and directions for participation. We asked ACIs to complete a Student Assessment Questionnaire (SAQ) and modified learning style inventory (LSI) at the survey website for each student under his/her supervision. After completing the modified LSI, the participating ACIs provided electronic mail addresses for each of their ATSS. The primary investigator (CR) used this information to match each ATS to their respective ACI and to contact each ATS directly to solicit his/her participation. We contacted ATSS via electronic mail, requesting that students complete the LSI on the survey website. **Main Outcome Measures:** Dependent variables were ACI-

estimated ATS LS and actual ATS LS. We assessed agreement between ACI-estimated ATS LS and actual ATSS LS using the Kappa coefficient. We excluded any data from unmatched ACI-ATS relationships before analyzing the data using SPSS (version 15.0; SPSS Inc, Chicago, IL) with an α -level for all comparisons set *a priori* at $P<0.05$. **Results:** The ACI-estimated ATS LS and actual ATS LS displayed substantial 78.26% (18/23) overall agreement ($\kappa=0.67$). **Conclusions:** Our findings suggest ACIs are able to estimate the preferred LS of their assigned ATSS. Therefore the supposition that LS needs to be assessed prior to interaction with an ACI is not grounded in the evidence. Further research may be necessary to evaluate how ACIs may effectively exploit this information to benefit ATS learning.

Evidence-Based And Critical Appraisal Characteristics Of The Journal Of Athletic Training: 2002-2006

Parsons JT, Snyder AR, Fried A, Wade R, Bay RC: A.T. Still University, Mesa, AZ

Context: Evidence-based athletic training (EBAT) requires a foundation of useful clinical literature to assist clinicians in making decisions. The usefulness of evidence is dependent on several factors, including study design, study quality, and the ability to produce patient-oriented evidence. To date, the athletic training literature has not been studied for its ability to support EBAT. **Objective:** To determine the evidence-based and critical appraisal characteristics of articles published in the Journal of Athletic Training (JAT) between 2002-2006. **Design:** A descriptive, content analytic study. **Setting:** Computer search of existing JAT articles. **Patients or Other Participants:** We categorized all JAT articles published between 2002-2006 (n=267) by article type, using the JAT table of contents. A final sample of articles (n=183) was created from all "clinical" (n=147) or "basic science" (n=8) original research articles. Clinically relevant "observation" articles (n = 28) were also included in the final sample. All other articles were excluded to avoid a selection bias. **Interventions:** Two researchers were trained on the use of a coding schema representing 6 evidence-based and critical appraisal variables. Inter-rater reliability was established using Krippendorff's α , and was determined acceptable (≥ 0.80) for all variables. An expert panel reconciled coding disagreements. Descriptive frequency analysis was used to analyze all variables. **Main Outcome Measures:** Variables included: 1) nature of the research participants (subject vs. patient); 2) dimension of disability represented by dependent variable(s); 3) study design using AJSM categories; 4) study level of evidence using the Strength of Recommendation Taxonomy (SORT); 5) nature of evidence

(disease- vs. patient-oriented); and 6) SORT study category. **Results:** One-hundred-and-thirty-seven (74.9%) of the articles studied subjects instead of patients. Seventy-four (83.1%) of the 89 identified dependent variables reflected origin or organ levels of disablement models, representing a focus on pathology and impairment. Controlled/descriptive laboratory studies were the most common study design ($n=138$; 75.4%), followed by cross-sectional studies ($n=29$; 15.8%). One-hundred-and-sixty-two (88.5%) and 21 (11.5%) studies were SORT level 3 and 2 respectively, with lower evidence numbers indicating a higher quality study. No level 1 studies were found. One-hundred-and-sixty-one (88%) articles investigated topics that were disease-oriented in nature. Of the 21 (11.5%) patient-oriented articles, 7 (33.3%) were diagnostic or prognostic, 2 (9.5%) were preventive, and 8 (37.8%) addressed treatment or screening. **Conclusions:** Clinical and basic science articles published in the JAT between 2002-2006 tend to be disease-oriented laboratory studies, which have limited and indirect impact on patient care. The studies evaluated pathology and impairment dimensions of disablement, employed subjects instead of patients, and had a moderate level of evidence. These findings suggest that articles published in the JAT between 2002-2006 are of limited value to clinicians practicing EBAT.

Coaches' Knowledge Of Athletic First Aid Principles In Texas High Schools

Ransone JW, Wright CJ, Walker J, Pankey R: Texas State University, San Marcos, TX

Context: Approximately 2 million injuries related to high school athletic participation are reported annually, half of which occur during practice when the coach is least likely to have the support of a certified athletic trainer or physician. Therefore it is important to ensure that coaches have adequate knowledge of basic first aid and cardiopulmonary resuscitation (CPR). **Objective:** The purpose of this study was to identify potential predictors of adequate knowledge of athletic first aid principles among Texas high school coaches. **Design:** Cross-sectional survey and descriptive questionnaire. **Setting:** Public high schools in central Texas. **Patients or Other Participants:** 169 head or assistant high school athletic coaches ($n=123$ males, $n=46$ females, years of experience $=12.1 \pm 9.3$) recruited from a convenience sample of 18 high schools. All coaches within each selected school were invited to participate via a letter and survey sent to their school mailbox and/or school email account (38% response rate). **Interventions:** Subjects completed a self-administered Demographic Questionnaire and a 27-item modified First Aid Assessment (FAA,

validity and reliability established by Ransone and Dunn-Bennett, 1999), which assessed both first aid and CPR knowledge. Multiple independent variables such as coach's gender, years of experience, sport coached, competitive division, college major, certifications held and time since last certified were included in the analysis. Data was analyzed using Statview 5.0 for correlation and/or group differences between FAA score and demographic data. ANOVA and multiple regression analysis were performed with an alpha level of $p < .05$. **Main Outcome Measures:** FAA score was expressed on a scale of 0-100%. Passing was defined as a score $\geq 70\%$. **Results:** The sample averaged 75.5% (± 13.0) on the FAA, 69.8% passed (95% CI=62.5, 76.2) and 30.2% (95% CI=23.8, 37.5) failed. A significant positive correlation existed between years of experience and FAA score ($F_{1,167}=9.58$, $p < .002$, $R=0.23$). There was no significant relationship between FAA score and certification in first aid, certification in CPR, gender, sport coached, or undergraduate major. Regression analysis revealed no significant correlation between FAA score and the number of months since first aid or CPR certification ($F_{1,144}=1.23$, $p=0.27$; $F_{1,149}=0.11$, $p=0.74$; respectively). **Conclusions:** Coaches' overall knowledge of first aid principles was found to be insufficient to adequately safeguard the health of high school athletes, with 30.2% failing the FAA. Results indicate that years of experience are the most important factor in predicting coach's knowledge of first aid principles. Since no significant relationship was found between FAA score and certification in CPR and first aid, the efficacy of these certifications to increase coach's knowledge of athletic first aid principles should be questioned. Results emphasize the importance of employing professionally trained personnel to provide health care to athlete.

Comparison Of Entry-Level Master's Athletic Training Programs' First Time Passing Rate To The National Average Passing Rate On The BOC Exam

Fuller D, Schroeder J, Johnson D: Baylor University, Waco, TX, and University of Findlay, Findlay, OH

Context: After graduating from a Commission of Accreditation of Athletic Training Education (CAATE) accredited program, most students must pass the national Board of Certification (BOC) exam to become certified athletic trainers. With many entry-level programs available to prospective students, the success of a program graduates' passing rate on the BOC exam may be a determining factor in where these students decide to attend colleges. **Objective:** The purpose of the study compared the first attempt passing rate of accredited entry-level master's

athletic training (EL-MAT) programs on the BOC exam to the national average for all first exam takers. **Design:** Descriptive survey. **Setting:** The Program Director at each institution was electronically sent a copy of an informed consent as well as the survey. They were informed that all information collected from the study would be completely confidential. IRB approval was obtained. **Participants or Other Participants:** Seven (47%) of the 15 CAATE accredited EL-MAT programs completed surveys. **Interventions:** 27-question descriptive survey was developed. Inter-rater reliability (.82 between two program directors), content and construct validity of the survey instrument were established. An electronic copy of the survey and consent letter was emailed to all program directors of EL-MAT programs. **Main Outcome Measurements:** Frequencies and percentages were calculated on SPSS 15.0. **Results:** The mean number of years programs were accredited was 4.21 ($SD = 2.23$) years with an average of 3 ($SD = 1.81$) graduating classes. The average number of years of an EL-MAT program was just over 2 years (2.28 $SD = 0.39$) and the average credit hours was 53 ($SD = 17.22$). The total number of clinical education hours required was 997 ($SD = 265.94$). The majority of programs also included a preparation class to help students prepare for the BOC exam ($n=5$, 71.4%). Of the EL-MAT programs, 85.7% ($n=6$) did not overlap with their respective physical therapy programs. All of the EL-MAT programs encouraged their students to attend BOC preparation workshops, with 65% ($SD = 35.05$) whom actually attended such workshops. A study examined a total of 36 students who took the BOC exam. The study concluded that the average EL-MAT first attempt passing rate on the entire BOC exam was 71.43% ($SD = 21.38$). The total amount of students who passed the exam was calculated to be 26 out of a total 36. The EL-MAT program success rate was higher than the national averages in both 2004 and 2005 where the first attempt passing rates were 35% ($n=813$), and 26% ($n=496$) respectfully. **Conclusions:** This research concluded EL-MAT programs to be better at preparing students for the BOC exam. These programs may be better because they are shorter and more focused on BOC preparation (i.e., no general education).

An Assessment Of Personality Traits Of Athletic Training Students

Caswell AM, Caswell SV, Gould TE, Ambegaonkar JP, Piland SG: George Mason University, Manassas, VA, and University of Southern Mississippi, Hattiesburg, MS

Context: Extensive published research exploring student personality traits exists in the allied health literature. However, no published research has examined the psychological construct in the profession of athletic training. **Objective:** To examine athletic training students (ATS) personality traits using the Five Factor Model of Personality and explore how gender and education level relate to ATS personality types. **Design:** Correlational. **Setting:** Large southeastern university. **Patients or Other Participants:** A convenience sample of 86 students declared as athletic training majors course participated in this study. Forty-eight participants (M = 24; F = 24) (21.49 ± 1.69 years) returned complete survey instruments. The response rate was 56%. An institutional

review board approved this investigation. **Interventions:** Participants completed the NEO Five Factor Inventory (NEO FFI) instrument in a classroom setting. The NEO FFI is a measure of the Big Five Factors of personality: neuroticism, extraversion, openness, agreeableness, and conscientiousness. Research literature provides strong support for reliability and construct validity via Cronbach's alpha (.77 to .92) and test-retest coefficients (.63 to .87). **Main Outcome Measures:** The NEO-FFI Form S is a 60-item instrument that has individuals rate 12 sets of 5 statements using a 5-point Likert-type scale anchored by 0 (strongly disagree) and 4 (strongly agree) Combined means for both sexes as well as male and female means where calculated for each of the five domains. **Results:** Combined mean scores, male mean scores and female mean scores respectively for: Neuroticism 19 ± 7.91 , 17 ± 7.59 , and 21 ± 7.91 ; Extraversion 31 ± 5.64 , 31 ± 6.16 , and 32 ± 5.19 ; Openness to Experience 26 ± 4.71 , 25 ± 3.77 , and 27 ± 5.40 ; Agreeableness 29 ± 5.48 , 30 ± 5.52 , and 30 ± 5.56 ; and Conscientiousness were 35 ± 4.69 , 36 ± 4.34 , and 33 ± 4.82 . Requirements

of an *a priori* power analysis were met. **Conclusion:** Male and female respondents scored high on Extraversion, however females also scored low on Agreeableness. Individuals with high scores on Extraversion and low scores on Agreeableness, as with the female participants, are described as dominant and self-assured individuals that tend to be assertive, forceful, firm, persistent, and selfconfident. These individuals tend to seek out leadership positions and enjoy managing others. Whether such personality traits relate to exceptional athletic training clinical practice remains unknown. Similar to other psychological constructs (e.g. learning styles) personality traits may have considerable influence in student and instructor interactions, academic performance, and the development of foundational behaviors of professional practice. Future research with the aim of better understanding the relationship between predominate personality traits and effective clinical practices is needed.

Free Communications, Poster Presentations: Psychometrics in Athletic Training

Friday, June 19, 2009, 8:00AM-11:30AM, Park View Lobby, Concourse Level; authors present 10:30AM-11:30AM

Evaluation Of The Western Ontario And McMaster Universities Osteoarthritis Index (WOMAC) For Response Shift Among Surgical Knee Patients

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Context: Response shift is the phenomenon by which individuals alter their self-evaluation via reconceptualization, recalibration, or reprioritization over time. Response shift has been documented as influencing health related quality of life measures in a variety of populations. Should this change typology occur without being recognized, it may alter long-term outcomes of clinical research as patients' conceptions of pain, function, and health change over time. **Objective:** The purpose of this study was to evaluate the 24-item Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) for response shift among knee surgical patients. **Study Design:** Longitudinal cohort design. **Setting:** Orthopaedic sports medicine clinic. **Patients:** Patients ($n = 66$, age = 26 ± 9 , height = 175 ± 10 cm, weight = 86 ± 22 kg) undergoing surgery for ligament, meniscal, or articular cartilage knee pathologies. **Interventions:** All patients completed the WOMAC as part of inclusion in a patient data registry pre- and post-

operatively following knee surgery (average of 15.5 ± 3 weeks). **Main Outcome Measures:** A principle component analysis was completed using a varimax rotation and an eigen value of 1.0 as criteria for component inclusion for both pre-operative and post-operative data. The coefficient of congruence—“the sum of the products of the paired loadings divided by the square root of the product of the two sums of squared loadings”—was then used for factor comparison between pre-operative and post-operative total WOMAC scores using Korth and Tucker methods for determining minimum values for statistically significant changes in factor structure. **Results:** Mean pre-operative total WOMAC scores were 31 ± 18.5 , while post-operative total scores improved to 17 ± 14.5 . Both data sets demonstrated 4 significant factors consistent with the previously identified WOMAC factors of “lying/sitting,” “standing/walking,” “bending,” and “ascending/descending.” Coefficients of congruence ranged from 0.75 to 0.93. There was no evidence of changes in factor structure suggestive of response shift among our patients at the $P < 0.001$ level. **Conclusions:** Our results support the use of the WOMAC as a short-term outcome measure for longitudinal studies concerning patients with knee pathology. It does not appear to be influenced by changes in patients' internal reference scale. Further research is

needed to address the ability of the WOMAC to resist response shifts that may occur over longer time periods than those examined in this study.

Establishing The Foot And Ankle Disability Index As A Sensitive, Specific, And Valid Tool For Identifying Deficits Related To Chronic Ankle Instability

Siegel N, Erickson K, Thompson J, Abraham K, Telemeco T, Hale SA: Shenandoah University, Winchester, VA

Context: The sports subscale of the Foot and Ankle Disability Index (FADI Sport) is a region-specific, patient self-report of function designed for high functioning individuals. Evidence of reliability and sensitivity support the use of this tool in those with chronic ankle instability. There is no literature however to suggest a cutoff score and there has been no analysis of individual items of the FADI Sport. **Objective:** To examine the following measurement properties of the FADI Sport: (1) the predictive validity of the individual items of the tool for identifying individuals with chronic ankle instability (CAI), (2) a cutoff score, with corresponding sensitivity and specificity for the tool to identify individuals with CAI and (3) the positive likelihood ratio using the cutoff score for detecting CAI. **Design:** Prospective

cohort **Setting:** Laboratory **Patient or Other Participants:** Eighty-six recreationally active individuals (31 men/55 women, 91 stable ankles/81 ankles with CAI) participated in this study **Interventions:** Participants completed a separate FADI Sport for each ankle. **Main Outcome Measures:** Mann-Whitney U-tests and a logistic regression were used to examine the ability of each FADI Sport item to detect differences between stable and unstable ankles. A receiver operating characteristic (ROC) curve was constructed to determine a cutoff score and then sensitivity, specificity, and positive and negative likelihood ratios were calculated for the cutoff score. **Results:** Every question was able to differentiate between healthy individuals and individuals with CAI ($P < 0.001$ for all questions). A logistic regression indicated that question 3 ($P < 0.001$) and question 5 ($P = 0.003$) were most predictive of individuals with CAI. The threshold FADI Sport score was 27.5, with a sensitivity of 84.2%, and a specificity of 93.3%. The positive likelihood ratio for this threshold score is 12.57. **Conclusions:** The FADI Sport appears to: (1) differentiate between healthy individuals and individuals with CAI, with questions 3 and 5 indicating that deficits in landing and cutting/lateral movements are the most predictive for individuals with CAI, (2) have a sensitive and specific cutoff score for detecting CAI, and (3) has a positive likelihood ratio that indicates a moderate shift in probability for detecting CAI in individuals that score below a 28 on the FADI Sport.

Normalizing Hip Muscle Strength: Establishing Body Size-Independent Measurements

Bazett-Jones DM, Joshi M, Cobb SC, Earl JE: University of Wisconsin-Milwaukee, Milwaukee, WI

Context: Muscle strength has been shown to be positively correlated with body size measures, specifically body mass (BM) and height (H). Hip strength (HS) data in the literature is either non-normalized, or normalized to BM (i.e. BM, $BM^{0.67}$) or a combination of BM and H (i.e. $BM \times H$, BMI). Previous research has examined these normalization techniques for body size-independence, but has not been applied these to HS measures. **Objective:** To determine which method(s) of normalizing HS force and torque values results in a body size-independent measure(s). **Design:** Cross-sectional. **Setting:** Neuromechanics Laboratory. **Patients or Other Participants:** A convenience sample of 79 healthy, college-aged participants (32 men, 47 women; age = 22.6 ± 4.7 , mass = 71.7 ± 16.2 kg, height = 1.69 ± 0.11 m) volunteered to participate. **Interventions:** Participants attended a single testing session during which anthropometric measurements of the leg and thigh were obtained

and maximal HS was tested in all six directions (internal and external rotation, abduction, adduction, flexion, extension). Strength was measured isometrically with a hand-held dynamometer secured to a non-elastic strap. Torque was then computed by converting kg to N and then multiplying it by the moment arm length (m). Force was normalized in 4 different ways: to BM (kg/kg), $BM^{0.67}$ (N/kg), $BM \times H$ (N/kg-m), and BMI index (BMI; Nm^2/kg). Torque was normalized to BM (Nm/kg), $BM \times H$ (N/kg), and BMI (Nm^3/kg). Statistical analyses included Pearson correlations to determine the relationship between BM and strength, and linear regressions to determine if the normalized HS measures predicted BM. **Main Outcome Measures:** Dependent variables included both force and torque values for the six HS measures for each normalization method. The regression analyses compared BM to the 36 different measures, with an alpha level of $p < 0.05$. A significant relationship between BM and the normalized strength measure indicated that the measure was not independent of body size. **Results:** Significant correlations ($r = 0.247-0.510$, $p \leq 0.001$) between BM and all HS measures except extension force ($r = 0.209$, $p = 0.064$) were found. For all HS measures, force normalized to $BM^{0.67}$ (range of values for all HS measures: $r = -0.002-0.003$; $p = 0.253-0.787$), force normalized to BMI ($r = -0.012-0.020$; $p = 0.324-0.819$), and torque normalized to BM ($r = -0.377-0.017$; $p = 0.261-0.955$) were not significantly related to BM, therefore are body size-independent measures. Force normalized to $BM \times H$ ($r = -0.011-0.002$; $p = 0.002-0.128$), torque to $BM \times H$ ($r = -0.003-0.0003$; $p = 0.047-0.50$) and BMI ($r = -0.003-0.0004$; $p = 0.004-0.186$) were significantly related to BM. **Conclusions:** Normalizing force to $BM^{0.67}$ or BMI and torque to BM are the most effective methods of removing body size dependence and allowing comparisons of individuals with differing body sizes. Properly normalizing strength measures allows for comparisons between individuals with different body sizes (e.g. gender) and protocols where BM could change (e.g. long-term treatment). Using body-size-independent normalization techniques will produce a more consistent body of literature on this topic.

Determination Of Power With The Hawaii Anaerobic Run Test

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Context: Exercise tests of anaerobic power offer insight into athletes' performance, effectiveness of high intensity training programs, and may play a part in return to play guidelines following injury. The Hawaii Anaerobic Run Test (HART)

offers a practical and easy field test alternative to the Wingate Anaerobic Test (WAnT), which is more specific for runners than a cycling test. **Objective:** To test the reliability and validity of a new test of anaerobic power, the HART, by comparing momentum and fatigue values obtained during the HART to power and fatigue values from the WAnT. **Design:** A repeated measures, randomized crossover design. **Setting:** This study was performed in both an outdoor track environment (HART) and in a controlled laboratory setting (WAnT). **Participants:** 96 (52 males, 44 females) healthy, college-age individuals (age = 22.0 ± 2.8 yr, height = 163.9 ± 9.5 cm, 70.6 ± 14.7 kg, body fat % = 19.29 ± 5.39 %). **Interventions:** The HART consists of a 200-meter maximal effort sprint around a standard track. Infrared timing devices (Wireless Sprint System, Brower Timing Systems, Draper, UT) were placed at 25-meter increments throughout the test distance. Subjects were instructed not to pace themselves, but to complete each increment as fast as possible. The Subjects completed two trials of the HART. The established WAnT was conducted using a cycle ergometer (Monark Ergonomic 834 E, Monark Exercise AB, Vansbro, Sweden) and specialized computer software (SMI Power, Sports Medicine Industries, Inc., St Cloud, MN). **Main Outcome Measures:** The independent variable was exercise mode (HART and WAnT). The dependent variables were peak and mean momentum, determined from the collection of 25 meter split times throughout the 200 meter HART, peak and mean power, obtained from the WAnT. Validity was determined using face validity and concurrent validity as criterion measures. **Results:** The peak and mean momentum from the HART were 488.5 ± 139.9 and 448.0 ± 131.5 , respectively. Peak and mean power from the WAnT were 843.0 ± 279.5 and 648.5 ± 191.7 Watts, respectively. Correlations between peak power and peak momentum were $r = 0.88$; mean power and mean momentum were $r = 0.94$. The correlation between fatigue indices for the two tests was $r = 0.11$. The correlation between trial one and trial two of the HART was $r = 0.98$. **Conclusions:** The HART was judged to be a valid and reliable alternative to the WAnT for assessing anaerobic performance, which is specific to running. The high correlation between trial one and trial two of the HART demonstrated the HART was reliable. Thus, the HART can be used as a simple alternative for assessing anaerobic performance as part of the athletic trainers' return to play criteria.

