
JOURNAL OF ATHLETIC TRAINING

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Dear Colleagues:

On behalf of the National Athletic Trainers' Association Research & Education Foundation and the Free Communications Committee, I would like to thank all of the authors who submitted abstracts to the Free Communications Program. We received over 375 peer-reviewed submissions this year. This year's Program is exciting as it contains a fantastic mix of high caliber research reports and clinical case studies delivered live. We appreciate the presenters' time and commitment to offering amazing content to attendees.

I would also like to take this opportunity to extend a special thanks to all of the NATA and NATA Foundation staff and especially Velma Meza, who works tirelessly behind the scenes and whose attention to detail and dedication makes the Free Communications Program possible. Additionally, many individuals have worked very hard to review submissions, schedule presentations and produce this *Supplement* to the *Journal of Athletic Training*. Therefore, I would like to thank and recognize the efforts of the Free Communications Committee for their long hours of abstract reviews and creativity in developing this year's Free Communications program. The Free Communications committee members are:

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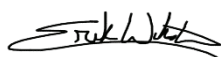
Erik Wikstrom, PhD, LAT, ATC
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I also acknowledge the unwavering support and guidance from Kenneth Cameron, PhD, MPH, ATC, and the rest of the NATA Foundation Board and staff. Lastly, I wish to thank Leslie Neistadt and the staff of the editorial office of the *Journal of Athletic Training* for making the *Supplement* possible.

As we move forward, we continually try to improve and make the review process more transparent. Our goal is to be as inclusive as possible while maintaining the high level of scholarship that readers expect of the *Journal of Athletic Training*. To further improve the process, we appreciate the feedback from authors and suggestions are always welcomed and discussed in committee meetings.

Our Committee looks forward to seeing you in Indianapolis. Please take the opportunity to view the posters and attend the Free Communications Rapid Fire Oral presentations. Please note that projects funded by the NATA Research & Education Foundation are specified in this *Supplement*. Finally, please offer your thanks to those recognized above if you have the opportunity.

Sincerely,



Erik Wikstrom, PhD, ATC, FNATA, FACSM

Chair, NATA Research & Education Foundation, Free Communications Committee

JOURNAL OF ATHLETIC TRAINING

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Medal for Distinguished Athletic Training Research

**Tamara C. Valovich McLeod, PhD, ATC
A.T. Still University**

Dr. Tamara Valovich McLeod was first introduced to the world of sports medicine in high school, when her guidance counselor suggested the field. She had always been around health care, as her mother was an ICU nurse for 30+ years. She applied to Mercyhurst College because it was a “really good program” and close to home. After earning her degree in sports medicine, she completed her master’s degree in kinesiology at the University of Colorado and then pursued a fellowship at the HealthSouth/New Hampshire Musculoskeletal Institute, where she met Julie Bernier, PhD, ATC. Dr. Bernier told Valovich McLeod that she had a “knack for research” and persuaded her to pursue her doctorate at the University of Virginia with David Perrin, PhD, ATC. She worked clinically as the head athletic trainer at Blue Ridge School during her time at Virginia and then decided to shift her attention to research. Her dissertation was on the use of the Standardized Assessment of Concussion and the Balance Error Scoring System and learning effects in youth sports participants.

At A.T. Still University, where she holds the John P. Wood, D.O., Endowed Chair for Sports Medicine, Valovich McLeod chairs the Department of Athletic Training and served as the founding director of the Athletic Training Practice-Based Research Network (AT-PBRN). The AT-PBRN was designed to bring clinicians and researchers together to improve the quality of care provided by athletic trainers through research, education, and resource sharing. The free electronic medical record provided through the AT-PBRN allows clinicians to document patient care and contribute to larger investigations of patient outcomes after sport-related injury. She wants to engage athletic trainers in “understanding that what they do with their daily facility data can contribute to the big picture” and aid in advancing the profession of athletic training. Her particular research interest is in understanding the patient perspective and improving patient outcomes after sport-related concussion.

As if these activities were not enough, Valovich McLeod has published or collaborated on more than 200 research articles and serves as a Senior Associate Editor for the *Journal of Athletic Training*.

In the future, Valovich McLeod plans to continue focusing on building the A.T. Still University Department of Athletic Training. She also intends to continue research that was thwarted by COVID, developing a concussion-specific patient-report outcomes measure to better assess how student-athletes perceive their injury and how it affects their academic life.

For those considering an academic career path in athletic training, she advises being passionate about teaching the next generation of athletic trainers. It also helps to find an environment in which everyday work is fun and talented colleagues are available for collaboration. This “makes everything so easy” and putting the best interests of the program over any individual aims enables faculty at different stages of their career to reach their goals.