Test-Retest Reliability Of Measurement Line Placement On Radiographs For Assessing Ankle Joint Motion

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Context: Ballet dancers exhibit extreme dorsiflexion and plantar flexion. This consists of motion at the ankle joint and at joints of the foot. Angular measurements on x-rays are required for accurate assessment of the relative contributions of the various joints; thus, reliability of such techniques is important. Reliability in making radiographic measurements also is important in other populations.

Objective: To determine whether measurement lines placed on x-rays of the ankle and foot can be reliably reproduced. **Design:** Within-subjects test-retest. **Setting:** Professional ballet company, vocational ballet school, and hospital radiology department. **Participants:** Eight professional and vocational female ballet dancers (age=23.0±3.3 yrs, dance experience =18.6±3.1 yrs) without ankle pathology volunteered for the study and gave their informed consent to be x-rayed. **Interventions:** Each volunteer donned ballet pointe shoes and underwent a lateral x-ray of her ankle and foot in weightbearing with the ankle in neutral position. Using digital illustration software (Adobe Illustrator CS3), three lines commonly used for ankle range of motion measurement were placed on each x-ray image: tibial shaft axis (TIB), fibular shaft axis (FIB), and collum tali axis of the talus (CTA). Three weeks after the first set of lines were drawn, the process was repeated on the same x-ray images. A new set of measurement lines were drawn on each x-ray without referring to the initial set of lines. Angular measurement pairs for TIB, FIB, and CTA lines were analyzed using Pearson correlation and T tests. Significance level was set at $p<.05$. **Main Outcome Measures:** Using trigonometry and the software's ability to precisely locate line coordinates, each line's angular position on an x-ray with reference to horizontal was calculated from its horizontal and vertical components. **Results:** The mean values for the lines' angles to horizontal were: $TIB_1=85.8\pm3.0^\circ$; $TIB_2=85.6\pm2.7^\circ$; $FIB_1=82.1\pm3.2^\circ$; $FIB_2=82.4\pm3.1^\circ$; $CTA_1=17.8\pm4.9^\circ$; $CTA_2=19.8\pm4.6^\circ$. Pearson correlations for the pairs were: $TIB=.99$ ($p<.001$); $FIB=.98$ ($p<.001$); $CTA=.84$ ($p=.009$). T test results indicated that the means of the test-retest measurements were not significantly different for any of the lines ($p>.05$). However, the

coefficients of variation were: $TIB=.060\%$; $FIB=.085\%$; $CTA=14.34\%$. Therefore, poorer test-retest reliability of CTA versus both TIB and FIB was demonstrated by the substantially greater variability in CTA compared to TIB and FIB. **Conclusions:** The current data suggest that lines representing the axes of the tibia and fibula are more reliable than those representing the axis of the talus when utilizing these lines to measure ankle motion on x-rays. These results may be related to greater ease in identifying an axis in long bones compared to short bones. These results also suggest the need to research the reliability of other common measurement methods that incorporate x-ray landmarks.

Validity And Reliability Of The NCAA's Web-Based Injury Surveillance System

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Context: The National Collegiate Athletic Association (NCAA) Injury Surveillance System (ISS) involves hundreds of certified athletic trainers (ATC) in the USA entering injury surveillance data into a web-based system. These data are used by NCAA committees to make decisions relevant to student-athlete welfare and are used by sports medicine researchers around the world. However, the validity and reliability of this data are currently unknown. **Objective:** To quantify the proportion of injuries captured by the ISS by comparing the data in the system to other types of clinical records maintained by the ATCs. **Design:** Validation study using record abstraction. **Setting:** A sample of 15 NCAA colleges and universities who had provided data on men's and women's soccer to the ISS for at least 2 years. **Participants:** Men's and women's soccer athletes at these institutions and their team ATCs. Out of 45 eligible schools, 21 were initially enrolled into the study. Five schools withdrew and one was lost to follow up, leaving 15 schools and 33 ATCs in this study. **Main Outcomes Measures:** Athletic injuries resulting from participation in NCAA collegiate sports that resulted in one day or more of restricted activity in games or practices and required medical care. Injury data reported to the ISS was compared to injury data from the ATCs' paper files or some other (non-ISS) electronic injury-tracking database. Capture-recapture analysis was conducted using a generalized linear model to

compare the ISS to the other injury database. **Results:** Six schools used another electronic database and eight schools used paper records (in addition to their reporting to the ISS). A total of 703 (93%) of men's and women's soccer athletes consented to participate in this study. Participation did not vary by sex, however did vary by division. Overall, a greater proportion of athletes at Division-I (95%) and Division-III (92%) schools consented to participate compared to athletes at Division II schools (89%). The research team abstracted 672 injury events at 14 schools (abstraction at one school is still in progress). Capture-recapture analysis estimated that the ISS captured 88.1% (95% CI: 85.6%-90.5%) of the injury events. The proportion of events in both data sources increased over the three-season period: 48.6% in 2005-06, 67.3% in 2006-07, and 78.7% in 2007-08, possibly indicating a "learning curve" with the ISS. The proportion of events captured in both sources was higher among Division I (73.7%) and Division III (68.2%) schools compared to Division II (61.2%) schools. These proportions were similar for men and women. **Conclusions:** The capture of the ISS (88%) is very good. However, no source captured completely all time-loss/medical-attention sports injuries. The percent of events captured in both sources varied by year and division.

Reliability Of Tibial Bone Mineral Density Measures Using A Novel Manual Regional Analysis Of Dual-Energy X-Ray Absorptiometry Scans

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Context: Novel regional bone mineral density (BMD; g/cm^2) measurements may provide valuable information for injury prevention and evaluation of rehabilitation intervention strategies. It is important to evaluate the reproducibility of these BMD measures to assess their usefulness for clinical and research settings. **Objective:** To determine the intra and inter-tester reliability of BMD measures of young athletes using manually created distal tibial regions from total body dual-energy x-ray absorptiometry (DXA) scans. **Design:** A cross-sectional descriptive design was employed. **Setting:** Total body DXA scans were performed in the University of Kentucky Body Composition Core Laboratory. **Patients or Other Participants:** Forty-nine (26 men and 23 women) varsity Division I swimmers ages 18.2 to 24.7 years served as subjects. **Interventions:** Acquired total body DXA scans were subsequently analyzed by two independent investigators, twice by one investigator for intra-tester reliability and once by a second investigator to provide inter-tester reliability measures in a

blinded manner, by manually creating regions of interest that included the distal one-third of right and left tibias. The DXA scans were measured using a Lunar DPX-IQ (GE Lunar Inc., Madison, WI) bone densitometer and analyzed using software version 4.3. **Main Outcome Measures:** The right and left distal regional tibial BMD measures were the main outcome measures. Repeated measures analysis of variance and correlation analyses were used to determine the reliability of the BMD measures. Bland-Altman plotting was used to demonstrate the group mean differences and the 95% confidence intervals (95% CI). **Results:** There were no significant intra-tester reliability group mean differences for the right (1.085 ± 0.126 versus 1.089 ± 0.124 g/cm²; $P = 0.141$) or the left (1.075 ± 0.124 versus 1.077 ± 0.126 g/cm²; $P = 0.623$) distal tibial BMD regions. There were significant intra-tester reliability correlations between the right ($r^2 = 0.98$; $P < 0.0001$) and left ($r^2 = 0.96$; $P < 0.0001$) BMD measures. The group mean differences and the 95% CI for the right and left intra-tester reliability measures were -0.004 ± 0.038 and -0.002 ± 0.052 g/cm², respectively. There were no significant inter-tester reliability group mean differences for the right (1.085 ± 0.126 versus 1.084 ± 0.126 g/cm²; $P = 0.729$) or the left (1.075 ± 0.124 versus 1.077 ± 0.126 g/cm²; $P = 0.409$) distal tibial BMD regions. There were significant inter-reliability correlations between the right ($r^2 = 0.98$; $P < 0.0001$) and left ($r^2 = 0.96$; $P < 0.0001$) BMD measures. The group mean differences and the 95% CI for the right and left inter-reliability measures were 0.001 ± 0.038 and -0.003 ± 0.052 g/cm², respectively. **Conclusions:** These findings suggest that distal regional tibial BMD analysis measures from DXA scans have excellent intra-tester and inter-tester reliability, and thus can be used in clinical and research settings with confidence.

Development Of A Rehabilitation Adherence Measure For Athletic Training

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Context: Rehabilitation adherence (i.e., attendance, participation) is accepted as a critical component for attaining optimal rehabilitation outcomes. Poor adherence is reported as a common occurrence and recognized as a major problem affecting rehabilitation in the athletic training setting. To date, only one measure of adherence has been published for use with sport injury: the Sport Injury Rehabilitation Adherence Scale (SIRAS) (Brewer, et al., 2000). However, the SIRAS was developed specifically for use

with community-based rehabilitation (physical therapy clinics) not athletic training. **Objective:** This investigation aimed to 1) identify indicators (i.e., behaviors) of adherence that are relevant to collegiate athletic training and 2) develop a rehabilitation adherence measure for athletic training (RADMAT) based on these indicators. **Design:** Mixed methods. **Setting:** Collegiate athletic training in the US. **Patients or Other Participants:** ATCs practicing in the collegiate setting ($n=7$) participated in item generation; experts (sport injury/rehabilitation researchers, athletic training faculty/staff) ($n=12$) reviewed preliminary items; ATCs practicing in the collegiate setting ($n=164$) completed the RADMAT for their most, average and least adherent athlete. **Data Collection and Analysis:** Three steps were included in the development of the RADMAT. First, ATCs identified clinically relevant indicators of adherence with open-ended questionnaires; these indicators were used to generate preliminary measure items. Second, an expert panel reviewed the preliminary items and provided feedback pertaining to content/clarity of items. Expert review was used to revise the measure and provide initial content validity assessment. Third, the preliminary RADMAT was administered to a larger sample of ATCs to provide data for reliability/validity analyses. An internet-based survey tool was used to collect responses. **Results:** Step 1 resulted in three categories (presence, participation, attitude) with ten subcategories of adherence indicators; 49 items were created from these indicators. For most items, ATCs' original wording was used. Step 2 resulted in the preliminary 25-item RADMAT. Step 3 demonstrated the preliminary 25-item RADMAT had good internal consistency (Cronbach's $\alpha > .926$) and exploratory factor analyses revealed 6 factors. Additional factor analyses reduced the measure to 16 items and suggested three sub-scales (attendance/participation, communication, attitude/effort) that explain 57.93% of the variance. The resulting 16-item RADMAT subscales and total all have good internal consistency (Cronbach's $\alpha > .748$) and discriminate among adherence levels ($F(2, 163) = 614.77$, $p < .001$, $\eta^2 = .790$). **Conclusions:** The RADMAT has a conceptual and practical base in athletic training practice that make it particularly relevant and appropriate for use in athletic training settings. With only 16 items in a simple format, the RADMAT is also relatively easy to use, whether by athletic trainers in clinical practice or for research purposes. The RADMAT's subscales are an improvement on the SIRAS' single factor structure. Future investigations are needed to further establish the measure's reliability.

Psychometrics Of Ankle Self-Report Survey (PASS)

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Context: One challenge athletic training faces in establishing an evidence based profession is the lack of outcome instruments appropriate for physically active clientele. Although there are over 40 self-reported ankle/foot scales, none have been validated for the physically active. The Foot and Ankle Disability Index (FADI) has merit but has not been psychometrically analyzed for physically active individuals with varying levels of ability. **Objective:** Our purpose was to determine the measurement capabilities of the FADI using Rasch modeling for athletic training clientele (injured to highly physically active). **Design:** We used a non-experimental, observational design. **Setting:** Data were collected in collegiate athletic training rooms and outpatient rehabilitation clinics. **Participants:** Two-hundred-and-forty-four participants (age: 18-50 years) volunteered in accordance with university IRB. The participants (146 males, 98 females) represented four sub-groups: a) 39 healthy/elite, b) 110 healthy/physically active, c) 20 healthy/not active, and d) 75 injured. **Interventions:** Participants completed the FADI, a 34-item scale that consists of two subscales (ADL = 26 items; Sport = 8 items). We used the Rasch Rating Scale Model to examine the FADI. Additional analyses using the calibrated estimates in the form of logits were also performed. **Main Outcome Measure:** We established model-data fit using infit/outfit statistics ($>.5 < 1.5$). The item difficulties range, ability estimate range, precision (Conditional Standard Error ≤ 0.4 ; CSE), and visual inspection of the Wright Item-person map were performed. We addressed ceiling effects by examining the percentage of maximum scores, using a five percent error tolerance. **Results:** Overall, the data fit the model well with 27 of 34 items having adequate infit/outfit statistics. There were seven misfitting items: "Walking without shoes", "Squatting", "Sleeping", "Walking 10 minutes", "Home responsibilities", "Personal care", and "Low-impact activities". Whereas item difficulty ranged from -2.80 to 2.20 logits, ability estimates ranged from -1.91 to 8.07 logits. Based on the accepted CSE (≤ 0.4), the instrument precisely measured ability estimates that ranged from -1.91 to 4.35 logits. Eighty-four participants had a CSE ≤ 0.4 , indicating that only 34.4% of the participants were measured precisely and over 65% were not. Of the 84 participants that had scores less than 0.4, only two (5.1%) were healthy/elite and 64 (85.3%) were injured. Furthermore, 120 of the 244 participants (49.2%) obtained the maximum FADI score, indicating a severe ceiling effect. **Conclusions:**

The FADI-Total can precisely measure individuals with low ability levels, such as those with ankle/foot injuries. However, it is severely limited in its measurement capabilities and lacks items difficult enough to measure healthy active

individuals. Once an individual's ability approaches anything beyond what is considered low, the FADI becomes useless. For the FADI to be applicable in athletic training, more difficult items must be developed. *Funded by a Master's*

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Free Communications, Poster Presentations: Case Report Posters

Friday, June 19, 2009, 8:00AM-10:30AM, Park View Lobby, Concourse Level; authors present 10:30AM-11:30AM

Great Toe Injury In A Collegiate Softball Player

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Background: A 20 year old female softball player (body mass=72.7 kg, height=175.26 cm) reported to the ATC with right great toe pain. The athlete had a previous history of foot pain resulting from completing eight practices in two days during the pre-season. Pain was localized to the first metatarsal-phalangeal (MTP) joint and over the dorsum of the foot along the extensor hallucis longus tendon. The athlete complained of pain with extension against resistance. At this time, she was treated conservatively with a boot and allowed to participate during the regular season as radiographs (AP and oblique views) were ordered and found to be negative. After completion of the season, the athlete was again referred to her physician due to the return of pain, this time localized over the sesamoids.

Differential Diagnosis: Turf toe, sesamoiditis, sesamoid stress fracture, sesamoid fracture, flexor hallucis brevis tendinopathy, extensor hallucis longus tendinopathy. **Treatment:** At the conclusion of the season a second set of radiographs (AP and oblique views) were taken, which were negative as well. Therefore, her physician ordered an MRI, which revealed a bipartite sesamoid and edema in both aspects of the tibial sesamoid. Following the diagnosis of a stress reaction to the bipartite tibial sesamoid bone, the athlete was instructed to be non-weight bearing with a boot and crutches for three weeks. During this period the athlete performed non-weight bearing activities focusing on maintaining cardiovascular endurance via bike and swim-ex workouts. After three weeks the athlete was allowed to initiate weight bearing activities, such as stationary hitting drills, and progressed to jogging after two months. The athlete performed all weight bearing activities related to rehabilitation and softball without the support of the boot. Supportive taping and padding was used to limit great toe extension. The athlete remained in the boot when not performing softball related activity. She is currently participating in all activity with no restrictions and is no longer wearing the boot.

Uniqueness: Injuries to the sesamoids compromise 12% of injuries to the great toe complex and pain usually results from a traumatic injury to the ball of the foot. The prevalence of

bipartite sesamoids ranges from 11-13.5%. In this case, the initial signs and symptoms were not consistent with a tibial sesamoid pathology and the athlete completed the season before reporting any disability associated with the sesamoid area. The athlete suffered no traumatic injury and did not initially report pain localized to the ball of the foot over the sesamoids until mid-season play, two months after the initial complaint. In addition, it is not known if the treatment of the turf toe pathology resulted in complaints from the previously undiagnosed bipartite tibial sesamoid. **Conclusions:** Location of pain may not always be the best indicator of an injury or pathology. The underlying cause may often remain unclear. If pain is persistent or a condition is resistant to treatment, there may be other, previously undiagnosed contributing factors. In this case, irritation to an undiagnosed bipartite tibial sesamoid was associated with turf toe-like symptoms. Stress injury to the bipartite tibial sesamoid initially presented with pain along the dorsum of the foot for two months before pain presented along the plantar aspect of the base of the first metatarsal in the sesamoid region.

Bilateral Multipartite Sesamoidectomy In A Recreational Athlete: A Case Report

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Background: This case discusses a patient with bilateral multipartite plantar sesamoids. A 22-year-old female recreational athlete presented with pain over the first metatarsophalangeal joint in her left foot of an insidious onset. Initial examination found slight swelling, erythema, and point tenderness directly over both the tibial and fibular sesamoids. The patient reported the pain was very similar to her prior two incidences of sesamoiditis and reached its highest severity at night or after long bouts of time standing or walking. Initial diagnosis was sesamoiditis and the patient was placed in a walking boot for two weeks and prescribed NSAIDs. Two weeks after the initial diagnosis, pain had subsided in the left foot, however the patient reported the same pain in her right foot. Upon evaluation, the same symptoms were presented and a diagnosis of sesamoiditis of the right tibial and fibular sesamoids was made. The same conservative

treatment was administered to the patient's right foot. One week later, the pain in the left foot had returned and the resultant treatment was for the patient to wear two walking boots simultaneously until further diagnosis could be reached. **Differential Diagnosis:** Sesamoiditis, sesamoid fracture, first MTP joint stress fracture, turf toe, hallux valgus. **Treatment:** Four weeks post initial evaluation, a consultation with an orthopedic specialist was obtained. Radiographic evaluation and bone scan indicated bilateral partite fibular and tibial sesamoids. Both fibular sesamoids and the tibial sesamoid of the left foot were reported to be bipartite while the tibial sesamoid of the right foot was tripartite. Since this condition had become a chronic issue and the patient's goal was to return to recreational activity without future complications, surgical intervention was chosen as the best treatment route. In January 2007, a complete sesamoidectomy was performed on the patient's left foot. Immediately post surgery the patient was placed in a padded soft cast covering the proximal phalanges up to the fibular head. The cast was removed two weeks post-op and a post-op shoe was applied. After six weeks on crutches the patient progressed to full weight bearing in a walking boot on the left, and a complete sesamoidectomy was performed on the right foot. Immediately post surgery of the right foot the patient was placed in a compression wrap. Due to extensive pain two weeks post-op, the patient was placed in a custom made hard cast that covered the entire plantar aspect of the foot while allowing for MTP extension dorsally. After two weeks in the hard cast the patient was placed into a walking boot on the right foot while still using crutches for ambulation; at the same time the patient was allowed to wear a fully supported sneaker on the left foot. Over the course of the next three weeks, the patient was allowed to progress to full weight bearing while in the walking boot. At twenty-four weeks post initial diagnosis, the patient was allowed to wear two sneakers for the first time. **Uniqueness:** The presence of bilateral multipartite sesamoids is extremely rare in recreational athletes. Approximately 26% of the normal population has been found to have a unilateral bipartite sesamoid, and unilateral multipartite sesamoid is found in less than 1% of the normal population. However, we found no reports of bilateral multipartite sesamoids in the feet of a recreational athlete. Therefore, a diagnosis of this osteopathic

condition in both feet of a recreational athlete makes this particular case extremely rare. **Conclusions:** It is important for team physicians as well as certified athletic trainers to take a more pro-active approach to conclusive diagnosis of individuals who present with signs and symptoms of sesamoiditis.

Double Achilles Rupture And Repair In Division I Men's Gymnast

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Background: 19 YO WM, sophomore male gymnast who is a vault and floor specialist. NCAA All-American on both events freshman year. Complained of previous right Achilles soreness intermittently and was seen by team physician. No increased thickness of the tendon or crepitus palpated. Received daily treatments for Achilles tendonitis/tenosynovitis and was tapped for workouts daily with Achilles strap. On November 16, 2008 athlete punched for a tumbling pass and felt like he hit a hole in the floor on his takeoff. No immediate pain felt and thought he could walk on his own but was unsuccessful. Tape was removed and Thompson test was positive for Achilles tendon rupture.

Differential Diagnosis: Was seen immediately by team physician where x-rays were obtained to rule out possible avulsion of Achilles as well as an MRI to rule out complete tear of Achilles tendon. **Treatment:** X-rays were negative for avulsion. MRI showed complete tear of Achilles tendon just distal to the musculotendinous junction. Surgery was successfully performed five days later to repair tendon. Athlete was placed in a cast for six weeks in slight plantarflexion and then into a walking boot with instructions to progress to normal gait without boot over the next two weeks. Eight weeks post-op athlete had normal gait. While leaving class walking down a small incline athlete felt like someone shot him in the back of the leg. Evaluation showed no obvious defect in the tendon. Thompson test was negative, active and resistive dorsiflexion and plantarflexion performed with no problems. There was a palpable superficial soft spot distal to initial repair site. Was evaluated by team physician immediately and diagnosed with possible disruption of scar tissue or possibility of a popped stitch. Placed back in a walking boot for comfort for one week then progressed with rehab to normal gait, continued with daily rehabilitation over next four weeks. Started small functional progression at fourteen weeks post-op. At week sixteen post-op while walking on the trampoline athlete felt another pop in right Achilles. MRI was done revealing a new complete tear of right Achilles tendon distal to original repair site. Athlete went in for second Achilles repair surgery one week later. After second surgery, blood work

was done to rule out a thyroid condition that may have impaired the healing process of the first repair. All blood work came back WNL. The athlete was immobilized for six weeks in a cast in slight plantarflexion and six weeks in a walking boot only removed for rehabilitation. The athlete then progressed through a rehabilitation process over the next five months and released for full participation seven months post-op from his second surgery. **Uniqueness:** The athlete tore his Achilles twice on the same leg and the second tear was non-impact. The athlete was an NCAA All – American on both floor and vault his freshman year and was able to return to All – American status on floor his junior year even though the consensus was doubtful if he would ever be able to do gymnastics again.

Conclusion: Tearing your Achilles tendon once is hard enough to come back from as a gymnast, but returning to full competition status after tearing the same Achilles twice is unthinkable let alone to return to previous competition status and make All – American. The athlete's commitment, determination and hard work throughout the rehabilitation process enabled him to overcome the mental and physical struggles along the way and allowed him to continue his career as a Division I gymnast.

Mastisol® Reaction Following The Removal Of A Second Metatarsal Exostosis In A Female Collegiate Volleyball Player: A Case Report

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Background: We present the case of a volleyball player suffering an allergic skin reaction to the adhesive glue Mastisol® after removal of a dorsal exostosis. A 19-year-old female intercollegiate volleyball player (body mass = 62.5 kg, height = 176.5 cm) suffered a sesamoid fracture of the right foot which required a sesamoidectomy. Prior to the surgery, the athlete was also diagnosed with a large right dorsal exostosis over the second metatarsal. The surgeon and athlete agreed to remove the exostosis simultaneously with the sesamoidectomy. The dorsal incision used to excise the exostosis was closed using Mastisol®, a surgical adhesive. The sesamoidectomy required a temporary non-weight bearing splint. Four days later the athlete observed a rash and blistering around the dorsal incision where the adhesive was applied. **Differential Diagnosis:** Contact dermatitis, pressure ulcer, bacterial infection, vasculitis, necrosis, diabetes. **Treatment:** After the rash and blisters were noted a topical hydrocortisone cream, applied 2-3x daily was prescribed by the physician. On follow-up 3 days later, there was noticeable improvement around the wound; however, the physician prescribed Elidel® (1%), a topical immunosuppressant. A non-weight bearing cast

was then placed on the foot to support the sesamoidectomy. Two weeks later the cast was removed and she was placed in a walking boot. Twenty-four hours later the athlete experienced increased dorsal pain. Follow-up revealed superficial eschar and erythema over the dorsal foot in and around incision site. The athlete was diagnosed with a severe allergic reaction to the Mastisol® adhesive. Antibiotics (Clindamycin 450 mg and Silvadene 1% cream) were prescribed to treat the wound. Over the next 5 weeks the dorsal foot continued to display superficial eschar and erythema. The Mastisol® reaction eventually resulted in a 2 cm x 3 cm full-thickness ulcer which required debridement and skin grafting in order to repair the damaged tissue. The dorsal wound was prepared to ensure an adequate vascular bed and a uniform and flat wound bed. An Integra™ derma graft made with a thin outer silicone film that acts as the skin's epidermis and an inner layer constructed of a complex matrix of cross-linked fibers acting as scaffold for dermal cell regeneration was sutured into place. The athlete responded well to the graft and ten days after undergoing the procedure the silicon film covering was removed. Approximately 9 weeks after placement of the graft, the wound was fully healed. The athlete was then allowed to return to full athletic participation. **Uniqueness:** Mastisol® has been reported to have a lower incidence of postoperative contact dermatitis than other adhesive compounds used to secure incisions. While there are some reported cases of contact dermatitis as a result of an allergic reaction to Mastisol®; patients in these cases recovered after being treated with corticosteroids and antibiotics. To our knowledge this is the only case in which tissue damage was so severe that skin grafting was needed to repair the ulcer caused by the allergic reaction. **Conclusion:** Retrospectively, the Mastisol® reaction in this situation may have been avoided had the exostosis been removed as a separate procedure instead of combined with sesamoidectomy. The sesamoidectomy required the athlete be placed in a cast before it was known whether reaction completely cleared in order to stabilize the sesamoid joint. It is important for clinicians to be aware that even though medical devices such as Mastisol® may have a lower incidence of complication, reaction can still occur. Periodic inspection of the foot may have resulted in a different outcome. Proper precautions should be implemented when treating patients with medications or topical agents that could result in an allergic reaction and tissue destruction.

Ankle Injury In A Collegiate Rugby Player

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Background: A 24 year-old collegiate rugby player took a low hit to the lateral right leg as his foot was planted during an unrecorded scrimmage. Upon reaching the athlete, both the head athletic trainer (ATC) and the athletic training student noticed the right foot positioned in external rotation. The foot and talus appeared to be disarticulated and malaligned with the tibia and fibula. Observation revealed a large lump at the medial malleolus, indicating a gross deformity, dislocation or fracture. The ATC immediately stabilized the foot and ankle and directed the athletic training student to call an ambulance. As the student directed the paramedics to the site, the ATC removed the laces and tongue of the shoe to check the dorsal pedal pulse for compromised circulation, and then neural inhibition and motor function of the toes. The athlete was kept warm and calm and monitored for signs of shock until transport arrived. The shoe was then carefully removed and the sock was cut to expose the injury. An unanticipated open dislocation of the talocrural joint, distal to the medial malleolus was found. A gaping wound of 3cm x 5cm exposed the entire mortise of the ankle including the tibia, medial fibula and talus. The open dislocation was wrapped with sterile roller gauze and stabilized with an ankle boot vacuum splint. The athlete was then transported to a nearby hospital where a more detailed evaluation exposed a complete fibular fracture, 15cm-20cm above the base of the calcaneus.

Differential Diagnosis: Possible differential diagnoses include a fracture of the tibia, fracture of the distal fibula, deep contusion of the tibia, fibula or talus, medial lower leg muscle tear, motor or nerve damage, vascular compromise, and medial ligamentous sprains. **Treatment:** Upon arrival to the emergency room, the athlete was put under anesthetic and the talocrural joint was reduced. The athlete's orthopedic surgeon then made an incision along the lateral lower leg, and inserted a plate with seven screws. The screws consisted of five short screws going through only the fibula, and two long screws connecting both the tibia and fibula distally, to support the fibular fracture and the talocrural joint. The orthopedic surgeon then closed the opening on the medial ankle. Post surgery, the athlete was placed in a boot and ordered to remain non-weight bearing for eight weeks, with long-term rehabilitation to follow. Doctors assume the athlete will regain 90 percent mobility of the ankle. **Uniqueness:** From a general perspective, within the world of athletics open dislocations are fairly uncommon. Although the mechanism of injury is not completely clear, it is rare that any hit could provide a large enough force to

cause both a fibular fracture and an open dislocation. Also unique to this case was the fracture of the fibula located lateral to and well above the site of the dislocation which was approximately 6cm-8cm above the base of the calcaneus. **Conclusions:** The fibular fracture was a gross injury that went undiagnosed on the field. The severity of this open dislocation with a fibular fracture resulted in a long-term rehabilitation prognosis for this athlete. Recovery and rehabilitation will help increase this athlete's mobility, but activities of daily living and not return to competitive play is the goal. Open dislocations to this degree must be treated with the assistance of an orthopedic surgeon. First responders in this situation must check the athlete's vascular and neural signs of the ankle and motor function of the toes. Careful splinting of this injury is critical.

Management Of Cuboid Subluxation In Female Distance Runners: A Case Series

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Background: This case involves the evaluation, assessment and management of two female distance runners with different presentations of cuboid subluxation. Subject A: A 22 year-old female (mass=52.27kg, height=162.6cm) NCAA collegiate cross country and 1500 meter runner presented during the spring 2007 track season with lateral ankle pain originating at the base of her fifth metatarsal extending to the lateral aspect of her distal one third of the left lower leg. Her pain was exacerbated during walking, after running on uneven surfaces and with extreme ankle inversion. Subject B: A 21 year-old female (mass=59.09kg, height=160cm) cross country runner, presented during the 2008 summer training camp with pain in her right Achilles tendon approximately 5.08cm superior to the insertion, the inferior aspect of her right lateral malleolus, and along the mid one-third of the plantar surface of her foot. This athlete also exhibited reduced plantarflexion and dorsiflexion due to pain and muscle tightness. **Differential Diagnosis:** Extensor digitorum brevis tendonopathy; peroneal brevis tendonopathy; fifth metatarsal ligament injury; sinus tarsi syndrome; unrecognized fracture or stress fracture; malalignment of lateral talocrural and subtalar joints; meniscoid of the ankle; Jones fracture; subluxating peroneal tendons; lateral plantar nerve entrapment; Lisfranc injuries. **Treatment:** Both athletes were evaluated by the team physician in September 2008. Subject A: Palpation revealed grinding and hypermobility of the left cubo-metatarsal joint. The physician prescribed cross training for several days to allow

pain to subside, tape application to immobilize the cuboid during activity and a wedge-shaped orthotic to increase foot pronation and to allow the peroneal muscles to rest. The athlete reported increased pain after one day with the wedge, and so discontinued its use. She continued to tape her foot during activity utilizing a "four mini stirrup method" to provide minimal foot disturbance while still preventing further cuboid subluxation. She participated in a daily ankle strengthening program followed by cold whirlpool submersion for pain control. Periodic petrissage was needed to relieve gastrocnemius, soleus and peroneal muscle tightness that exacerbated the pain. Subject B: Palpation revealed point tenderness over the calcaneal fat pad, mid portion of the medial arch, and along the peroneal tendon of the right foot. Pain was experienced during resisted external rotation and subtalar motion was reduced compared to the contralateral side. The fourth metatarsal head was depressed and the cuboid dislocated. The physician used the "cuboid squeeze" method to reduce the cuboid and advised tape immobilization during weight bearing until custom orthotics could be made. The athlete was given orthotics within two days. She cross trained for two days and then returned to normal training while receiving continuous ultrasound (1.2 MHz, 8 min) before practice and electrical stimulation (pre-mod, 15 min) combined with ice for three days to control pain. Seven days after the cuboid reduction, this athlete began a daily ankle strengthening program followed by cryotherapy for pain control. Both athletes followed the daily ankle strengthening program for four weeks. Both athletes reported a significant decrease in pain and increased range of motion and continued with full activity. **Uniqueness:** Cuboid subluxation is rarely found in athletes, with the exception of ballet dancers. While this condition is more prevalent in endurance sports, it only accounts for 4% of athletic foot injuries, but 17% of injuries in ballet dancers. **Conclusion:** This case series provides evidence that athletic trainers should be more aware of this condition and include this in the differential diagnosis. With thorough palpation, evaluation and recognition of the clinical signs and symptoms presented by this condition, cuboid subluxations can be quickly diagnosed and easily managed resulting in decreased discomfort to the athlete and faster return to play.

Primary Abscess In The Iliopsoas Muscle Of A Division I Collegiate Athlete

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Background: We present a case of a unique primary abscess in the iliopsoas muscle of a 23 year old male Division I collegiate football player. The athlete initially complained of pain in his right hip which subsequently caused him to be removed from play. After evaluation by an ATC it was suspected that he had a hip flexor strain and was started on treatment consisting of an ice bag and electrical stimulation for 20 minutes 2-3 times a day. Approximately 4 days later, the athlete had improved and was cleared for practice. However, 2-3 days after return to play, the pain returned and he was immediately removed from practice. After evaluation the athlete was treated for a re-aggravation of the previous hip flexor strain but this time no improvement was made, and the symptoms progressively got worse. This lead to further evaluation by an ATC and the athlete was then referred to a physician where he received a steroid injection which resulted in the athlete reporting immediate improvement. Two days after the injection the athlete's pain increased, and he reported having problems sleeping, was unable to stand up straight, had lost 22 pounds in weight and eventually began vomiting from the pain. **Differential Diagnosis:** Because the athlete was complaining of constant pain in the right hip, primarily with running, it was believed the athlete had a hip flexor strain, or possible labral tear or acetabular fracture. **Treatment:** The athlete was sent for an MRI which resulted in the arthrogram revealing an abscess in the iliopsoas muscle approximately 10 centimeters in diameter. He was transported immediately to the emergency room where the abscess was cultured and found to be primary as well as septic. This finding resulted in the diagnosis that this primary abscess was caused by a staph infection. Due to the septic nature of the abscess it was immediately drained. Approximately 800 cc of exudate was drained from the abscess. After four days, the athlete was released from the hospital and prescribed to be on an IV of antibiotics for 2 weeks. Following the removal of the IV antibiotics, he was then put on oral antibiotics for a further 2 weeks. On conclusion of the antibiotic treatment the athlete was prescribed 2 weeks of rest to allow for full recovery followed by 1 week of light activity. The rehabilitation then progressed to hip strengthening, conditioning and football specific drills for 3 weeks before returning to play. **Uniqueness:** With only an average of 12 cases of iliopsoas abscesses reported per year worldwide it can be concluded that primary iliopsoas abscesses are rare within the general

population and to date unreported in athletics. This type of abscess is most often seen in immunosuppressed individuals which makes it particularly unique in a Division I football player. **Conclusion:** A primary abscess in the iliopsoas muscle in this case resulted from a staph infection. Symptoms included consistent pain, point tenderness, limited range of motion and weight loss. This case study highlights the importance for athletic trainers to follow up on injuries on a daily basis. Injuries that are not following a normal healing pattern should be referred to a physician for further evaluation. Being able to quickly recognize and diagnose conditions such as this, the athletic trainer can avoid further complications and infection, which could potentially cause an end to an athlete's career.

NaCl Supplementation Appeared To Prevent EAMC In An NFL Player With High Sweat Sodium Losses And A History Of Cramping

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Background: A 25-year-old NFL defensive lineman with a history of exercise associated muscle cramps (EAMC) during pre-season training camp was: height = 191cm, mass = 120kg and body fat = 12%. He sustained 6 episodes of multi-site EAMC between 2nd and 10th day of the previous preseason. During the first 3 days of that pre-season this player's core (intestinal) temperature (T_{ci}) was monitored (HQI) and his mean maximal T_{ci} in full-padded morning (AM) practices was 40°C and in afternoon (PM) practices in shorts and shells was 39°C (range = 38.5 to 41.1°C). His sweat rate was 2.48 l/h and sweat sodium concentration was 85 mmol/l and he lost over 21g of sodium in one day of twice-a-day practices. In response to his high daily sodium losses and history of EAMC he was sodium supplemented during the first week of this pre-season training camp. At meals he consumed fruit drinks with added table salt = 24.7g of NaCl per day (50% of his daily sodium losses). This player practiced twice per day on days 2, 3, 4 and 6 and once in the AM of days 5 and 7 without incidence of EAMC. Average %~mass the first 7 days was 2.7% and 1.8% in AM and PM practices, respectively. After the AM practice on day 8, approximately 36 hr after the NaCl enhanced drinks were discontinued, the athlete sustained EAMC in multiple muscles (quadriceps, hamstrings, triceps, biceps and back). AM mean WBGT was 26.1 ± 2°C days 2-7 and 26.4°C on day 8.

Differential Diagnosis: EAMC, heat cramps, metabolic alkalosis, hyperkalemia, hypochloridemia. **Treatment:** An 18 gauge catheter was inserted into an anti-cubital vein and 10 cc of blood was drawn while the athlete was cramping. The blood was analyzed on site and revealed Na^+ = 138 mmol/l, K^+ = 7.6 mmol/l, Cl^- = 98 mmol/l, Hct = 52%, Hb = 17 g/dl and lactate = 4.6 mmol/l. The athlete was treated with 2 liters of IV fluids (½ saline with 5% dextrose) and ice application to the muscles that were cramping. EAMC resolved during fluid administration after which blood was again drawn and immediately analyzed with the following results: Na^+ = 138 mmol/l, K^+ = 4.5 mmol/l, Cl^- = 101 mmol/l, Hct = 48%, Hb = 16.2 mg/dl and lactate = 2.4 mmol/l. This player resumed the NaCl supplementation at his request and fully participated in all of the subsequent 6 practices over the next 4 days with no incidence of EAMC. **Uniqueness:** We are unaware of any case study with extensive data related to history of EAMC (core temperature, sweat rate, sweat sodium losses and weight losses) including an intervention (NaCl replacement), which appeared to successfully prevent EAMC during the supplementation period. During EAMC, hyperkalemia, likely due to rhabdomyolysis and hypochloridemia are also of interest and require further study of the anion gap. **Conclusions:** Sufficient NaCl replacement may be helpful in preventing EAMC. Although sodium is the ion most frequently implicated in EAMC, the passive ion chloride is highly correlated ($r = .998$) with sodium in sweat. Importantly, we reported significantly lower blood chloride in a group of football players while experiencing EAMC compared to after similar practices with no EAMC. Clinically low blood Cl^- may play a role in reducing hyperpolarization of the alpha motor neuron thus allowing easier excitation. It is also possible that Cl^- is being displaced by bicarbonate as a consequence of metabolic alkalosis. Regardless, replacement of salt in amounts equal to at least 50% of sweat NaCl losses with minimal potassium intake may thwart EAMC without contributing to hyperkalemia in professional football players.

Free Communications, Poster Presentations: Lower Extremity Function

Friday, June 19, 2009, 8:00AM-11:30AM, Park View Lobby, Concourse Level; authors present 10:30AM-11:30AM

Hip Flexibility And Strength Characteristics In Semi-Professional And Collegiate Ice Hockey Athletes

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Context: Ice hockey differs from many sports due to the extreme tri-planar motion that occurs at the hip joint during the skate stride. This functional difference, as well as the large forces and repetitive nature of skating may affect the hip range of motion (ROM) and strength patterns of ice hockey athletes. However, currently there are no data comparing the functional hip ROM and strength characteristics of hockey players to individuals with no ice hockey experience. **Objective:** To determine if the hip ROM and strength of ice hockey athletes differ in the three planes of motion as compared to controls. **Design:** Descriptive statistics.

Setting: University biomechanics laboratory and various athletic training facilities.

Participants: Forty eight male participants, including 27 semi-professional and collegiate ice hockey players (age=21.0±2.7 yrs, height=179.4±5.8 cm, mass=83.3±7.8 kg, experience=3.7±2.5 yrs) and 21 collegiate, recreationally active control participants (age=21.7±1.2 yrs, height=182.8±7.7 cm, mass=85.2±16.3 kg) volunteered to participate. All participants had no recent history (within 6 months) of hip or knee injury and no history of hip or knee surgery. **Interventions:** Hip ROM was assessed using the Pro Digital Inclinometer (SPI-Tronic, Garden Grove, CA). Hip strength was measured using the Lafayette Manual Muscle Test System hand held dynamometer (Lafayette Instrument, Lafayette, IN). The peak force created during three isometric contractions was divided by each participant's body weight to calculate peak force as a percentage of their individual body weight (%BW). Multiple unpaired t-tests were used for statistical analysis with an applied Bonferroni correction ($P<.005$).

Main Outcome Measures: Hip ROM for flexion, extension, abduction, internal and external rotation, as well as peak strength as a percentage of body weight for hip flexion, extension, internal and external rotation, abduction, and adduction.

Results: No significant differences were noted between groups for ROM of hip flexion (hockey=48.6±10.9°, control=51.4±8.3°, $P=.49$), extension (hockey=23.2±5.2°, control=19.9±4.0°, $P=.10$), internal rotation (hockey=31.4±5.2°, control=37.4±6.3°, $P=.0.3$), external rotation (hockey=36.2±5.3°, control=33.7±7.2°, $P=.34$), or abduction (hockey=48.6±13.0°, control=48.4±7.8°, $P=.96$). There were also no significant differences between

groups for strength of hip flexion (hockey=42±7%BW, control=39±8%BW, $P=.14$), extension (hockey=47±10%BW, control=42±11%BW, $P=.08$), internal rotation (hockey=28±6%BW, control=24±6%BW, $P=.02$), external rotation (hockey=25±4%BW, control=22±5%BW, $P=.07$), abduction (hockey=44±9%BW, control=43±9%BW, $P=.85$), or adduction (hockey=37±8%BW, control=36±8%BW, $P=.70$). **Conclusion:** Our results indicate that hockey players do not have any hip ROM or isometric strength differences compared to a control group. Clinicians who work with hockey players can expect to find similar hip ROM and strength patterns compared to the non-ice hockey players. These data provide normal hip isometric strength and ROM values that may assist with the prevention, evaluation, and rehabilitation of lower extremity injuries among ice hockey players.