Beyond her day job, Valovich McLeod loves to participate in anything outdoors, especially running and hiking. Her family lives near a trailhead, which allows them to spend plenty of quality time outside.

Valovich McLeod thanks David Perrin, PhD, AT Ret; Sandra Shultz, PhD, ATC; and Kevin Guskiewicz, PhD, ATC, for their friendship and mentorship throughout the years. She also recognizes her colleagues at A.T. Still University: Eric Sauers, PhD, ATC; Alison Snyder Valier, PhD, ATC; Kellie Bliven, PhD, ATC; Bart Anderson, DHSc, ATC; Kenneth Lam, ScD, ATC; Cailee Welch Bacon, PhD, ATC; Sue Falsone, PT, MS, SCS, ATC; and Nicolette Harris, DAT, ATC, CSCS, for their support and collaboration. In addition, she appreciates the many secondary school athletic trainers who have collected data for her research. She is grateful for her husband, Ian, and her children, Allister and Kalyn, who have provided love and encouragement over the years.



The Dr. Freddie & Mrs. Hilda Pang Fu New Investigator Award

**Neal Glaviano, PhD, ATC
University of Connecticut**

Neal Glaviano's introduction to athletic training occurred when he was a high school athlete on the swim and dive team. On sustaining a partial-thickness tear of his rotator cuff, he saw his physician and was referred for physical therapy. After the evaluation, when his physical therapist asked why he hadn't gone to his school's athletic trainer in the first place, Glaviano admitted he didn't know what an athletic trainer was, but he soon found out.

Glaviano attended the University of Connecticut for his undergraduate degree in athletic training. It was there that he started to become interested in the research side of the profession. In one of his classes, he had the opportunity to shadow and work with Douglas Casa, PhD, ATC. Glaviano was inspired by Casa's work in heat and hydration and how passionate Casa was in treating his patients.

An aspect of Glaviano's current research holds a special place in his heart because he experienced patellofemoral pain (PFP) while training for a half-marathon in college. Originally, Glaviano never would have imagined himself training for such an event, but friends talked him into it. He quickly understood how debilitating a PFP injury can be, which prompted him to read the limited literature on PFP, and he soon realized this was an area he could pursue. Glaviano hopes that his research will allow patients with PFP to have normal lives. If his work can contribute on even a small level to allow patients to remain active, play with their children, or just go on walks, he considers it all worthwhile.

Recently, Glaviano was funded by the US Department of Defense for a 4-year study in 3 cities to assess the long-term effects of PFP rehabilitation. Glaviano aims to identify better ways to evaluate and treat PFP. He is passionate about improving outcomes for service members because he has participated in the Connecticut Army National Guard for the last 21 years.

As an assistant professor at the University of Connecticut, Glaviano enjoys teaching modalities and physiology. He finds interventions and the dynamics of the human body to be fascinating, although he is not entirely sure his students always feel the same!

Glaviano credits Douglas Casa, PhD, ATC, for exposing him to research and giving him the opportunity to fall in love with it. He also recognizes his advisors at the University of Virginia: Susan Saliba, PhD, PT, ATC; Jay Hertel, PhD, ATC; Christopher Ingersoll, PhD, ATC; and Joseph Hart, PhD, ATC, for being incredible mentors and friends, and he is thankful for classmates and lab mates Grant Norte, PhD, ATC; Mark Feger, PhD, ATC; John Goetschius, PhD, ATC; L. Colby Mangum, PhD, ATC; and Ashley Marshall, PhD, ATC. Shari Norte, MS, ATC, with whom he worked clinically, also provided support and encouragement. He also appreciates Michelle Boling, PhD, ATC, for her continued research support and all of the collaborators he has had the opportunity to work with over the last few years. Glaviano thanks the faculty at the University of Connecticut, who have enabled him to be successful: Lindsay DiStefano, PhD, ATC; Michael DiStefano, MA, ATC; Stephanie Singe, PhD, ATC; and Eleni Diakogeorgiou, PhD, MBA, ATC. Finally, Glaviano recognizes his parents, Gwen and Robert Glaviano, for instilling the values of hard work, perseverance, and responsibility.