Strength And Performance Deficits In NCAA Soccer Athletes With A History Of Hamstring Injury

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Context: Hamstring strains are one of the most common muscular injuries to the lower extremity and reoccur at an alarming rate. Clinicians need to determine attributes that may be linked to predisposal to injury recurrence. **Objective:** To evaluate the presence of strength and performance deficits in athletes with a history of hamstring strain. **Design:** Case-control study.

Setting: University Athletic Training Clinics.

Patients or other Participants: 16 NCAA collegiate soccer athletes with a self-report of hamstring injury in the past two years: 8 males (20.12±1.73 years, 182.38±3.31 cm, 88.47±3.89 kg), 8 females (18.25±.89 years, 166.08±3.73 cm, 58.68±6.81 kg) and 16 matched uninjured controls: 8 males (20±1.31 years, 179±5.43 cm, 78.32±6.25 kg), 8 females (18.50±1.07 years, 165.46±6.11 cm, 60.86±6.88 kg). Subjects were matched by age, height, mass, side and gender.

Interventions: The independent variables were *side of injury* (injured vs. non-injured) and *group* (history of injury vs. control). Paired *t*-tests were conducted to assess differences between side of injury, and separate independent *t*-tests were conducted to evaluate differences between groups for all dependent measures. Strength [hip extension (HE), knee flexion (KF)] was quantified using a portable fixed dynamometer (Eval-tech, BTE Technologies). Balance was assessed with the Star Excursion Balance Test (SEBT). Hamstring range of motion was

measured using the active knee extension (AKE) technique. Significance was set *a priori* at $p<.05$.

Main Outcome Measures: The average of three trials for each measurement was used for analysis. The dependent variables included standing HE and seated KF strength measures (N/m), SEBT reach scores [anterior (A), posterior-lateral (PL), and posterior-medial (PM)] measured in centimeters and recorded as percentage of leg length, and AKE (degrees). **Results:** There were no *side of injury* differences for AKE ($p=.730$, $t=.352$) (Injured=77.43±7.86°, non-injured=76.77±10.64°), hip extension strength ($p=.945$, $t=.070$) (Injured=32.51±11.61 N/m, non-injured=32.62±11.42 N/m), knee flexion strength ($p=.230$, $t=1.254$) (Injured=58.17±16.59 N/m, non-injured=47.89±20.02 N/m), SEBT anterior ($p=.322$, $t=-1.026$) (Injured=58.96±4.52, non-injured=60.02±5.47), SEBT posterior-lateral ($p=0.809$, $t=-.247$) (Injured=84.56±15.49, non-injured=84.88±15.20). *Side of injury* differences occurred for the posterior-medial SEBT with the non-injured limb (89.16±17.00) having greater reach than the injured limb (85.56±15.01) ($p=0.021$, $t=-2.594$). There were no *group* differences for SEBT posterior-medial ($p=.340$, $t=.970$) (Injured=84.78±14.84, control=91.945±12.47), SEBT anterior ($p=.880$, $t=.152$) (Injured=58.65±4.54, control=58.97±7.23), hip extension strength ($p=.957$, $t=-0.055$) (Injured=33.93±13.49, control=33.63±11.95), and knee flexion strength measures ($p=0.745$, $t=.329$) (Injured=48.15±17.96, control=58.39±20.03). Group differences occurred for AKE with the injured group (77.43±7.86°) having greater motion than the control group (76.77±10.64°) ($p=0.023$, $t=-2.311$). **Conclusions:** Individuals with past hamstring injuries have deficits in the injured limb for posterior-medial reach, however those with a history of hamstring injury had greater AKE than matched controls. More assessments are needed to determine additional deficits related to hamstring injury. Funding Source: National Institutes of Health RO3: PA 04-002 NIAMS Small Grant Program for New Investigators: 1R03AR054031-01

Differences In Hip Strength Among Individuals With Different Arch Heights

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Context: Foot structure, particularly arch height, and weak hip musculature have both been linked to lower extremity (LE) injuries. It is possible that foot anatomical structure influences the strength of the proximal hip musculature, particularly in the frontal and transverse planes. However, the relationship between hip strength and arch height has never been investigated. **Objective:** To determine if differences in hip strength exist among individuals with low, typical, and high arch height foot structures. **Design:** Single-session, cross sectional. **Setting:** Neuromechanics Laboratory. **Patients or Other Participants:** A convenience sample of 74 healthy, college-aged participants (29 men, 45 women; age=22.6±4.8, mass =70.2±13.4 kg, height=1.68±0.11 m) were tested bilaterally to create an n=148 feet. **Interventions:** A hand-held dynamometer and immovable straps were used to determine the maximal voluntary isometric contraction for hip flexion, extension, abduction, adduction, and internal and external rotation. Peak strength (force, N) was normalized using an allometric normalization technique [force/(mass^{0.67})]. Foot structure was assessed via the Digital Photographic Measurement Method using the Arch Index (AI) technique during 90% weight bearing. Participants were categorized into the low or high arch groups if their AI was one standard deviation below, or above the group mean, respectively. **Main Outcome Measures:** The independent variable was arch height group (low n=26, typical n=100, high n=22), dependent variables were normalized peak strength of hip flexion, extension, abduction, adduction, and internal and external rotation. Data were analyzed using one-way ANOVA with Tukey post-hoc analyses, p<0.05. **Results:** Mean±SD AI measures were 0.355±0.029 across all 148 feet. The AI means±SD for low, typical, and high groups were 0.31±0.01, 0.36±0.02, and 0.40±0.01 respectively. Hip external rotation was significantly stronger in both the high (4.55±1.27 N/kg) and low arch (4.43±1.31 N/kg) groups compared to the typical arch group (3.68±0.97 N/kg) (p=0.006 and p=0.003, respectively). No other significant differences were found. **Conclusions:** Individuals with high or low arches have greater peak isometric hip external rotation strength than those with typical arches. There is a relationship between the foot structure of an individual and the strength of their hip external rotators; however, the impact on these factors during dynamic activities is not known. It is possible that those with high and low arches undergo greater transverse plane

motion at the hip during movement, and therefore have adapted to have greater hip external rotation strength to control this motion. Further study of foot structure, hip strength, and lower extremity motion during functional tasks is needed to fully understand how these factors relate to lower extremity injury.

Hip Muscle Activity During Three Side-Lying Hip Strengthening Exercises In Distance Runners

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Context: Hip weakness is linked to several lower extremity injuries, therefore hip strengthening is often performed for injury rehabilitation and prevention. There are several variations of side-lying hip strengthening exercises that are commonly performed, and hip muscle activity during these exercises is unknown. **Objective:** To quantify electromyographic (EMG) activity of the hip muscles during three side-lying hip strengthening exercises: side-lying hip abduction (ABD), side-lying hip abduction with external rotation (ABDER), and combined hip abduction and external rotation ("the clamshell", CLAM). **Design:** Descriptive cohort, repeated measures design. **Setting:** Controlled, laboratory setting. **Participants:** Twenty (9M, 11F) healthy adults (5.4±5.8 yrs, 1.7±0.07 m, 64.4±7.75 kg) running an average of >25 miles/week, and no concurrent lower extremity injury. Runners were chosen because of the high incidence of lower extremity injury in this group. **Interventions:** Surface EMG data were collected from the gluteus medius (GMed), tensor fascia latae (TFL), anterior hip flexors (AHF) and gluteus maximus (GMax) of the dominant (kicking) leg during a maximal voluntary isometric contraction (MVIC), and during each of the three exercises with a cuff weight resistance equal to 5% body mass. The Stabilizer Pressure Biofeedback unit was placed beneath the participant's trunk to provide feedback on trunk position. **Main Outcome Measures:** Peak root mean square (RMS) for each exercise was normalized to peak RMS during the MVIC, and the dependent variable was % MVIC. The independent variables were exercise (ABD, ABDER, CLAM) and muscle (GMed, TFL, AHF, GMax). A two-way repeated measures ANOVA and Tukey's post hoc testing were conducted, p<0.05. **Results:** There was a significant interaction between exercise and muscle (p<0.001). For the ABD exercise, the GMed (79±30%) and TFL (54±19%) were significantly greater than the AHF (28±21%) and GMax (25±24%). For the ABDER exercise, the TFL (71±17%) was significantly greater than the AHF

(54±25%), GMed (53±28%), and the GMax (32±24%). For the CLAM exercise the AHF (54±25%) was significantly greater than the GMed (33±17%), TFL (34±20%), and GMax (34±25%). The exercise that produced the greatest GMed activity was the ABD (79±30%), followed by the ABDER (53±28%), and the CLAM (33±17%). **Conclusions:** As performed, each of the exercises has the potential to activate one or more of the hip muscles beyond 40-60% MVIC, a level that has been reported necessary to elicit strength gains. The CLAM exercise did not show high activation of the GMed or GMax, and may activate the AHF and TFL beyond what is desired in certain cases. No exercise activated the GMax above 40% MVIC. The goal of many hip-strengthening programs is to strengthen the GMed and GMax, while limiting activity of the TFL and AHF. The ABD exercise appears to be optimal for producing high GMed activity with little TFL and AHF activation.

The Effect Of Fatigue On Center Of Pressure And Impulse During A Single Leg Bound

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Context: Recent research has shown that negative effects on physical performance may be associated with fatigue. These effects include difficulty in maintaining balance, producing force, or absorbing force all of which may predispose an athlete to injury. Previous studies have not examined the effect of fatigue on a dynamic task such as the single leg bound. **Objective:** The purpose of this study was to determine the effects of whole body fatigue produced by physical exercise on Center of Pressure and Peak Impulse, while performing a single leg bound onto a force platform. **Design:** Repeated measures design. **Setting:** Controlled laboratory setting. **Participants:** Fifteen physically active college students (age = 21.1 ±1.6 yrs, mass = 128.1 ±23.2 kg) who were currently free of injury. **Interventions:** Fifteen physically active college students volunteered for this study. Each subject was tested on 2 different days once under each of the fatigue conditions (fatigued/not fatigued). All subjects performed a 5-minute warm-up at 3.5 mph on a treadmill prior to testing. When under the fatigue condition, subjects next performed a fatigue protocol consisting of aerobic and anaerobic activities and then reported their RPE. If Borg RPE was not at 13 or above, subjects repeated the fatigue protocol until meeting the RPE goal. Subjects then performed 3 single leg bounds, landing on a force plate on their middle jump, allowing for center of pressure

(COP) and peak impulse (PI) values to be measured during this dynamic activity. **Main Outcome Measures:** COP and PI mean values were computed from all three trials for subjects under the fatigued and not fatigued conditions. **Results:** Subject COP was a significantly decreased following the fatigue protocol ($t(14) = -7.508, P < .001$). Non-fatigued mean COP was $2.160 \pm .511$ cm while fatigue measures were $2.946 \pm .538$ cm. PI measurements were likewise decreased under the fatigue condition ($t(14) = -2.605, P = .021$). Non-fatigued mean PI was 2868 ± 1269 N while fatigue measures were 3539 ± 977 N. **Conclusions:** This study revealed that fatigue significantly affected a person's center of pressure and force absorption during a single leg bound. These performance deficits could predispose a fatigued athlete to injury. This may indicate a need for balance and landing training while under fatigued conditions.

The Effect Of A One-Time Abdominal Muscle Training Session On The Ability To Contract The Transverse Abdominus In Low Back Pain Patients
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Context: Real-time ultrasound (RTUS) has been shown to be a reliable way of measuring muscle activation in the transverse abdominus muscle (TrA). TrA thickness changes, as measured using RTUS, directly correlates with activation. Long-term core stability programs have been beneficial in improving activation of the TrA in individuals with LBP. Some clinicians believe that improvements in TrA activation can be made in as little as one training session, although no evidence exists to support these claims. **Objective:** The purpose of this study was to determine the effect of a one-time core stability training session on TrA muscle thickness in people with LBP. **Design:** Randomized controlled trial. **Setting:** Physical therapy clinic. **Patients or Other Participants:** 20 patients (6 males, 14 females; height= 170 ± 10 cm, mass= 82 ± 26 kg, age= 36 ± 14 yrs) with LBP who were referred for physical therapy volunteered to participate in this study. **Intervention(s):** Subjects were randomly assigned to a training ($n=9$) or non-training ($n=11$) group. Individuals in the training group were taken through a 45 minute core stability exercise program while those in the non-training group sat for 45 minutes. RTUS images of the TrA were taken of the right TrA in the hook lying (rest) position and while the patient was performing a straight leg raise with the right leg. Images were taken before and after the subject's treatment intervention. **Main Outcome**

Measures: Changes in TrA muscle thickness across time and between groups were measured using a 2x2 repeated measures ANOVA. Measurements were captured before a therapy session and then immediately after. **Results:** Mean change scores at pretesting for the training and control groups were 0.0587 ± 0.1934 cm and 0.0506 ± 0.0516 cm, respectively, compared to posttesting scores of 0.0817 ± 0.1374 cm and 0.0227 ± 0.0751 cm. Statistical analysis showed no significant group by time interaction ($F_{1,18} = 1.541, P = 0.230$) or main effects for group ($F_{1,18} = 0.438, P = 0.517$) or time ($F_{1,18} = 0.014, P = 0.907$). **Conclusions:** Based on our data, we conclude that one session of core stability exercises is not sufficient to affect the ability of patients with low back pain to contract their TrA muscle with lower extremity movement any better than a control group. We do not support the clinical idea that improvements in TrA activation can be made in as little as one training session.

The Impact Of Knee Injury On Physical Activity Outcomes In Young Female Athletes

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Context: The impact of knee injuries on desired physical activity levels is poorly understood in young female athletes. While significant attention is given to understanding the increased rate of injury for this population, little research is available on broader health outcomes. Ability to maintain desired physical activity levels is a key to overall health and fitness. **Objective:** Describe the long-term (one year) changes in physical activity levels following knee injury in young female athletes who have sustained three types of common knee injuries. **Design:** Prospective cohort. **Settings:** Data were collected at a sports medicine clinic and university student health service. **Participants:** A convenience sample of 119 high school and college female athletes (age = 17.2 ± 1.5 years) who sustained a knee injury while participating in a sport or regular fitness activity. Injuries were classified as: anterior cruciate ligament tear (ACL, $n=51$), anterior knee pain (AKP, $n=48$), and patellar instability (PAT, $n=20$). All subjects returned to their sport within one year following injury. **Interventions:** Each subject completed the International Physical Activity Questionnaire (IPAQ – short form) five times over one year. The International Physical Activity Questionnaire (IPAQ) is a widely used and valid method to assess physical activity levels using a self-report questionnaire. The intervals included pre-injury, at diagnosis, and 3, 6 and 12 months post-injury. The test-retest reliability of the IPAQ short form has been reported to be good to excellent ($r=0.76, 95\% \text{ CI}$

$0.73-0.77$). **Main Outcome Measures:** Dependent variables included the difference in the IPAQ scores (METs) for walking, moderate activity, vigorous activity, and total activity from pre-injury to 12 months post injury for subjects in each injury classification. Paired differences were assessed with the Wilcoxon Signed-Rank Test ($p \leq 0.05$) reported as the median (interquartile ranges [IQR]: 25th and 75th). **Results:** IPAQ scores for vigorous activity at 12 months were significantly lower than pre-injury scores for all three injury classifications: ACL (Pre= $5220 [2880, 6720]$; 12Mo= $2880 [960, 5760]$; $p < 0.001$), AKP (Pre= $4480 [2640, 5760]$; 12Mo= $1920 [960, 3960]$; $p=0.007$), and PAT (Pre= $4560 [1440, 5040]$; 12Mo= $1440 [840, 4800]$; $p=0.026$). IPAQ scores for total activity were significantly lower for ACL (Pre= $8545.5 [5226, 11727]$; 12Mo= $6030 [3819, 8999]$; $p=0.039$) and AKP (Pre= $7495.5 [3409, 8821]$, 12Mo= $3880.8 [2671.5, 6826.5]$; $p=0.007$). There were no significant differences between 12 month and pre-injury scores for walking or moderate activity. **Conclusions:** Female athletes who sustained ACL, AKP, and PAT injuries had lower levels of vigorous physical activity one year following injury. Total activity levels were lower for those sustaining ACL and AKP injuries. Decreases in desired physical activity can have long-term health consequences. Researchers and providers should include measures of actual physical activity, in addition to knee function, for more authentic outcomes assessment.

Relationships Between Measures Of Core Stability and Dynamic Postural Control

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Context: Core stability and dynamic postural control have been recognized to have important roles in athletic performance, injury prevention, and rehabilitation. While the relationship between core stability and dynamic postural control has been theoretically linked, there has been little research examining the relationship between measures of these constructs. **Objective:** To examine the effect of core stability measures on dynamic postural control as assessed with the Star Excursion Balance Test (SEBT). **Design:** Observational study. **Setting:** Laboratory. **Patients or Other Participants:** 60 healthy subjects (23 males, 37 females; age= 22.8 ± 3.8 years, mass= 71.3 ± 12.8 kg, height= 171.3 ± 8.3 cm) with no lower quarter or abdominal within 6 months participated. **Intervention(s):** Predictor variables were maximum voluntary isometric force for hip abduction (ABD) and external rotation, lateral step down test score (on a 6 point scale), double limb lowering test (DLLT)

angle, and maximum endurance time on the modified Biering-Sorenson test (MBST). All measures were performed using established and previously published testing protocols and were taken by the same examiner. The force measures were taken with a handheld dynamometer in kg and were normalized to subject body mass. The hip force and stepdown tests were each performed 3 times on each limb the means of the 3 trials from both limbs were calculated. The DLLT and MBST were each performed 3 times. For the DLLT the mean of the 3 trials was calculated, while for the MBST, the single highest value from the 3 trials was utilized. Stepwise multiple regression analysis was used to determine the influence of the 5 core stability measures on SEBT performance. The alpha level was set a priori $p < .05$. **Main Outcome Measures.** The dependent variable was SEBT reach distance. Subjects performed 3 trials in each of 3 directions (anterior, posteromedial, posterolateral) while balancing on the right and left limbs. Reach distances were normalized to subject leg length. The scores of all 3 trials from all 3 reach directions across both limbs were used to calculate the mean SEBT reach distance. This value served as the dependent measure. **Results.** The only significant predictor was hip abduction strength which explained 8% of variance of SEBT reach distance ($R^2 = .08$, $p = .03$). None of the other measures of core stability significantly predicted SEBT reach distance ($p > .05$). Means and standard deviations for the measures were: SEBT ($88.8 \pm 7.2\%$), hip abduction force ($162.3 \pm 36.7\text{N}$), hip external rotation force ($269.061.0 \pm 67.0\text{N}$), stepdown test (2.6 ± 0.9 points), DLLT ($68.1 \pm 9.5^\circ$), and MBST (161.0 ± 74.4 s). **Conclusions.** There were minimal relationships between measures of core stability and dynamic balance with only maximum voluntary hip abduction force being a significant performance of SEBT performance. It is apparent that dynamic postural control and core stability are mostly independent constructs.

Knee Extension Exercises Do Not Immediately Increase Quadriceps Activation In Individuals With Anterior Knee Pain.