The Dr. Freddie & Mrs. Hilda Pang Fu New Investigator Award

Dr. Fu was a pioneer and authority in sports medicine and recognized as a preeminent leader in orthopaedic surgery and sports medicine across the globe. He earned his MD from the University of Pittsburgh, spending more than 3 decades as the head team physician for the University of Pittsburgh's Department of Athletics, including secondary appointments at Pitt as Professor of Mechanical and Material Sciences, Physical Therapy, and Health and Physical Activity. Dr. Fu founded the University of Pittsburgh School of Medicine's sports medicine program in 1986. In 1998, he was named the David Silver Professor and Chairman of the Department of Orthopaedic Surgery at the University of Pittsburgh Medical Center (UPMC). In 2018, the University of Pittsburgh sports complex medical building was renamed the UPMC Freddie Fu Sports Medicine Center. As a leader in sports medicine, Dr. Fu was a proponent for athletic trainers and an ardent supporter of the athletic training profession.

Dr. Fu was also a pioneer in sports medicine and ACL research. In 1996, he was the recipient of the American Academy of Orthopaedic Surgeons Kappa Delta Award. He published more articles concerning the ACL than any other author and more of the top 100 cited papers on ACL research than anyone else in the world. His published work has been collectively cited more than 60,000 times by other authors. In total, Dr. Fu published 705 peer-reviewed articles, 200 non-peer-reviewed articles, 145 book chapters, and 33 major textbooks on sports medicine. He gave 1315 national or international presentations. Dr. Fu was always passionate about supporting and recognizing excellence in sports medicine research.

Dr. Fu passed away on September 24, 2021, at the age of 70. Dr. Fu is survived by his wife of 47 years, Hilda Pang Fu; his daughter, Joyce Lok-See Fu; his son, Gordon Ka-Hong Fu; 5 grandchildren, Ludvine Ling-Yun Fu Martin, Alexander Zee-Yun Fu Martin, Axel Wei-Yun Fu Martin; Kendrick Kai Cheng Fu, and Kasen Kai Sheng Fu; his mother, Mabel Foo; 2 brothers, Frank Fu and Nigel Fu; and 2 sisters, Susan Lam and Jeanette Maeba.

Mrs. Hilda Pang Fu is a graduate of St. Stephen's Girls' School and Hong Kong University and holds a Master of Library Science degree from the University of Pittsburgh and a Master of Public Management degree from Carnegie Mellon University. She is the founder and president of Luminari, a Pittsburgh-based non-profit formed to broaden minds and inspire innovation.

Mrs. Fu has also served as Director of External Relations of Health Sciences at the University of Pittsburgh, Executive Director of Summer Programs at Point Park University, and founding Director of the Pittsburgh Regional Champions. She was the creator of the Pittsburgh Regional Brag Book and was former Chairwoman of the Board of Women and Girls Foundation of Southwestern Pennsylvania. She was also a founding board member of ToonSeum.



**The Doctoral Dissertation Award
Presented in Honor of David H. Perrin,
PhD, AT Ret, FNATA, FACSM
Sponsored by Friends of Dr. Perrin**

**Allyssa Memmini, PhD, LAT, ATC
University of New Mexico**

Allyssa Memmini knew she wanted a career in health care but wasn't sure that medical school was the answer. An introduction to athletic training course she took as a college freshman piqued her interest, and in her junior year, she fell in love with the profession and committed to the athletic training program. During her undergraduate program, she found joy applying her newfound knowledge at her clinical sites. Her favorite clinical setting was track and field; she appreciated the creativity needed to refine manual therapy and hone her rehabilitation skills to assist each patient.

Memmini's research path was set in motion when she attended a lecture on concussion during her undergraduate program, which opened the door to a summer research internship at Boston University, where she gained first-hand experience in how research is conducted. Upon completing her undergraduate degree, Memmini pursued a master's in athletic training from the University of Kentucky, where she studied under Timothy Butterfield, PhD, ATC, for her thesis project.

In college, Memmini had become interested in the concept of student identity. Growing up on the north side of Chicago, she lived in a diverse community, which she has always been very proud of. During her graduate studies, she served as a graduate assistant athletic trainer working with both domestic and international student-athletes of various identities, including race, ethnicity, and first-generation and socioeconomic status. Through these experiences, she learned how difficult it can be to adjust to campus culture, and this further shaped her awareness of how marginalized groups on campus may be treated differently based on these identities and other social determinants of health, which could greatly affect their access to health care. Eventually, this led her to focus her doctoral work on how student identity affected the return to learn after concussion, an area in which research was notably lacking.

Memmini is currently working on a new project studying individual and environmental barriers to concussion knowledge among health care providers. She is also interested in how the return-to-learn experience differs between minority-serving and majority-White institutions, barriers to students receiving academic supports after concussion, and overall, how to improve institutional policy to promote equity across campuses.