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Context: Individuals with anterior knee pain (AKP) may experience weakness and inhibition of the quadriceps muscles. It is not known whether weight-bearing (WB) or non-weight-bearing (NWB) exercises elicit immediate improvements in quadriceps activation. **Objective:** To determine the immediate effects of WB and NWB knee extension exercises on quadriceps force output and activation in

individuals with AKP. **Design:** A single-blind randomized control trial. **Setting:** University laboratory. **Participants:** Thirty subjects (16 female and 14 male; age = $26.0 \pm 10.2\text{y}$) with self-reported AKP. **Interventions:** Quadriceps force was measured using a dynamometer and quadriceps activation was measured using the superimposed burst technique. Subjects performed a maximal voluntary isometric contraction (MVIC) of the quadriceps with the knee at 90° . Once the MVIC reached a plateau, an electrical stimulation was manually delivered percutaneously and transmitted directly to the quadriceps via stimulating electrodes. Quadriceps activation was quantified using the central activation ratio (CAR; $\text{CAR} = \text{MVIC} / (\text{MVIC} + \text{superimposed burst force})$) and calculated by dividing the MVIC force by total force. Subjects performed 3 trials with the mean utilized for data analysis. Following baseline testing, subjects were randomized to 1 of 3 intervention groups: WB knee extension, NWB knee extension, or control. WB knee extension exercise was performed using a sling-based exercise while NWB knee extension exercise was performed on an isotonic dynamometer. Exercises were performed using 3 sets of 5 repetitions at approximately 55% MVIC. Measurements were obtained at 4 time intervals: baseline, post-exercise-0, 15, and 30 minutes. **Main Outcome Measures:** Dependent measurements included normalized quadriceps force output, and quadriceps CAR. Two separate 3x4 repeated measures ANOVAs were performed to compare force and CAR scores between groups across time. Probability was set at $P \leq .05$ for all statistical tests. **Results:** For quadriceps force (n-m/Kg) there was not a significant group by time interaction ($F_{6,81} = 0.386$, $P = 0.886$), between groups main effect ($F_{2,27} = 0.592$, $P = 0.56$), or time main effect ($F_{3,81} = 1.857$, $P = 0.14$); WB: Pre = 1.80 ± 0.55 , Post-0 = 1.72 ± 0.69 , Post-15 = 1.70 ± 0.75 , Post-30 = 1.68 ± 0.70 ; NWB: Pre = 1.75 ± 0.55 , Post-0 = 1.71 ± 0.65 , Post-15 = 1.62 ± 0.49 , Post-30 = 1.72 ± 0.49 ; Control: Pre = 1.56 ± 0.51 , Post-0 = 1.38 ± 0.35 , Post-15 = 1.41 ± 0.51 , Post-30 = 1.50 ± 0.61). For quadriceps activation ratio (%) there was not a significant groups by time interaction ($F_{6,81} = 0.14$, $P = 0.99$), group main effect ($F_{2,27} = 0.069$, $P = 0.93$), or time main effect ($F_{3,81} = 0.895$, $P = 0.45$); WB: Pre = 72.4 ± 0.09 , Post-0 = 72.8 ± 0.12 , Post-15 = 72.3 ± 0.12 , Post-30 = 73.8 ± 0.11 ; NWB: Pre = 71.4 ± 0.14 , Post-0 = 71.8 ± 0.15 , Post-15 = 70.9 ± 0.14 , Post-30 = 74.9 ± 0.15 ; Control: Pre = 70.3 ± 0.17 , Post-0 = 70.4 ± 0.12 , Post-15 = 70.8 ± 0.12 , Post-30 = 71.7 ± 0.13 . **Conclusions:** Both WB and NWB knee extension exercises do not acutely increase quadriceps force output or activation. It may be necessary to perform exercises over a number of sessions and incorporate other disinhibitory interventions such as cryotherapy, electrical stimulation, or joint mobilization. **This study**

was supported by a gift from Redcord AS, Staabo, Norway.

A Comparison Of Hip Muscle Activation During Four Closed-Kinetic Chain Exercises In Those With And Without Chronic Ankle Instability

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Context: Previous literature has reported those with chronic ankle instability (CAI) show proximal neuromuscular changes at the hip, specifically gluteus medius (Gmed) and gluteus maximus (Gmax) activity. These changes have been proposed to be attributed to lack of stability in ankle joint. However, earlier work has studied hip musculature activity in those with CAI only while performing open-kinetic chain activity. **Objective:** The objective of this study was to compare hip muscle activity during four closed-kinetic chain (CKC) exercises in those with and without CAI. **Design:** Cohort study with repeated measures. **Setting:** University research laboratory. **Patients or Other Participants:** Nine subjects with unilateral CAI (age 20.89 ± 2.42 , height 164.5 ± 8.78 cm, mass 68.08 ± 9.42 kg) and nine healthy control subjects (age 22.9 ± 4.56 , height 164.5 ± 6.45 cm, mass 65.4 ± 10 kg) volunteered for this study. **Interventions:** All subjects performed four CKC hip exercises: hip hike (HH), hip abduction (HA), rotational lunge (RL), and single-leg rotational squat (RS). Surface electromyography (EMG) was used to collect mean muscle activity of the Gmed and Gmax during the four exercises. EMG data for the Gmed and Gmax were rectified, smoothed, and normalized as a percentage of maximum voluntary contractions. **Main Outcome Measures:** Mean EMG activity of the Gmed and Gmax was compared between Groups and Exercises using a separate 2-way repeated measures ANOVA design for each muscle. **Results:** There were no statistically significant Group by Exercise interactions for Gmed ($F_{3,48} = 1.09$, $p = .361$) or Gmax ($F_{3,48} = 1.20$, $p = .288$). However, during the RL exercise, a strong effect size ($d = 0.91$) was associated with the differences in Gmed activity between the CAI ($.84 \pm .33$) and Healthy groups ($.55 \pm .29$) and a moderate effect size ($d = .48$) associated with the differences in Gmax between the CAI ($.75 \pm .57$) and Healthy groups ($.54 \pm .29$). There was a significant difference in both Gmed ($F_{3,48} = 3.16$, $p = .033$) and Gmax ($F_{3,48} = 15.90$, $p = .001$) EMG activity across the Exercises, regardless of Group. For the Gmed, the RS ($.82 \pm .37$) had the highest activity level and HH ($.72 \pm .36$) was significantly higher than the HA ($.63 \pm .32$). For the Gmax, RS ($.67 \pm .31$) again had the highest activation level. Additionally, for the Gmax, both RS ($.67 \pm .31$) and RL ($.65 \pm .45$)

produced significantly higher activity than HH (.41±.24) and HA (.30±.22) and the HH demonstrated significantly higher activity than HA. **Conclusions:** Despite there being no statistically significant differences in EMG activity of the Gmed and Gmax during the four CKC exercises between groups, the effect sizes indicate RL may be an appropriate CKC exercise for rehabilitation as well as an outcome measure when comparing those with CAI to those without CAI. In addition, regardless of group, RS demonstrated the highest EMG activity of both Gmed and GMax across exercises. This may be useful information to clinicians seeking to develop rehabilitation programs for strengthening Gmax and Gmed.

The Acute Effects Of A Corrective Exercise Strategy On Knee Valgus Angle And Muscle Activity During A Squat Exercise

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Context: Knee valgus is a theorized risk factor for both acute and chronic lower extremity injuries including anterior cruciate ligament

injuries and patellofemoral pain. Muscle imbalances are proposed as one cause of increased knee valgus position during dynamic activities; however, it is not known if an acute intervention can correct this faulty knee valgus position and muscle activation patterns. **Objective:** To determine if a one time exercise program can alter muscles activation and decrease knee valgus during a squat exercise. **Design:** Repeated measures. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty-eight subjects (24 females, 4 males; age=19.83±1.47yrs; ht=165.71±7.13cm; m=63.83±8.76kg) free from lower extremity injury in the past six months volunteered for this study. All subjects presented with knee valgus during a double leg squat that was corrected when a lift was placed under the heel. Knee valgus was defined if the midpoint of the patella passed medial to the great toe. **Interventions:** Subjects were randomly assigned to either a control (CON) or intervention (INT) group. Kinematics and EMG were recorded during five double-leg squats (DLS). The INT group completed exercises aimed at correcting muscle imbalances thought to contribute to knee valgus. These exercises included foam rolling of the gastrocnemius and peroneals (2x1minute), static stretching of the gastrocnemius and soleus (2x30seconds), isolated muscle strengthening (3x10reps of the tibialis anterior), and a single-leg balance training. The

CON group rested for ten minutes between the pre and post-tests. **Main Outcome Measures:** Peak knee valgus angle and mean EMG activity of the tibialis anterior (TA), medial gastrocnemius (MG), and lateral gastrocnemius (LG) were assessed during the descending phase of the DLS and averaged over the 5 trials. Separate 2 (group) x 2 (time) repeated measures analyses of variance were performed for each dependent variable ($\alpha \leq 0.05$). Tukey HSD was used for post hoc analysis. **Results:** No significant interactions were found between the CON and INT groups: peak knee valgus angle ($P=0.08$), TA ($P=0.38$), MG ($P=0.51$), and LG ($P=0.65$). A group main effect was found for peak knee valgus angle (CON: -4.89 ± 5.74 , INT: -10.29 ± 5.33 , $F_{1,24}=6.98$, $P=0.01$) as well as a time main effect (Pre: -6.09 ± 4.93 , Post: -9.09 ± 6.94 , $F_{1,24}=16.62$, $P<0.001$). **Conclusions:** A single bout of foam rolling, stretching, strengthening, and single leg balance exercises did not alter muscle activation nor improve knee valgus angle during a DLS. In fact it seems that the intervention caused knee valgus angle to worsen possibly because of fatigue. Future research should determine the effect of multiple sessions of an intervention on knee valgus angle and muscle activation during a DLS. *Funding provided by the National Academy of Sports Medicine and the National Basketball Athletic Trainers Association.*

Free Communications, Poster Presentations: Instrumentation

Saturday, June, 20, 2009, 8:00AM-12:00PM, Park View Lobby, Concourse Level; authors present: 11:00AM-12:00PM

Validity And Reliability Of The Monitored Rehabilitation Functional Squat Proprioception Test Component

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Context: Assessing and restoring proprioception are important aspects of rehabilitation programs. The Monitored Rehabilitation Functional Squat System (MRFSS, Haarlem, The Netherlands) may be a simple and time-efficient means for clinicians to objectively assess joint reposition sense (JRS) during a functional task but its validity and reliability have not been studied.

Objectives: To assess the measurement accuracy of the MRFSS and determine validity and reliability of the MRFSS proprioception test component. **Design:** Single group repeated measures. **Setting:** Outpatient physical therapy clinic. **Participants:** Convenience sample of 14 subjects (5 males, 9 females, age=25.6±2.1 yr, height=170.5±10.8 cm, mass=67.6±17.0 kg) with no back, lower extremity, nervous, or

uncorrected visual conditions. **Interventions:** Prior to subject enrollment, the accuracy of MRFSS measurement of sled travel (500 mm) was compared with actual position measured by tape measure twice per day over 10 days. To study the proprioception test component, subjects completed a single-leg squat on a leg-press-like device interfaced with a computer providing real-time visual feedback of sled position (MRFSS). After providing consent, the subject's knee was fit with an electrogoniometer (Biopac Systems, Inc, Santa Barbara, CA) to determine whether the MRFSS sled position is a valid indicator of knee position during the proprioception test. Then, subjects completed five 60-second trials of a single-leg squat JRS activity involving knee flexion and extension with a resistance of approximately 25% of body mass. The goal was to vary squat position in response to a computer-generated line representing sled/joint position first using visual feedback then attempt to reposition the joint at the same angle without visual feedback. **Main Outcome Measures:** A t-test was used to compare the mean sled position from the MRFSS to tape measure to assess the MRFSS'

measurement accuracy. To establish validity of the proprioception test, we used a recognized valid tool, an electrogoniometer. Knee angle data from the electrogoniometer were correlated with millimeters of sled travel using Pearson correlation. Test-retest reliability (ICC(2,1)) was assessed between trials 4 and 5 using normalized performance accuracy ((measured value / target value)*100) for both sled position and knee angle. **Results:** MRFSS measurement of sled travel (499.8 ± 1.2 mm) was not different compared to tape measurement (500 ± 0 mm, $P=0.35$). During the JRS task with visual feedback, sled travel and knee angle were strongly correlated ($r>.9$, $P<0.001$); the test-retest reliability was strong for knee angle ($r_{13}=.79$), and was moderate for sled travel ($r_{13}=.65$). **Conclusion:** The MRFSS device provides accurate measurement of sled travel and the proprioceptive test component provides a valid and reliable measure of JRS in this sample of healthy adults. Therefore, the MRFSS may provide clinicians with an objective tool to assess joint proprioception in the clinical setting.

Comparison Of Three Different Hand-Held Dynamometry Measurement Techniques

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Context: Hand-held dynamometry (HHD) is one device used to assess muscular strength. However, different techniques for HHD measurement have been reported. The 'make' test requires the patient to exert a maximal voluntary isometric contraction (MVIC) into a dynamometer that is held stationary by either an examiner's hand (MTh) or using a strap (MTs) or other stable apparatus. The 'break' test (BT) requires the examiner to "break" the MVIC produced by the patient, resulting in the measurement of eccentric force production. No study has specifically examined the differences in force production between these techniques. In addition, few studies have reported the coefficient of variation (CV) between trials using these techniques as a method to understand the reliability of data across trials. **Objective:** To determine the reliability and differences in hip abductor muscle force production between three HHD methods. It was hypothesized that MTs would have the greatest reliability, BT would have the lowest reliability, and BT would produce the highest force, comparatively. **Design:** Single group, repeated measures. **Setting:** Clinical research laboratory. **Patients or Other Participants:** Twelve subjects (5 males, 7 females; age: 25.2 ± 4.4 years; mass: 67.3 ± 9.9 kg) participated. All participants were injury-free and had not sustained a musculoskeletal injury within the past year. **Interventions:** Measures of hip abductor muscle strength were made using a Lafayette HHD. For all 3 techniques, patients were placed in a side-lying position and 30° of hip abduction. One strap was placed across the iliac crest and secured firmly to stabilize the pelvis. Patients grasped the edge of the treatment table to self-stabilize. The HHD was placed immediately proximal to the lateral malleolus. Testing order was counterbalanced and randomized. Five trials per technique were recorded. Each trial was measured over 4-seconds with 1 minute of rest between trials. **Main Outcome Measures:** MVIC values were normalized to subject mass (%BW). CV values were calculated between trials and expressed as percent differences. One-way, repeated-measures ANOVAs and post-hoc tests were used to determine differences, if any, between techniques ($P=0.05$). **Results:** Significant ($P=0.01$) differences in force production were measured between techniques. Post-hoc analysis revealed MTh ($11.92 \pm 2.33\%$ BW) and MTs ($13.32 \pm 1.65\%$ BW) produced 44.12% and 37.52% less force compared to BT

($21.33 \pm 3.49\%$ BW), respectively. No significant differences in force production ($P=0.55$) were measured between MTs and MTh. No significant differences ($P=0.79$) were measured for differences in CV between trials for any technique (MTh: $CV=7.61 \pm 0.04\%$; MTs: $CV=7.74 \pm 0.04\%$; BT: $CV=7.18 \pm 0.05\%$). **Conclusions:** Regardless of HHD technique, the CV across trials was less than 10%. BT produced, on average, 40% greater force compared to the MTs and MTh since an eccentric component of muscle contraction was involved as compared to the MVIC. The MTs and MTh methods were comparable with respect to MVIC force production.

The Relationship Between Portable Fixed Dynamometry And Isotonic Dynamometry

Kollock RO, Oñate JA, Linza J, Van Lunen B: Old Dominion University, Norfolk, VA

Context: The use of objective dynamometry has been proposed as a means of collecting baseline strength values prior to sports participation. **Objective:** The purpose of this study was to determine the relationship between isometric and isotonic strength assessments. **Design:** Correlational Research Design. **Setting:** University sports medicine research laboratory. **Patients or Other Participants:** The sample population consisted of 19 physically active individuals both males ($N=9$) and females ($N=9$) participants (22.33 ± 3.01 years, 173.00 ± 10.49 cm, and 73.77 ± 16.69 kg). **Interventions:** Two test sessions separated by approximately one week were utilized for this study. Session one consisted of isotonic strength measures using the Primus RS (Baltimore Therapeutic Equipment (BTE), Hanover, MD). Prior to the start of the isotonic strength evaluation the subject's maximal isometric strength was determined by taking the peak measure of a three-trial isometric strength evaluation on the Primus RS. Each trial lasted for five seconds. Following the isometric evaluation, each subject performed an isotonic strength assessment consisting of three to five repetitions, using 50 percent of his or her maximal isometric strength values. For the isotonic assessment, the weight was increased by 10 pounds after each attempt until the subjects were unable to move the weight throughout the full range of motion or they had to alter their form to move the weight. Session two consisted of isometric testing using a portable fixed dynamometer (Evaluator, Baltimore Therapeutic Equipment (BTE), Hanover, MD). Each subject performed three maximal isometric contractions for five seconds, with a rest period of fifteen seconds between each contraction. All measures except IR and

ER were assessed in a standing position. **Main Outcome Measures:** The strength measures collected in both sessions were hip abduction (AB), adduction (AD), internal rotation (IR), external rotation (ER), flexion (HF), and extension (HE). The variables for this study were isotonic (Primus RS) and isometric [Evaluator Portable Fixed Dynamometer (PFD)] measures. All measures were recorded in pounds and later converted to Newtons. Separate Pearson product moment bivariate correlations were used to evaluate the relationships between the two test modes. The alpha level was set *a priori* at $p \leq .05$. **Results:** PFD displayed a significant positive correlation with isotonic HF ($r^2=.50$, $p<.01$), AB ($r^2=.22$, $p=.05$), and AD ($r^2=.34$, $p=.01$). However, a significant correlation was not found between PFD and Isotonic measures for HE ($r^2=.07$, $p=.29$), ER ($r^2=.10$, $p=.19$), and IR ($r^2=.03$, $p=.50$). **Conclusion:** While significant positive correlations were observed for HF, AB, and AD, other muscle groups did not show this relationship. It appears that AB, AD, and HF isometric dynamometry may be a viable means of collecting baseline measures prior to sports participation.

The Relationship Between Isotonic And Isokinetic Dynamometry

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Context: Traditionally isokinetic dynamometry has been used to assess strength when determining return to play status. However, researchers have proposed isotonic assessments as another viable means of assessing muscular strength. **Objective:** The purpose of this study was to determine the relationship between isotonic and isokinetic strength assessments. **Design:** Correlational Design **Setting:** University sports medicine research laboratory. **Patients or Other Participants:** Nine male and nine female volunteer subjects (22.33 ± 3.01 years, 173.00 ± 10.49 cm, and 73.77 ± 16.69 kg) were recruited for this study. In order to participate in this study the subject had to meet the following criteria: they must have been a recreational athlete engaged in moderate activity, such as tennis, biking, jogging, etc, 2-3 times a week for at least 30 minutes. **Interventions:** The study consisted of two test sessions separated by approximately one week. Session one consisted of isotonic strength measures using the Primus RS (Baltimore Therapeutic Equipment (BTE), Hanover, MD). Each subject performed three maximal isometric contractions for five seconds, with a rest period of fifteen seconds between each contraction. After completion of the isometric protocol each subject then performed isotonic strength protocol. Each subject performed 3-5 repetitions using fifty

percent of his or her maximal isometric strength measures. The weight was increased by 10 pounds after each attempt until the subject was unable to move the weight throughout the full range of motion or they had to alter their form to move the weight. Each attempt was performed in one second. Session two consisted of isokinetic testing using the Primus RS. The isokinetic strength protocol was performed at 60 degrees/second. **Main Outcome Measures:** The strength measures collected for both sessions were hip abduction (AB), adduction (AD), internal rotation (IR), external rotation (ER), flexion (HF), and extension (HE). The variables for this study were the two assessment modes (i.e. isotonic and isokinetic). Separate Pearson product moment bivariate correlations were used to evaluate the relationships between the two modes of testing for each of the hip motions. The alpha level was set *a priori* at $p \leq .05$. **Results:** Isotonic AD showed a significant correlation with isokinetic dynamometry, while all other isotonic measures did not show a significant correlation with isokinetic measures: AB ($r^2=.12$, $p=.15$), AD ($r^2=.41$, $p<.01$), IR ($r^2=.00$, $p=.90$), ER ($r^2=.19$, $p=.07$), HF ($r^2=.09$, $p=.22$), and HE ($r^2=.00$, $p=.80$). **Conclusion:** With the exception of AD, isotonic dynamometry appears to have a low relationship with isokinetic dynamometry at 60°/s for all hip measures. However, further research involving larger sample populations are needed before definite conclusions can be made.

NIH ImageJ Computer Software Program: A Reliable Tool With Questionable Validity For Measuring Shoulder External Range Of Motion
Jessee AD, Kingma JJ, Nosbisch EA, Bay RC, Valovich McLeod TC: A.T. Still University, Mesa, AZ

Context: Range of motion is used in clinical evaluations to help understand the extent of a patient's limitations. Evaluating ROM is an important assessment skill utilized by clinicians and can be used to determine the course of action to be taken to improve the function of a joint. Many different instruments have been developed over time to measure ROM of various joints. By using the NIH ImageJ computer software program, clinicians can manipulate, display, and analyze images of various joints to measure ROM. Unfortunately, there is little known about the reliability and validity of this program. **Objective:** Examine the validity and reliability of ImageJ computer software program in measuring external rotation of the shoulder joint complex. **Design:** Within-Subjects Repeated Measures Experimental Design. **Setting:** Research laboratory. **Patients:** Convenience sample of 40 healthy subjects of varying fitness levels and demographics (13 Male, 27 Female,

28 $\pm$ 9.1 yrs, 77 $\pm$ 21 kg, 170 $\pm$ 8 cm). **Interventions:** Each subject was positioned supine on a Cybex table with their right arm resting at 90 degrees of shoulder abduction with their elbow flexed at 90 degrees. The investigator passively ranged the subject's shoulder to assure a pain-free range of motion for external rotation between 0-90 degrees. Prior to the positioning of their arm on the Cybex isokinetic dynamometer, bony landmarks on the extremity were palpated and marked using a colored marker. The participant's elbow rested on the designated elbow pad and they grasped the handgrip with their wrist in neutral. At this time the Cybex apparatus was positioned in external rotation at some range between 45 and 90 degrees. The dynamometer was "locked" at this specific range, a goniometric measurement was taken and both of these measurements were recorded. A single digital photograph was then taken of the subject's shoulder making sure that the two bony landmarks were visible in the picture. Photos were then downloaded and digitized on a computer. The photos were again digitized by a secondary investigator for comparison. The NIH ImageJ software program was used to determine the external range of motion measurement. Tests for validity and reliability were run using the SPSS analysis program. **Main Outcome Measures:** Goniometric, Cybex, and ImageJ measurements of external ROM. **Results:** High intra-tester reliability ($r = 1.0$, $p < .01$), High inter-tester reliability (ICC = 1.0), High correlation for validity ($r = .966$, $p < .01$) with an overestimation of the angle in 85% of the trials. **Conclusions:** The NIH ImageJ computer software program is a highly reliable measurement tool for assessing shoulder external rotation ROM. Questions remain as to the validity of the instrument due to some limitations of the study. Future research studies should focus on answering the questions of validity of this tool.

Significance Of Camera Positions When Using The NIH ImageJ Angle Tool In Measuring Shoulder External Rotation Range Of Motion
Nosbisch EA, Kingma JJ, Jessee AD, Bay RC, Valovich McLeod TC: A.T. Still University, Mesa, AZ

Context: ROM measurements are useful measurements clinicians use to aid in an assessment of a patient. A goniometer has been a standard tool used by many clinicians to measure ROM because of its proven validity, reliability, affordability and ease of use. NIH ImageJ angle tool is a relatively new tool for measuring ROM, but there is minimal literature on its reliability and validity to measure ROM, and a lack of established standard operating procedures. **Objective:** To determine if ROM measurement differences exist with various

camera positions relative to the axis of the rotation of the joint being measured when comparing ImageJ to goniometric measurements. **Design:** Within subjects repeated measures. **Setting:** Research laboratory. **Patients:** A convenience sample of 40 healthy subjects of varying fitness levels and demographics (12 men, 28 women; 27.5 $\pm$ 8.1 yrs; 170.3 $\pm$ 7.9 cm; 77.1 $\pm$ 21.3 kg). **Interventions:** A goniometric measurement and six digital images were taken at varying positions relative to the joint's axis of rotation with the participant supine and shoulder positioned in external rotation (ER). The six digital images differed from each other by either horizontal or vertical camera positioning or by zoom feature. The images were downloaded on a computer and ER measurements were determined using the angle tool function of ImageJ. The images were digitized using the ulnar styloid and olecranon process as landmarks, and the level table top as the horizontal alignment. **Main Outcome Measures:** ER shoulder ROM measured with goniometer and ImageJ. **Results:** The ICC for reliability of camera position and goniometer measurement was .989 (95% CI .983, .994). The correlation coefficient for intra- and inter-tester reliability ranged from .99 to 1.00 (r). The absolute difference in ROM between ImageJ and goniometer measurements ranged from 2.985 to 3.919°. **Conclusion:** ImageJ was found to have high intra- and inter-tester reliability at different camera angles. Camera positioning did not effect the ROM measurements for shoulder ER using ImageJ; however standard operating procedures aligning the camera with the joint axis of rotation should be developed to assure consistency in measuring. For clinical or research purposes, the use of ImageJ could decrease the need for multiple skilled clinicians when taking ROM measurements.

Interpretation Of Gluteal Muscle Activity During A Functional Task Differs Depending Upon The Normalization Method Utilized
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Context: Maximal voluntary isometric contraction (MVIC) and single-leg stance (SLS) methods for normalizing surface electromyography (sEMG) amplitudes demonstrate acceptable intrasession reliability for the gluteus maximus (GMax) and gluteus medius (GMed). However, the relationship between these methods has not been investigated, and it is unknown whether they lead to the same interpretation of EMG activity during human movement. **Objective:** To assess the relationship between GMax and GMed MVIC and SLS EMG normalization methods, and to compare the interpretations of EMG activity during a

functional task using these methods. **Design:** Correlational. **Setting:** Research laboratory. **Patients or Other Participants:** 16 Female (Age:20.56±0.73 years, Height:1.66±0.05 m, Mass:64.71±8.24 kg) and 11 Male (Age: 20.82±3.31 years, Height:1.78±.65 m, Mass:70.38±4.49 kg) volunteers. **Interventions:** Subjects executed five single-leg, 100 cm forward jump landings using their dominant leg onto a force plate. Five-second trials of GMax and GMed MVIC and dominant leg SLS were also performed. Muscle activity was recorded using sEMG. Lower extremity kinematics were assessed via a camera-based motion capture system. **Main Outcome Measures:** Mean GMax and GMed EMG amplitudes during the loading phase of the jump landing (initial ground contact to peak knee flexion) were calculated and normalized to mean EMG amplitudes during SLS and MVIC. The relationships between normalized EMG amplitudes using each method were assessed via bivariate Pearson correlation coefficients ($\alpha=0.05$). **Results:** MVIC and SLS normalized EMG amplitudes for GMed were significantly and positively correlated ($r=0.612, p=0.001$). However, these values were unrelated for GMax ($r=0.168, p=0.401$). **Conclusions:** While the normalized EMG amplitudes using MVIC and SLS methods were highly correlated for GMed during a landing task, EMG amplitudes using these same methods were not correlated for GMax. This suggests that interpretation of EMG amplitudes for GMax may differ depending on the choice of normalization procedure. We propose that subjects utilize different strategies to achieve hip extension moment during SLS and MVIC. Specifically, while MVIC methods isolate activation of the GMax, SLS incorporates potentially different contributions from the GMax and hamstrings muscles in subjects to attain the necessary hip extension moment. Therefore, these normalization methods may produce disharmonious results in closed kinetic chain tasks where multiple muscles are capable of contributing significantly to a given action.

These data highlight the caution with which EMG amplitude data should be evaluated. We suggest the use of SLS for EMG amplitude normalization for tasks during which EMG is being sampled from multiple muscles as this method 1) minimizes subject effort by requiring subjects to perform a single reference procedure for multiple muscles simultaneously, 2) requires substantially less effort than MVIC, thus reducing the likelihood of fatigue, and 3) provides a normalization criterion that more closely resembles the coordinated function of the lower extremity musculature during closed kinetic chain tasks.

Reliability Of The Tissue Compliance-Algometer Outcome Assessment System On Healthy Rugby Players

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Context: Tissue compliance (T.C.) or firmness historically has been used as a means to evaluate musculoskeletal abnormalities. Muscular changes such as muscle spasm and cramps, or muscle atrophy and hypertrophy, are typically evaluated by subjective palpations. Objective measurements are necessary to accurately assess changes in T.C. **Objective:** Test the reliability of the tissue compliance meter. **Design:** A 3 x 6 repeated measures design. **Setting:** The biomechanics research laboratory at Brigham Young University. **Patients:** 20 male rugby players (age: 21.10±2.40 yrs, height: 179.47±6.32 cm, weight: 83.78±18.10 kg) were recruited by volunteer sample. **Interventions:** Subjects reported to the biomechanics lab wearing shorts.

Subjects were seated in a Biodex (Biodex Medical, Shirley, NY) with their right leg stabilized and right knee fixated at a 60 degree angle. A 90.9 kg capacity strain gauge was strapped to the right leg just proximal to the malleoli. The strain gauge was kept at a 90-degree angle to the leg and was interfaced with a computer and the measurements from the strain gauge were recorded using Quick DAQ Data Collection Software. Tissue Compliance was measured using the handheld Tissue Compliance-Algometer (Accelerated Care Plus, Reno, Nevada). The measurements were taken on the right quadriceps muscles at the mid point between the ASIS and the superior pole of the patella. The handheld device consists of an outer disc with a diameter of 7.5 cm and a measurement rod with a diameter of 1 cm. Subjects performed an isometric knee extension while TC measurements were taken. Three T.C. measurements were taken and averaged at 6 different isometric contractions of 4.5, 9.07, 13.61, 18.14, 27.22 kgs, and a Max Load. **Main Outcome Measures:** The average TC reading for each contraction was the dependent variable. Statistical analysis was performed using SAS software. Hierarchical Linear Model was fit to the repeated measures from each subject to estimate the effect of isometric contraction on T.C. **Results:** The graph was linear; at every increase in 1Kg, the meter reading increased 0.5. ($p=.0001$) an R-Square test showed a value of .478. **Conclusions:** The Tissue Compliance-Algometer Outcome Assessment System is a reliable way to measure tissue stiffness and force in the quadriceps muscle. This is a much more objective measure of muscle force than the subjective 1-5 scale frequently used in physical medicine and rehabilitation. More research is needed to determine the reliability of this gauge in other muscles and on injured or post operative patients.

Free Communications, Poster Presentations: Muscle Function and Performance Testing

Saturday, June 20, 2009, 8:00AM-12:00PM, Park View Lobby, Concourse Level; authors present 11:00AM-12:00PM

Differences In Spinal Kinematics Between Low And High Handicap Golfers

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Context: Golf instructors have proposed maximizing the separation between upper torso

and pelvic axial rotation (aka 'X-factor') during the swing to increase club head velocity and driving distance. Golf-fitness and rehabilitation programs aim to maximize upper torso-pelvic separation to enhance performance. Little evidence has quantified differences in spinal kinematics between low (LHC) and high handicap (HHC) golfers. **Objective:** Compare spinal kinematics between LHC and HHC golfers. **Design:** Static group comparison research design. **Setting:** Indoor university golf and sports biomechanics laboratory. **Participants:** Twenty-four healthy recreational ($n=21$) and

professional ($n=3$) right-handed golfers (21M, 3F; age=34±13yrs; height=177.4±6.2cm; mass=87.8±11.1kg). We classified subjects with handicap index ≤ 12 as LHC and ≥ 24 as HHC. Groups included 11-LHC (index=4±4) and 13-HHC golfers (index=28±4). **Interventions:** We compared spinal kinematics between HHC and LHC golfers. After warming-up, subjects struck 10 standard golf balls off artificial turf using their own driver and 10 using their 6-iron. We measured spinal kinematics using electromagnetic tracking sensors taped to C7 and L5/S1. A golf simulator projected a target and performance-feedback for

each shot 5m in front of golfers. **Main Outcome Measures:** We recorded 3-dimensional spinal motion and angular velocity during each swing including: upper torso and pelvic axial rotation with reference to (w.r.t.) the target-line (global X-axis), torso-pelvic separation (difference between two aforementioned rotations); and upper torso rotation (axial rotation w.r.t. the pelvis). Before exporting data, we identified kinematic data at four points in each swing: address, top of backswing, 40ms before ball-strike, and ball-strike. Because within-subject kinematic variability (i.e. between-shot variation) may provide insight into performance differences, we also calculated variability for each measure. A one-way analysis of variance compared demographics and kinematics between HHC and LHC golfers. **Results:** Differences in demographics between LHC and HHC golfers included experience (LHC=26±15; HHC=7±7yrs; $P=0.001$) and rounds played per month (LHC=7±5; HHC=3±2; $P=0.03$). Groups were not different in age, height or mass ($P>0.05$). Using the driver, LHC golfers displayed more upper torso rotation at the top of backswing (LHC=30.4±11.1°; HHC=18.9±13.6°; $P=0.03$), 40ms before ball-strike (LHC=22.0±6.6°; HHC=11.1±10.3°; $P=0.006$) and at ball-strike (LHC=13.5±9.8°; HHC=0.8±11.3°; $P=0.008$) compared to HHC. We observed similar between-group differences at ball-strike for the 6-iron. With the driver, LHC golfers exhibited less variability 40ms before ball-strike in pelvic (LHC=2.7±1.3°; HHC=3.7±0.8°; $P=0.04$) and upper torso axial rotation (LHC=2.9±1.1°; HHC=4.3±1.1°; $P=0.008$). For the 6-iron, LHC golfers demonstrated less variability for velocity of upper torso axial rotation and maximum torso-pelvic separation. **Conclusions:** LHC and HHC golfers displayed differences in magnitude, velocity and variability of spinal kinematics. LHC golfers demonstrated more upper torso rotation and torso-pelvic separation. LHC golfers also exhibited less variability in multiple kinematic measures, indicating greater between-swing consistency. These observations can assist clinicians and fitness-instructors in designing conditioning and rehabilitation programs for golfers.

Field And Laboratory Testing Variance And Application To Daily Physical Training

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Context: Army physical training is often performed at the unit level utilizing similar activities for each soldier regardless of differing musculoskeletal and physiological abilities. The current training format may not most effectively address unit variance to ensure the proper load application or musculoskeletal and physiological progression results. **Objective:** The purpose of this study was to identify the between-subject variance of physical and physiological testing of the 101st Airborne (Air Assault) Division.

Design: A retrospective cohort design was utilized. **Setting:** University sports medicine laboratory. **Patients or Other Participants:** A total of 111 male and female 101st Airborne (Air Assault) soldiers participated (Age: 28.1 ± 6.8 years; Height: 1.74 ± 0.09 m; Mass: 79.7 ± 14.4 kg). **Interventions:** Subjects performed the standard Army Physical Fitness Test (APFT) and a battery of laboratory assessments consisting of strength, cardiorespiratory, anaerobic, and body composition tests. Isokinetic strength testing was performed on the shoulder, knee, and torso. VO₂ max and lactate threshold were measured with a portable metabolic system during an incremental treadmill protocol to exhaustion. Anaerobic power and anaerobic capacity were measured during a 30 second maximal effort sprint on a cycle ergometer. Body composition was measured using air displacement plethysmography. The laboratory testing battery was based on variables that would most contribute to combat readiness and those most likely related to injury in the Army. A coefficient of variation (CV) was calculated for each dependent variable to determine the relative variance for APFT, musculoskeletal, and physiological testing within the Division. **Main Outcome Measures:** The dependent variables were the APFT, peak torque (normalized to body mass) for knee flexion and extension, shoulder internal and external rotation, and torso rotation, VO₂ max, anaerobic power and capacity, and percent body fat. **Results:** The CV for the APFT ranged from 13.9-28.1% for the push-up, sit-up, and run components. The CV for strength testing was 32.6% for shoulder internal rotation and 23.5% for shoulder external rotation, 24.8% for knee flexion and 21.6% for knee extension, and 24.7% for the torso. The CV for physiological testing was 37.3% for percent body fat, 18.1% for anaerobic power, 14.3% for anaerobic capacity, and 15.5% for VO₂ max.

Conclusions: The CV for testing ranged from approximately 14-40% indicating a large variance of scores for the APFT, musculoskeletal, and physiological testing. Such variance may support stratified within-unit training that accounts for the different musculoskeletal and physiological abilities, particularly if optimal performance is being sacrificed or high injury rates are observed. Stratified, within-unit training will allow for proper modification of the training stimulus that promotes optimal fitness, without inducing injury.

A Novel Clinical Agility Test To Discriminate Between Law Enforcement Officers Who Are Obese And Who Are Not

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Context: Variety of valid and reliable functional testing for the physically active population that is clinically meaningful is lacking. **Objective:** To determine the validity and reliability of a novel clinical agility task, designed to evaluate fitness level and agility in a physically active population. **Design:** Cohort **Setting:** Research laboratory. **Patients or Other Participants:** Forty-two law enforcement officers from central Kentucky (34 males; age=35.8±6.6 years, height=179.7±8.0cm, mass=93.2±14.0kg, body fat percentage(Fat%)=22.0±4.5% and 8 females; age=38.5±5.4 years, height=163±4.2cm, mass=60.9±8.5kg, Fat%=31.7±8.4% participated in this testing as part of a larger fitness study. **Interventions:** Two clinical agility tests were analyzed. The T-agility test (T-Agility), a previously established, valid and reliable test of leg speed, leg power, and agility was compared to a novel clinical agility test, the Prone-Up-and-Go (PUG). The PUG, a timed test, was modified after a functional test used for testing in geriatrics. Modifications included an increase in intensity and duration. For the PUG, the subject started in a prone position. On the command of "go", the subject stood up, and sprinted to a cone 10 yards away. The subject touched the base of the cone and sprinted back to the starting spot. Fat% was also determined on all officers using a multi-frequency bioelectric impedance device. **Main Outcome Measures:** Dependent variables were Fat%, and Time for each task. Fat% was used to classify subjects into the nominal variables of "Obese" and "Not obese" based on standards by the American Council on Exercise. Reliability was determined by intrasession and intersession test-retest. Interclass correlation coefficients were used to analyze test-retest reliability. Pearson's product moment correlations and stepwise discriminant analysis were used to

determine validity. Concurrent validity was determined by correlation to a previously established functional test (T-agility). Construct validity was determined by the predictive value of these tests to discriminate between those officers who were obese from those who were not. Statistical significance was set at $P < .05$. **Results:** Intrasection ($ICC = .99$, $P < .001$) and intersession ($ICC = .98$, $P < .001$) reliabilities for the PUG were excellent. Correlations between PUG and T-agility was significant ($r = .87$, $P < .001$). Correlation between the PUG and Fat% ($r = .77$, $P < .001$) was slightly larger than correlation between the T-agility and FA% ($r = .70$, $P < .001$). The PUG was included in the model ($r = .52$, $P < .001$) as a predictor of obesity, however the T-agility was not. Twenty-seven percent of the variance associated with obesity as determined by Fat% could be predicted by the PUG. **Conclusions:** The PUG was determined to be valid and reliable, and able to discriminate between obese and non-obese officers, while the previously established T-agility test was not. Results suggest that movement from a prone horizontal position is more difficult than simple change of direction tasks, while also stressing both the upper and lower extremities.

The Effect Of Acute Static Stretching On Countermovement Vertical Jump: A Systematic Review

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Context: Pre-event static stretching is a common practice in both recreational and competitive athletics. It is a commonly held belief that static stretching will improve athletic performance, however, recently the performance benefits of pre-event static stretching has come under scrutiny in the literature with some authors suggesting that static stretching may cause acute decrements in performance. **Objective:** To perform a systematic review to determine if the inclusion of an acute bout of lower extremity static stretching adversely affects maximum countermovement vertical jump (CMVJ), a common measure of lower extremity power. **Data Sources:** PubMed, Web of Science, CINNAHL, and Sports Discus databases were searched exhaustively for original research articles published in English from 1966 to 2008. The search terms used were: "flexibility OR stretching" AND "vertical jump". Limits: English, human subjects, peer-reviewed, journal articles. **Study Selection:** Studies were included that evaluated CMVJ height following an acute intervention of static stretching. Each study needed to provide means, standard deviations, and sample sizes as well as be able to be assessed using the Physiotherapy Evidence Database (PEDro)

scale. Seven studies out of 1104 articles met all inclusion criteria. **Data Extraction:** Two independent researchers read and assessed each article to determine the PEDro score. The PEDro score ranged from 5-6 with an average score of 5.6. Changes in CMVJ height were assessed as mean differences in cm and with Cohen's d effect sizes (and their associated 95% confidence intervals) for comparisons: 1) between control groups and static stretching groups, and 2) within groups where pre- and post- CMVJ measurements were reported. **Data Synthesis:** The mean difference between the control groups and the static stretching groups in the seven included studies was -0.39cm (95% CI: -5.12cm to 4.35cm). The mean effect size between groups was -0.03 (95% CI: -0.60 to 0.59). Within group mean differences and effect sizes were obtained from 4 studies that included pre- and post-stretching CMVJ measurements. The mean difference within static stretching groups was -0.88cm (95% CI: -6.62 to 4.87cm). The mean effect size within static stretching groups was -0.12 (95% CI: -0.83 to 0.60). **Conclusions:** The data indicates that an acute bout of static stretching has no consistent detrimental or beneficial effect on vertical jump. Based on these results, a recommendation to alter clinical practice with regards to pre-event lower extremity static stretching based on concerns about diminishing power performance cannot be made.

The Effect Of The Graston Technique On Quadriceps Muscle Activation And Force Production

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Context: The Graston Technique (GT) is an advanced instrument-assisted soft tissue mobilization technique based on the concepts of cross friction massage. To date, limited research has been conducted on the effects of GT on muscle function. **Objective:** To determine the effect of GT on muscle activation and force production of the quadriceps muscles. **Design:** Repeated measures design. **Setting:** Controlled laboratory environment. **Participants:** Twenty-six subjects (21.1 ± 1.8 years, $175.9 \pm 10.4\text{cm}$, $55.8 \pm 11.5\text{kg}$) were recruited from a university population. All subjects were healthy with no history of lower extremity injury in the last two years. **Interventions:** The independent variables were day at 4 levels (1,3,5,7) and time at two levels (pre-treatment and post-treatment). Each subject participated in 4 one-hour treatments using the GT implements (TherapyCare Resources, Indianapolis, IN).

Before and after each treatment subjects completed three maximal voluntary isometric contractions (MVIC) to obtain force data and ten lateral step downs to obtain muscle activation data. Muscle activation was measured using the BIOPAC Systems MP150 hardware and AcqKnowledge 3.7.3 software (BIOPAC Systems Inc, Goleta, CA). Surface electromyography (EMG) data were collected on the vastus lateralis (VL), vastus medialis obliquus (VMO), and rectus femoris (RF) by a remote amplifier at a sampling rate of 1250Hz. EMG signals were filtered through a band-pass filter of 10-350Hz. The average Root Mean Square was calculated over a 15-millisecond period. A KinCom Isokinetic Dynamometer (Chattanooga Group, Chattanooga, TN) was used to stabilize the leg during MVIC trials and a 26.7cm step was used for the lateral step down trials. Separate RMANOVA were calculated on EMG data, one for each muscle. Another RMANOVA was calculated for MIVC force data. Tukey post hoc tests were calculated on all significant findings. **Main Outcome Measures:** Muscle activation (%MVIC) and force production (Newtons) were measured in each participant before and after GT treatments on four separate days. **Results:** For the force data, we identified a significant difference between test days ($F_{3,75} = 17.62$, $P = .01$). Specifically, we found an increase in force production between day 1 ($637.8 \pm 51.3\text{N}$) and each subsequent day (day 2 = $719.4 \pm 58.6\text{N}$, day 3 = $728.5 \pm 63.6\text{N}$, day 4 = $792.8 \pm 64.5\text{N}$). For the muscle activation data, we found a significant day by time interaction in the RF ($F_{3,75} = 2.92$, $P = .04$). Post Hoc analysis showed a decrease in RF activation between day 1 pre-treatment ($76.9 \pm 6.8\%$ MVIC) and the pre-treatment and post-treatment on days 2 (pre = $65.9 \pm 6.8\%$ MVIC, post = $61.7 \pm 6.6\%$ MVIC), 3 (pre = $59.3 \pm 5.9\%$ MVIC, post = $56.6 \pm 5.5\%$ MVIC), and 4 (pre = $54.7 \pm 5.4\%$ MVIC, post = $55.1 \pm 5.5\%$ MVIC). We also found a significant difference in muscle activation between the test days for both the VMO and VL ($P < .05$). Follow up testing showed a decrease in VMO muscle activation between day 1 ($96.6 \pm 6.5\%$ MVIC) and day 4 ($79.6 \pm 5.0\%$ MVIC). **Conclusions:** The GT resulted in decreased muscle activation but increased force production in the quadriceps muscles. Therefore, we can conclude that the GT has the potential to improve muscular contraction efficacy.

Assessing Ankle-Complex Laxity Following Lateral Ligament Injury: A Biomechanical Analysis Of How Much Load Should Be Applied

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Context: Damage to the anterior-talofibular (ATFL) and calcaneofibular (CFL) ligaments of the ankle is a commonly reported sports injury. The anterior-drawer test is used to evaluate whether the ATFL has been torn, while the inversion-test (talar tilt) is used to determine CFL injury. To accomplish objective ankle-complex laxity measurement, a six-degrees-of-freedom instrumented ankle arthrometer (Blue Bay Research, Navarre, FL) has been reported to effectively quantify laxity by assessing translatory and rotary displacements of the foot in relation to the leg that result from the combined motions within the talocrural and subtalar joints. Studies have reported good to high reliability, along with its use in detecting laxity in chronically unstable ankles. However, the optimal magnitude of loading required to detect ligamentous integrity after injury is unknown. **Objective:** To determine how much load should be applied during anterior-drawer and inversion-stress testing to detect ankle-complex laxity. **Design:** Within-subject, repeated measures. **Setting:** Research laboratory. **Participants:** Seven cadaver ankle specimens (mean age, 64 years). **Interventions:** All ankles underwent loading at 10° plantarflexion with laxity examined for the intact ankle and following sequential sectioning of the ATFL and CFL. A tibial rod was screwed into the medullary cavity and then mounted at the proximal end to a table clamp. The ankle arthrometer consisted of an adjustable-plate fixed to the foot and a load-measuring handle through which anteroposterior and inversion-eversion loading was applied. The positions at 125 N of posterior-load (drawer test) and 1 N-m of eversion-load (inversion test) were used as the reference positions because of difficulty in determining a reference position at zero-load. **Main Outcome Measures:** Increased anterior displacement (mm) from the reference position at 10, 25, 50, 75, 100, and 125 N of anterior-load and increased inversion rotation (degrees) from the reference position at 1, 2, 3, and 4 N-m of inversion-load. Separate repeated measures ANOVA's ($P < .05$), followed by pairwise comparisons with Bonferroni corrections analyzed effects of ligament sectioning at each load. **Results:** The ankle condition by loading interaction effects were significant for anterior laxity ($F_{5,30} = 4.95, P = .002$) and inversion laxity ($F_{3,18} = 15.02, P < .001$). Compared to the intact

ankle, sectioning the ATFL significantly increased displacement for anterior loading at only 100 N ($11.9 \pm 2.9; P = .007$) and 125 N ($13.1 \pm 2.9; P = .003$); and sectioning the CFL significantly increased inversion rotation across all loads (1 N-m: 13.6° ; 2 N-m: 19.9° ; 3 N-m: 25.3° ; 4 N-m: $29.9^\circ; P < .005$). **Conclusions:** Findings indicate a 100 N load is necessary to detect ATFL injury during anterior-drawer testing when compared to the intact ankle. Whereas, a magnitude load as low as 1 N-m detects disruption of combined ATFL and CFL injury during inversion loading.

Relationships Between Measures Of Posterior Talar Glide And Ankle Dorsiflexion Range Of Motion In Healthy Subjects

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Context: Ankle dorsiflexion range of motion (DF ROM) after a lateral ankle sprain is usually decreased depending on the severity of the injury. Clinically, the use of an anterior to posterior mobilization of the talus has been used to increase DF ROM. However, the relationship between measures of posterior talar glide and ankle DF ROM have not been established. **Objective:** To investigate the correlations between measures of the posterior talar glide test and four different DF ROM measurement techniques in healthy subjects. **Design:** Descriptive laboratory study. **Setting:** Laboratory. **Patients or Other Participants:** A total of 48 limbs from 24 subjects (Male: 8, Female: 16; age: 27.9 ± 6.8 ; weight: 69.6 ± 13.8 ; height: 70.7 ± 22) from a sample of convenience were measured. Subjects did not have any previous injuries that would affect talar glide or DF ROM measurements. **Interventions:** Four different measurements of DF ROM were taken (prone bent knee (PBK), standing straight knee (STSK), standing bent knee (STBK) and seated straight knee (SSK)) with an inclinometer using standard clinical techniques. Measurement of posterior talar glide was performed with subjects sitting with knees flexed and legs hanging off a plinth. The passive knee flexion angle was measured at the point of restricted posterior talar glide as previously reported by Denegar et al. Three trials were performed for each of the five tests and the means of the three measurements were used for analysis. Pearson's moment product coefficients were calculated to examine relationships between the 5 measures. **Main Outcome Measurements:** Four DF ROM measures and posterior talar glide were measured. **Results:** There was a moderate positive correlation on the right side

between talar glide and both standing conditions ($r = .538$ STBK, $p = .007$; $r = .643$ STSK, $p < .001$). On the left side there was a moderate positive correlation between talar glide and the STSK position ($r = .440$, $p = .031$). Means and standard deviations for the four different DF ROM on the right side were: PBK ($15.6^\circ \pm 6.6^\circ$), SSK ($8.3^\circ \pm 6.0^\circ$), STBK ($36.2^\circ \pm 5.5^\circ$) and STSK ($33.2^\circ \pm 7.5^\circ$); on the left side were: PBK ($13.5^\circ \pm 6.5^\circ$), SSK ($8.1^\circ \pm 5.8^\circ$), STBK ($33.8^\circ \pm 5.8^\circ$), STSK ($29.5^\circ \pm 5.0^\circ$). For the posterior talar glide test means and standard deviations were: right ($24.2^\circ \pm 7.5^\circ$) and left ($22.2^\circ \pm 6.7^\circ$). **Conclusions:** Moderate correlations were observed bilaterally between measures of DF ROM in the STSK condition and posterior talar glide, while a moderate correlation was observed between DF ROM in the STBK condition on the right side only. In the non-weight bearing positions (SSK, PBK) no significant correlations were seen between talar glide and DF ROM. These results suggest that arthrokinematics and osteokinematics of the talocrural joint change with non-weight bearing and weight bearing measurements of DF ROM.

Non-Weight Bearing Lower Extremity Alignments Affect The Amount Of Rearfoot Angle In Static Weight Bearing

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Context: Standing rearfoot angle has been used to classify foot type and examine foot structure. However, the standing rearfoot alignment may be influenced by non-weight bearing proximal and distal structural alignments. The compensation of non-weight bearing structural alignments during weight bearing may alter standing rearfoot alignment. It is unknown how these lower extremity factors affect standing rearfoot angle and there is no published study to date examining the effect of non-weight bearing alignments on standing rearfoot alignment. **Objective:** To identify the effect of several non-weight bearing proximal and distal alignment measures on standing rearfoot angle. **Design:** Observational cross sectional study. **Setting:** Laboratory. **Patients or Other Participants:** 43 young adults (Male: 15, female: 20; age: 23.4 ± 5.3 ; weight: 63.5 ± 9.8 kg; height: 173.3 ± 5.1 cm) volunteered and each limb was treated as a subject for a total of 86 limbs. Subjects did not have any previous injury history that would affect lower extremity alignment and did not currently have any lower extremity injury. **Interventions:** The predictor variables were

rearfoot and forefoot varus/valgus alignment, navicular drop, tibial varum, tibial torsion, genu recurvatum, leg length discrepancy, femoral anterversion, pelvic tilt, and Q-angle. The procedures of all ten lower extremity alignment measures were based on commonly accepted measures in non-weight bearing supine or prone positions except pelvic tilt and navicular drop test which were performed using established methods in weight bearing. All the measurements were performed three times by a single examiner who established intersession intra-tester reliability of at least ICC=.80 for each alignment measures. The effect of these 10 lower extremity alignment measures on standing rearfoot angle was analyzed via stepwise multiple regression analysis. Thus, 10 lower extremity alignments predictor were used for each stepwise multiple regression analysis to account the variance of the standing rearfoot angle. Alpha level was set a prior $p < .05$. **Main Outcome Measures:** The dependent variable was standing rearfoot angle. **Results:** Non-weight bearing rearfoot angle ($3.8 \pm 3.0^\circ$) entered the model first and explained 44% of variance ($R^2 \text{ change} = .44$, $F = 54.09$, $p < .01$) of standing rearfoot angle ($5.8 \pm 4.1^\circ$). Leg length discrepancy ($.06 \pm .79 \text{ cm}$) entered the model next, explaining an additional 5% of variance of standing rearfoot angle ($R^2 \text{ change} = .05$, $F = 32.43$, $p < .01$). Finally, forefoot angle ($11.4 \pm 7^\circ$) entered and explained additional 5% ($R^2 \text{ change} = .05$, $F = 25.60$, $p < .01$) of variance of standing rearfoot angle. The other 7 alignment measures were not significant predictors of standing rearfoot angle ($p > .05$). **Conclusions:** The effect of non-weight bearing distal alignment measures, such as rearfoot and forefoot varus/valgus angles, clearly influence the standing rearfoot angle. However, only one proximal alignment factor, leg length discrepancy, contributed substantially to standing rearfoot angle. In order to understand the cause of increased standing rearfoot angle, it is recommended to examine non-weight bearing rearfoot and forefoot alignment and leg length discrepancy.

Difference In Latency Of The Peroneus Longus Between Dominant And Non-Dominant Leg

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Context: The latency of the peroneus longus in response to an inversion perturbation is a key component in the prevention of lateral ankle sprains. While the dominant ankle is sprained more frequently than the non-dominant ankle, the difference in the latency between the two legs has not been extensively studied. **Objective:** To use an inversion perturbation that more

accurately replicates the mechanism of a lateral ankle sprain to determine if there is a difference in the latency of the peroneus longus between the dominant and non-dominant legs. **Design:** A single group repeated measures study. **Setting:** The study was performed in a controlled laboratory setting. **Participants:** Fifteen healthy volunteers (age = 21.07 ± 1.10 years, mass = 63.46 ± 11.97 kg, height = 1.69 ± 0.093 m) with no previous history of an ankle sprain or lower extremity surgery. **Interventions:** The independent variable was the leg of the participant (dominant and non-dominant). Statistical analysis included a univariate analysis of variance with repeated measures to analyze the difference in the latency between the two legs. Muscle activity was recorded with a multichannel electromyography (EMG) amplifier/processor unit (MyoClinical, Noraxon USA INC; Scottsdale, AZ) using bipolar Ag/AgCl disc surface electrodes placed over the muscle belly of the peroneus longus. An outsole 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. A circuit was created between the fulcrum and landing area and interfaced with the EMG processor to signal contact with the ground and initiation of the inversion moment. **Main Outcome Measures:** The dependent variable was the latency of the peroneus longus, measured in milliseconds (ms). Latency was defined as the time from contact of the fulcrum with the landing area to when muscle activity exceeded 5 standard deviations from activity 200 ms before contact. A univariate analysis of variance with repeated measures was conducted to determine if there was a difference in the latency of the peroneus longus between the two legs. **Results:** There was a significant difference between the latency of the dominant leg and the non-dominant leg ($F_{1,13} = 9.34$, $P = .009$, $\eta^2 = .400$). The latency of the peroneus longus of the non-dominant leg was 34.40 ± 6.91 ms, while the latency of the peroneus longus of the dominant leg was 44.90 ± 12.75 ms. **Conclusions:** These findings reveal the non-dominant ankle had a significantly shorter latency of the peroneus longus than the dominant ankle. This may be due to the different demands placed on the dominant and non-dominant legs during activity. Future research should investigate if this difference pre-disposes the dominant ankle to a greater number of ankle sprains.

The Relationship Between Foot Posture, Lower Extremity Strength, Core Strength, Body Mass Index, And Postural Stability

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Context: Impaired postural stability (PS) has been associated with increased risk of lower extremity (LE) injury. Additionally, "abnormal" foot posture, decreased LE strength, decreased core muscle strength, and increased body mass index (BMI) have each been associated with decreased PS. It is likely, however, that a combination of structural and/or strength measures will more effectively predict PS than any single measure. **Objective:** Investigate the relationship between foot posture, LE strength, core strength, BMI, and PS. **Design:** Multiple linear regression model. **Setting:** Controlled, laboratory setting. **Participants:** 74 participants (45 F, 29 M; 22.8 ± 4.9 yrs; 168.3 ± 10.9 cm; 688.9 ± 131.4 N) with no LE injury within the previous 6 months and no history of LE surgery. **Interventions:** Dominant limb foot posture (arch index (AI), navicular index, relative arch deformity (RAD) ratio, navicular mobility ratio) was quantified during 10 and 90% weight-bearing (WB) conditions using the digital photographic measurement method. Isometric strength (peak force of 3 trials normalized to body mass^{2/3}) of the dominant limb ankle (invertors, evertors, plantar flexors, dorsiflexors) and hip (flexors, extensors, medial rotators, lateral rotators, abductors, adductors) musculature was quantified using an isokinetic and a hand held dynamometer, respectively. Core muscular strength (anterior (AC), posterior (PC), lateral) was assessed during single time-to-failure tests. BMI was computed and a force plate sampling at 100 Hz was used to quantify dominant limb mediolateral (ML) and anteroposterior (AP) PS (time-to-boundary) during an eyes closed (3 - 10 s trials) condition. Prior to running regression analyses, Pearson correlations were performed to identify predictor variable multicollinearity ($r > 0.70$). In cases of multicollinearity, clinical reasoning determined variable inclusion/exclusion. Multiple regression with 5 ordered sets of predictors were then performed to determine the structural and/or strength variable(s) that best predicted PS. **Main Outcome Measures:** The predictor sets were foot posture (AI in 90% WB, RAD), ankle and hip (ABD, MR, LR) strength, core strength (AC, PC), and BMI. Criterion variables were AP and ML PS. **Results:** None of the sets were statistically significant for predicting AP or ML PS. The best set for predicting AP PS was set 4 (foot posture, ankle, hip, and core strength) ($R^2 = 0.24$, adjusted $R^2 = 0.10$, $F_{11,62} = 1.78$, $p = 0.078$), and the best set for predicting ML PS

was set 3 ($R^2 = 0.20$, adjusted $R^2 = 0.11$, $F_{9,64} = 1.74$, $p = 0.097$). **Conclusions:** The static measures of foot structure, isometric LE strength, core strength, and BMI did not significantly predict AP or ML PS. Further research investigating the relationship between clinically assessed LE structural and strength variables and PS and/or the statistical procedures utilized to investigate the relationships is warranted.

An Evaluation Of Force Sense In The Ankle In Weight-Bearing And Non-Weight-Bearing Positions

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Context: The majority of conscious proprioception measures are performed in an open kinetic chain position. However, most injuries that create proprioceptive deficits occur in a closed kinetic chain position. Force sense is one such conscious proprioceptive sense that has primarily been evaluated in a non-weight-bearing position. **Objective:** To evaluate the difference in force sense errors when tested in three stance positions in participants with functional ankle instability (FAI) and uninjured participants. **Design:** Repeated measures design. **Setting:** Controlled laboratory environment. **Participants:** Thirty-six subjects (20 men, 16 females, 19.83 ± 1.63 years, 176.99 ± 10.10 cm, 73.88 ± 14.85 kg) volunteered to participate in this study, 18 with FAI and 18 with no history of ankle injuries. FAI was defined as a history of at least one ankle sprain, repeated episodes of giving-way, and feelings of instability during activities of daily life or sport participation. Participants were excluded from either group if they had a history of fracture or surgery to the lower extremity. **Interventions:** The independent variables were stance at three levels (seated with ankle in a neutral position[NU], seated with the ankle in a plantarflexed position[PF], and standing[ST]) and group at two levels (FAI and control). Ankle force sense testing was performed at 30% of eversion maximal voluntary isometric contraction. Using a load cell (Sensotec, Columbus, OH), participants were instructed to produce the target force for five seconds, relax, and then immediately reproduce the force. The reproduction force for each trial was subtracted from the target force to produce a trial error. This procedure was repeated three times in each stance position. Absolute (AE) and variable (VE) errors were then calculated. Separate 2x3 repeated measures Analysis of Variance were conducted for each error calculation. Tukey post hoc analysis was calculated on any significant findings. **Main Outcome Measures:** Absolute and variable force sense errors (Newtons). **Results:** For AE we found a significant main effect for stance

($F_{2,68} = 7.61$, $p = .01$). Follow-up post hoc test revealed increased errors in the ST position (10.52 ± 1.21 N) compared to the NU (7.87 ± 0.78 N) and PF (6.91 ± 0.76 N) positions. Similarly, for VE we found a significant main effect for stance ($F_{2,68} = 9.98$, $p = .01$). Follow-up post hoc test revealed increased errors in the ST position (6.65 ± 0.76 N) compared to the NU (4.84 ± 0.51 N) and PF (3.93 ± 0.39 N) positions. No significant main effect for group or significant stance by group interaction was identified ($P > .05$) for either error calculation. **Conclusions:** Test position has an impact on a participant's ability to accurately reproduce a given force. Interpretation of these results indicate that when participants are in a weight-bearing position the ability to accurately reproduce 30% of their eversion maximal force is more difficult. Since both activities of daily life and sport participation primarily occur in a weight-bearing position more extensive evaluation of this type of testing should be performed.

Stochastic Resonance Improves Ankle Force Sense But Not Reposition Sense

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Context: Previous work has shown that subjects with functional ankle instability (FAI) have both force sense (FS) and joint reposition sense (JRS) deficits. Recently, stochastic resonance (SR) has been shown to improve balance in FAI subjects. **Objective:** Our objective was to determine whether SR would improve subjects' force and joint reposition senses. **Design:** We used a two-group (FAI, no FAI), two-treatment (SR_{on}, SR_{off}) crossover design. **Setting:** A laboratory with controlled light and temperature conditions. **Patients and Other Participants:** We recruited fifteen uninjured (height= 169.6 ± 7.7 cm, weight= 63.8 ± 11.1 kg, age= 23.1 ± 3.8 yrs) and 15 FAI subjects (height= 171.7 ± 8.2 cm, weight= 66.5 ± 10.5 kg, age= 22.7 ± 2.6 yrs, sprains= 3.2 ± 2.5 , give-ways/week= $0.57 \pm .54$) from the local metropolitan area. FAI subjects were included if they had at least one ankle sprain requiring immobilization, a sense of giving-way during weight bearing activities, and at least 1 ankle sprain in the past year. All subjects had to be physically active and at least 18 years of age. Subjects were excluded if they had acute ankle symptoms, assisted ambulation, or a history of other lower extremity injuries that affected function. **Interventions:** SR stimulation, i.e. random subsensory noise, was applied to the peroneal, anterior tibialis, gastrocnemius, and posterior tibialis muscles via vibrating tactors. Prior to testing, each subject's sensory threshold was established. The subjects performed 3 trials of quiet balance under a control (SR_{off}) and 4 SR stimulation conditions administered at 25%,

50%, 75%, and 90% of sensory threshold. The SR intensity that produced the slowest center-of-pressure velocity for each subject was identified as the optimal intensity and used as our intervention (SR_{on}). Each outcome variable was analyzed using a two-factor mixed-model ANOVA with one between (FAI, no FAI) and one within (SR_{on}, SR_{off}) factor. **Main Outcomes:** The outcomes were constant error (CE), absolute error (AE), and variable error (VE) for FS at 10% of maximal voluntary contraction and for JRS at minus 5° full eversion. **Results:** For JRS we found no significant group-SR interactions ($F_{CE(1,28)} = 0.62$, $P = 0.44$; $F_{AE(1,28)} = 0.23$, $P = 0.64$; $F_{VE(1,28)} = 0.58$, $P = 0.45$) nor SR main effects ($F_{CE(1,28)} = 0.94$, $P = 0.34$; $F_{AE(1,28)} = 0.02$, $P = 0.88$; $F_{VE(1,28)} = 0.02$, $P = 0.89$). For FS we found no significant group-SR interactions ($F_{CE(1,28)} = 1.6$, $P = 0.22$; $F_{AE(1,28)} = 0.44$, $P = 0.52$; $F_{VE(1,28)} = 0.06$, $P = 0.81$) nor a main effect for FS CE ($F_{CE(1,28)} = 0.43$, $P = 0.52$). There was an SR main effect for FS AE ($F_{(1,28)} = 4.4$, $P = 0.045$, SR_{off}= $1.0 \pm .64$ N, SR_{on}= $0.77 \pm .47$ N) and FS VE ($F_{(1,28)} = 5.4$, $P = 0.028$, SR_{off}= $1.1 \pm .62$ N, SR_{on}= $0.85 \pm .64$ N). There were no main effects for group for either JRS ($F_{CE(1,28)} = 0.37$, $P = 0.55$; $F_{AE(1,28)} = 0.03$, $P = 0.86$; $F_{VE(1,28)} = 0.69$, $P = 0.41$) or FS ($F_{CE(1,28)} = 0.03$, $P = 0.86$; $F_{AE(1,28)} = 1.5$, $P = 0.23$; $F_{VE(1,28)} = 1.3$, $P = 0.26$). **Conclusions:** SR reduced the overall magnitude (i.e. AE) and variability (i.e. VE) of force sense errors but had no effect on the directionality (i.e. CE) of the errors. SR had no effect on JRS errors. Finally, no differences in JRS or FS were found between the FAI and uninjured groups.

Lateral Ankle Ligament Anesthesia Impairs Single Limb Postural Control

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Context: Lateral ankle anesthesia has been used as a model to explore the effects of ligament deafferentation related to ankle sprain on single-limb postural control with conflicting results. Time-to-boundary (TTB) is a postural control measurement technique that has detected subtle deficits in postural control in those with chronic ankle instability. **Objective:** To determine the effects of lateral ankle ligament anesthesia on TTB measures of single limb postural control in healthy adults. **Design:** Crossover design. **Setting:** Research laboratory. **Participants:** Twenty-two healthy adults (13 males, 9 females, age: 28 ± 6.6 yrs, mass: 83.62 ± 17.54 kg, height: 172.25 ± 8.35 cm) with no history of lower extremity injury within the past six months and no history of lower extremity surgery or balance disorders participated in the study. **Interventions:** On two separate days, subjects performed three, ten-second trials of barefoot single-limb stance on a forceplate

with eyes open and eyes closed. On one day, a board certified physician injected 10 ml of lidocaine to infiltrate the lateral ankle soft tissue structures from 3 o'clock to 9 o'clock surrounding the inferior tip of the fibula on the test limb of each subject prior to testing. On the control day, subjects did not receive an injection. The order of the testing day was counterbalanced. TTB measures were calculated from the forceplate center of pressure position and velocity data in the mediolateral (ML) and anteroposterior (AP) directions. The mean of each measure for the three trials was used for analysis. **Main Outcome Measures:** The dependent variables were the mean of TTB minima(s) and standard deviation of TTB minima(s) in (ML) and (AP) directions. Separate condition (anesthesia, control) by vision (eyes open, eyes closed) ANOVAs with repeated measures were used for each TTB variable to determine the effects of lateral ankle anesthesia on postural control. Alpha level was set a priori at $p < 0.05$. **Results:** There were no significant condition by vision interactions for any of the TTB measures, $p > 0.05$. There was a condition main effect for the mean of TTBAP minima (Anesthesia: 3.83 ± 1.10 , Control: 4.33 ± 1.30 s, $p = 0.008$) and the standard deviation of TTBAP minima (Anesthesia: 2.48 ± 0.74 , Control: 2.78 ± 0.95 , $p = 0.04$). The anesthesia day TTBAP measures were significantly lower than the control day, regardless of vision. There were no condition main effects found for TTBML measures. There were also vision main effects for all TTB measures ($p < 0.01$). All subjects had significantly lower TTB measures with their eyes closed compared to eyes open regardless of condition. **Conclusions:** A transient deafferentation of the lateral ankle ligamentous structures significantly reduced the magnitude and variability of TTB measures in the AP direction with eyes open and eyes closed. These findings are similar to deficits found in those with chronic ankle instability. Potentially, these postural control alterations represented a reorganization of the sensorimotor system due to the increased constraint of ligament deafferentation.

Bilateral Postural Control Deficits Are Present In Those With Unilateral Chronic Ankle Instability

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Context: Currently, there is a controversy over whether bilateral deficits in postural control exist in those with unilateral chronic ankle instability (CAI). Time-to-boundary (TTB) is a measurement technique that has been shown to be effective in detecting postural control deficits associated with CAI. **Objective:** To examine

postural control using TTB measures in males and females with and without unilateral CAI. **Design:** Case control. **Setting:** Laboratory. **Patients or Other Participants:** Five males and 12 females with self-reported unilateral CAI (age: 20.9 ± 3.9 years, height: 169.8 ± 7.3 cm, mass: 68.1 ± 11.8 kg, 6.0 ± 5.4 previous ankle sprains, FADI: $89.6 \pm 8.2\%$, FADI Sport: $70.8 \pm 14.3\%$) participated. Five males and 12 females (age: 22.3 ± 4.0 years, height: 166.0 ± 12.4 cm, mass: 67.0 ± 10.1 kg) with no history of lower extremity injury were gender and side matched to the CAI subjects for comparisons. **Intervention(s):** All subjects performed three, ten-second trials of barefoot single-limb stance on a forceplate with eyes closed on both limbs. The mean of each measure for the three trials was analyzed. The independent variables were group (CAI, control) and side (involved, uninvolved). **Main Outcome Measures:** The mean of TTB minima, the standard deviation of TTB minima, and the TTB absolute minimum in the mediolateral (ML) and anteroposterior (AP) directions were the dependent variables. Separate group by side ANOVAs were calculated for each measure. Post hoc Tukey HSD tests were utilized for any significant interactions. Alpha was set a priori at $p < 0.05$. **Results:** No significant group by side interactions were found for any of the TTB measures ($p > 0.05$), but there were significant group main effects for five of the six TTB measures ($p < 0.05$). Significantly lower TTB values were found in the CAI group for the mean of TTB minima in the ML (CAI: $1.68 \pm .50$ s, Control: $2.23 \pm .66$ s, $p = 0.005$) and AP (CAI: 4.44 ± 1.12 s, Control: 5.73 ± 1.60 s, $p = 0.004$) directions, the standard deviation of TTB minima in the AP direction (CAI: 2.93 ± 0.98 s, Control: 3.68 ± 1.19 s, $p = 0.02$), and the absolute TTB minimum in the ML (CAI: 0.44 ± 0.09 s, Control: 0.57 ± 1.00 s, $p < 0.001$) and AP (CAI: 1.24 ± 0.33 s, Control: 1.78 ± 0.50 s, $p < 0.001$) directions. The standard deviation of TTB minima in the ML direction was not significantly different between groups ($p = 0.08$). Only one main effect for side was found for the standard deviation of TTBAP minima. The unaffected side (3.52 ± 1.19 s) was significantly higher than the affected side (3.08 ± 1.07 s, $p = 0.03$) when data from both groups were pooled. **Conclusions:** TTB deficits were present on both limbs in those with unilateral CAI compared to healthy controls. Those with unilateral CAI had significantly less time to make postural corrections and utilized less strategies, based on the reduced standard deviation of TTB minima, on both limbs compared to healthy controls. These results suggest that unilateral CAI may act as a constraint on the organization of the sensorimotor system, resulting in central deficits in postural control.

The Effect Of Plyometric Training On Peroneal Latency

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Context: Previous studies have found that the reaction time of the peroneal muscles is not fast enough to control and overcome the inversion moment placed on the ankle during an inversion ankle sprain. Training protocols may assist in decreasing muscle activation reaction time, and therefore help reduce the risk of ankle injuries.

Objective: To determine the effect of a 6-week plyometric training program on reaction time of the peroneus longus muscle. **Design:** A repeated measures design. **Setting:** Controlled University Research Laboratory. **Participants:** Forty-eight healthy college students (age = 20.0 ± 1.2 years, height = 176.1 ± 16.9 cm, weight = 74.5 ± 27.9 kg) from a large midwestern university volunteered to participate in this study. All subjects were physically active, participating in exercise for at least 3 days a week for 30 minutes. Subjects were excluded if they had a history of an ankle sprain in the past 12 months, or a history of ankle surgery or fracture. Each subject was randomly assigned to either the training group or the no training control group. **Interventions:** The independent variables were plyometric training group at 2 levels (training and no training) and time at 2 levels (pretest and posttest). The dependent variable was peroneal latency, which was measured by using the BIOPAC systems MP150 with telemetry system (BIOPAC Systems Inc, Goleta, CA). Surface electromyography (EMG) data were collected through a remote amplifier at a sampling rate of 1250 Hz. EMG data were filtered through a band-pass filter of 10-350 Hz. A custom-made trapdoor device capable of inverting the ankle to 30 degrees was also used. Latency data were obtained from the time the trap door dropped until the peroneus longus muscle activated. Peroneal latency measurements occurred before and after the 6-week period. The no training group was instructed to maintain current activity level for a six-week period. The training group performed a six-week plyometric protocol 3 times weekly. Data were examined with a RMANOVA with one within subject factor (time at 2 levels) and one between subjects factor (group at 2 levels). A priori alpha level was set at $P \leq 0.05$. **Main Outcome Measures:** Pretest and posttest latency measurements (msec) were recorded for the peroneus longus muscle. **Results:** We found no significant group by time interaction ($F_{1,46} = .03$, $P = .87$). Additionally, we found no difference between the pretest and posttest values (pretest = 61.76 ± 14.81 msec, posttest = 59.24 ± 12.28 msec, $P = .18$), and no difference between the training

and no training groups (Training group=59.10 ± 12.18msec, No Training Group=61.79 ± 15.18msec, $P=.43$) **Conclusions:** Although latency measurements were consistent with previous literature, 6 weeks of training did not cause significant reflex adaptations in the peroneus longus muscle.

The Prevalence Of Knee Injury And Subjective Ankle Instability In Youth Soccer Players

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Introduction: Previous research indicates that lower extremity injury may lead to an early onset of osteoarthritis. However, there is limited information about injury prevalence in young athletes and how age and sex may influence these values. **Objective:** To determine the prevalence of reporting a history of knee injury and subjective ankle instability in youth athletes and compare the odds of these injuries between sexes and age groups. **Design:** Cross-sectional **Setting:** Research laboratory **Participants:** A convenience sample of 308 youth soccer athletes (Females: $n=148$, Age=13±2; Males: $n=160$, Age=13±2) volunteered to participate. **Intervention:** Participants and their legal guardian completed a demographic and injury history questionnaire in a private setting. Sex and age group served as the two main comparison variables. Two age groups were created according to the participants age at the time of questionnaire completion. The pre-high school group consisted of participants between 10-13 years old and the high school group included participants between 14-17 years old. **Main Outcome Measures:** Two injury categories were created: knee injury and subjective ankle instability. A participant was considered to have a history of a knee injury if he or she responded positively to any of the following injuries: knee ligament injury, severe knee pain in the past six months that lasted for more than a day, meniscal or cartilage injury, patellofemoral pain syndrome, or patella fracture. A history of subjective ankle instability was defined as a positive response to feeling that the participant's ankles did not support them or gave way in the past six months. Odds ratios were calculated and separate chi-square analyses were performed to evaluate significant associations between sex, age group, and the prevalence of a history of knee injury or subjective ankle instability ($\alpha \leq 0.05$). **Results:** The overall prevalence of a previous knee injury was 16.5%. High school aged athletes (prevalence=22.9%) had a higher odd of reporting a previous knee injury ($\chi^2=5.73$, $P=0.02$, OR=2.08, 95%CI=1.13-3.81) than pre-high school aged athletes (prevalence=12.5%). There was a weak and non-significant association

between sex (Males: 7.1%; Females: 9.4%) and a history of knee injury ($\chi^2=1.97$, $P=0.16$, OR=1.54, 95%CI=0.84-2.82). The overall prevalence of subjective ankle instability was 9.2%. High school athletes (prevalence=13.9%) had a higher odds of reporting subjective ankle instability than pre-high school athletes (prevalence=6.3%) ($\chi^2=5.03$, $P=0.02$, OR=2.41, 95%CI=1.10-5.30). Females (prevalence=13.8%) had a higher odds of reporting ankle instability than males (prevalence=5.0%) ($\chi^2=7.05$, $P=0.01$, OR=3.04, 95%CI=1.29-7.14). **Conclusions:** There is a high prevalence of knee injury and subjective ankle instability in youth soccer athletes. These numbers indicate that increased age is associated with more injuries. Given the relationship between lower extremity joint injury and early onset of osteoarthritis, these results suggest a strong need for injury prevention in youth athletes prior to high school. (Funded by the National Academy of Sports Medicine)

Prophylactic Ankle Brace Deterioration: An Analysis Of Range Of Motion

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Context: Ankle bracing is an important component in the prevention of lateral ankle injuries. Previous studies have examined the quality of prophylactic ankle taping and its deterioration over time; however, minimal focus has been placed on the effect of repeated use of prophylactic ankle bracing. **Objective:** To determine the time required for the ankle brace to deteriorate over the course of a high school basketball season. **Design:** A single group repeated measures design. **Setting:** This study was performed in the gymnasium of an area high school. **Participants:** Sixteen (10 females, 6 males) healthy high school students (16.25 ± 1.18 years, 68.03 ± 4.46 cm, 70.63 ± 9.59 kg) from a Midwestern high school volunteered to participate in this study. Subjects were students participating on a girls or boys Indiana High School Athletic Association (IHSAA) sanctioned basketball team. Subjects were excluded if they had a history of an ankle sprain in six months prior to testing or any previous lower extremity fracture or surgery. **Interventions:** The independent variable was time at 5 levels: baseline, week 2, week 4, week 6, and week 8. Subjects were instructed to wear the Active Ankle® AS1 Ankle Brace (Cramer Products, Inc., Gardner, KS) on both ankles during all practices and games. Ankle range of motion testing was measured using a custom built electronic goniometer. Two separate within-subjects Repeated Measures Analysis of Variance were calculated, one for each dependent variable. Dunnet's post hoc test was conducted on any

significant findings. **Main Outcome Measures:** Ankle range of motion was measured on 5 separate occasions. The dependent variables were inversion to eversion range of motion(°) and plantarflexion to dorsiflexion range of motion(°). **Results:** A significant difference was found in plantarflexion to dorsiflexion range of motion ($F_{4,124} = 5.71$, $p = .01$). Post hoc analysis revealed a significant decrease in plantarflexion to dorsiflexion range of motion between baseline ($69.34^\circ \pm 8.71^\circ$) and week 8 ($63.98^\circ \pm 11.77^\circ$). A significant difference was also identified in inversion to eversion range of motion ($F_{4,124} = 2.69$, $p = .03$). Post hoc analysis revealed a significant increase in inversion to eversion range of motion between baseline ($32.00^\circ \pm 10.84^\circ$) and week 4 ($37.33^\circ \pm 12.15^\circ$) and between baseline ($32.0^\circ \pm 10.84^\circ$) and week 8 ($36.01^\circ \pm 11.78^\circ$). **Conclusions:** Our findings revealed an increase in inversion to eversion range of motion and a decrease in plantarflexion to dorsiflexion range of motion over the testing period. The findings suggest that the brace lost some of its restrictive properties in the inversion to eversion direction. However, the athlete could apply the brace tighter and consequently compensate for loosening of the brace. This tightening of the ankle braces restricted plantarflexion to dorsiflexion motion of the ankle but inversion to eversion motion still increased.

Sagittal Plane Ankle Position Influences Frontal Plane Joint Stiffness In Stable And Unstable Ankles

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Context: The geometry of the talo-crural joint has led clinicians to believe that the ankle is more unstable in plantar flexion than in dorsiflexion. Up to this point, no research has been done to provide empirical evidence to back up that assertion. **Objective:** To measure frontal plane stability (stiffness) in both dorsiflexion and plantar flexion on stable and unstable ankles. **Design:** A mixed model, repeated measures design. **Setting:** The study was performed in a controlled laboratory setting. **Participants:** Forty-four college students with both stable ($n = 33$, 20.82 ± 2.30 yrs, 64.58 ± 10.62 kg, 166.10 ± 6.11 cm) and unstable ($n = 11$, 21.45 ± 1.63 yrs, 80.38 ± 12.84 kg, 181.96 ± 10.24 cm) ankles. **Interventions:** Frontal plane joint stiffness was measured in 15° of dorsiflexion (DF) and 36° of plantar flexion (PF) in stable and unstable ankles. All data were collected on a custom built swaying cradle device. Previous research has shown the device to be both a valid and reliable measure of joint stiffness. The average of five trials in each condition was used for analysis. **Main Outcome Measures:** All frontal plane stiffness data were

measured in Nm/rad and were normalized to body mass (kg) to allow for between subject comparisons. A mixed-model, repeated measures ANOVA was used to compare normalized frontal plane stiffness values across stability groups and sagittal plane joint angles. **Results:** Normalized stiffness values were significantly different between angles ($DF = 0.67 \pm 0.19 \text{ Nm/rad} \cdot \text{kg}^{-1}$; $PF = 0.60 \pm 0.17 \text{ Nm/rad} \cdot \text{kg}^{-1}$; $P = 0.002$). Stability groups were not significantly different (Stable = $0.66 \pm 0.18 \text{ Nm/rad} \cdot \text{kg}^{-1}$, 95%CI = 0.60, 0.72; Unstable = $0.57 \pm 0.15 \text{ Nm/rad} \cdot \text{kg}^{-1}$, 95%CI = 0.47, 0.67; $P = 0.149$). The stability x angle interaction was not significantly different (Stable-DF = $0.68 \pm 0.21 \text{ Nm/rad} \cdot \text{kg}^{-1}$, 95%CI = 0.62, 0.75; Stable-PF = $0.63 \pm 0.17 \text{ Nm/rad} \cdot \text{kg}^{-1}$, 95%CI = 0.58, 0.69; Unstable-DF = $0.63 \pm 0.14 \text{ Nm/rad} \cdot \text{kg}^{-1}$, 95%CI = 0.51, 0.75; Unstable-PF = $0.52 \pm 0.17 \text{ Nm/rad} \cdot \text{kg}^{-1}$, 95%CI = 0.41, 0.62; $P = 0.180$). **Conclusions:** The results of this study confirm the assertion that the ankle is more unstable in plantar flexion than in dorsiflexion. However, the more important findings are the differences between stability groups. While statistical significance was not achieved, the separation of the confidence intervals would suggest differences are present, but our power was too low to elucidate them. The interaction data in particular suggest that while differences do exist between stability groups, they are manifested primarily in the plantar flexed position. Future research comparing ankle stability groups should utilize a task that puts the subjects in a more unstable, plantar flexed position allowing for the greatest possible group differences.

Relative Phase Analysis Of Lower Extremity Kinematics Among Subjects With Chronic Ankle Instability

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Context: Chronic ankle instability (CAI) is associated with altered lower extremity kinematics and deficits in dynamic postural control in tasks such as the star excursion balance test (SEBT). Relative phase analysis (RP), using segment displacement and velocity, can be used to describe the coordination strategies between segments; but has had limited application to understanding CAI deficits. **Objective:** The purpose of this study was to analyze coordination of the limb segments of the lower extremity using RP during dynamic postural control assessment with the SEBT in subjects with and without CAI. **Design:** A one-between (Group), one-within (Side) repeated measures design. **Setting:** Athletic Training Research Laboratory. **Patients or Other Participants:** Fourteen subjects with unilateral CAI (5 male, 9 female; age 19.6 ± 1.45 years; height: 174.72cm; mass: 70.79 kg) and fourteen healthy subjects (5

male, 9 female; age 21.2 ± 3.1 years; height 173.08cm; mass: 70.95kg) volunteered for this study. **Interventions:** Subjects had their leg lengths measured and electromagnetic sensors placed on their first stance leg at the dorsum of the foot, lateral shank, lateral thigh, and the sacrum. Reaching distance was recorded and the kinematic data was sampled at 100hz using MotionMonitor software during five successful trials of the posteriomedial direction of the SEBT. The procedure was then repeated on the other limb, with the order of limbs being counterbalanced. The mean of the reaching distances, normalized to stance limb leg length (MAXD), were used. A cubic spline equation was applied to the kinematic data so that trials of different lengths could be compared to one another. Using Microsoft Excel, mean absolute RP (MARP) was calculated for the Ankle-Knee (AKMARP), Knee-Hip (KHMARP), and Ankle-Hip (AHMARP) segments. For the MARP comparisons, the SEBT task was divided into 4 equal quarters to examine specific portions of the task. **Main Outcome Measure(s):** MAXD, AKMARP, KHMARP, AHMARP. **Results:** There was a statistically significant Group by Side interaction ($F_{1,26} = 4.702$; $p = 0.039$) for the normalized reaching distance. Post-hoc analysis revealed that the Injured side of the CAI group ($82.2 \pm 8.29\%$) produced significantly less reaching distance than the Non-injured side ($85.6 \pm 7.89\%$). For the Ankle-Knee relationship during the first quarter of the SEBT task, there was a nearly statistically significant Group-by-Side Interaction ($F_{1,26} = 3.88$; $p = 0.059$). When comparing the first quarter AKMARP of the Injured Side of the CAI group ($49.23 \pm 14.90\%$) to the Non-injured Side ($32.44 \pm 18.75\%$), a large effect size was observed ($d = 1.00$). There were no significant influences of Group or Side on the AHMARP or the KHMARP relationships. **Conclusions:** Deficits in dynamic postural control in CAI subjects were observed. While not statistically significant, a large effect size suggests that an ankle-knee coordination during the task existed in the CAI group. Further research should examine intralimb coordination patterns during dynamic tasks as a source for developing more efficient interventions for CAI. *Funded by a Master's Research Program Grant from the NATA Research and Education Foundation.*

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