Memmini plans to unite her interests in student identity and return-to-learn strategies after concussion as she continues to develop her research agenda as a faculty member. She hopes to apply her findings to higher education by increasing cross-campus communication and collaboration to bridge gaps among students, medical providers, and their instructors. The University of New Mexico's diverse student population offers an ideal setting for exploring these topics and addressing how health care providers can better support their patients.

Outside of athletic training, Memmini enjoys hiking, cooking, working out, and visiting with family and friends across the country.

She recognizes Andrew Winterstein, PhD, ATC, who facilitated her undergraduate internship and continues to serve as a strong mentor in her life; Timothy Butterfield, PhD, ATC, for being an influential research advisor, sharing his passion and allowing Memmini to find hers; and Steven Broglio, PhD, ATC, for serving as her dissertation chair, mentor, and friend, who always valued her opinions, molded her research skills, and provided numerous opportunities to network with other concussion researchers to continue advancing her goals.

Finally, Memmini cites her husband, Kyle, for his continuous support throughout her graduate studies and as she transitioned into her new role as a faculty member, and her parents, Becky and Mike, whose dinner conversations about their days in the hospital as nurses inspired her interest in medicine. Memmini's passion for education was motivated by her mother, who was discouraged from attending college but did so anyway and subsequently supported her daughter's own educational journey.



David H. Perrin, PhD, AT Ret

David H. Perrin, PhD, FNATA, FACSM, is a respected researcher, educator, mentor and friend of athletic training. This 2003 NATA Hall of Fame inductee is a noted pioneer of terminal degrees in sports medicine, and his dedication to athletic training is making an impact on the profession's development even today.

Serving as editor-in-chief of the *Journal of Athletic Training* and founding editor of the *Journal of Sport Rehabilitation* are only two of Dr. Perrin's significant achievements. Others include being awarded NATA's Sayers "Bud" Miller Distinguished Educator Award in 1996, Most Distinguished Athletic Trainer Award in 1998, and All-University Outstanding Teaching Awards from the University of Virginia in 1997 and 1998.

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

Dr. Perrin was the dean of the College of Health from 2014 through 2022 and is a professor of physical therapy and athletic training and exercise and sport science at the University of Utah.

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, Rapid Fire Presentations: Sensing a Change: Novel and Existing Tools for Concussion Assessments

Thursday, June 22, 2023; 7:30 AM-8:25 AM; Room 231-233

Moderator: Jacob Resch, PhD, ATC

Force Attenuation Properties of New and Used Ice Hockey Helmets During Simulated Playing Surface Impacts

Bowman TG, Fonville TR, Cariappa K, Horstemeyer MF, Piland SG: University of Lynchburg, Lynchburg, VA; Liberty University, Lynchburg, VA; University of Southern Mississippi, Hattiesburg, MS

Context: Helmet use during athletic participation has been found to alter performance. Data for hockey helmets used during participation is limited. Our purpose was to determine impact attenuation properties of new and used hockey helmets. We hypothesized that all helmets would pass certification thresholds but performance would decrease in some locations and improve in others, similar to lacrosse helmets.

Methods: Following a previously reported modified NOCSAE test standard (ND030) we drop tested 3 new and 3 used (worn during 1 collegiate hockey season, including 35 games and 90 practices) Bauer ReAkt 95 adult hockey helmets (size medium). All drop tests were conducted using a standard NOCSAE twin-wire guided freefall test rig with an adult large headform and a 0.5-inch MEP test pad. Testing occurred at 4 locations (front, front boss, side, rear) at 4.5 m/s to replicate head to ice impacts, as validated previously. A drop height of 1.3 meters was necessary to achieve the desired impact velocity due to frictional losses in our system. Velocity measurements were collected using a PASCO smart timer photogate system (ME-8932). Calibration checks before and after each set of tests were conducted to ensure consistency in results. The head impact response was measured using a NOCSAE triaxial ceramic shear ICP accelerometer, 10 mV/g, 2-4

kHz, 14 mm cube size with built in filter. Each test was recorded in BioDAQ testing software, which calculated the peak linear accelerations (PLA), Gadd Severity Index (GSI) and Head Injury Criterion-15 (HIC-15) metrics. We used separate 2X4 mixed model ANOVAs for each dependent variable (PLA, GSI, and HIC-15) with helmet age (new, used; between factor) and location (front, front boss, side, rear; within factor) as the independent variables. We employed a Bonferroni technique for post hoc analyses to determine pairwise differences when interactions were significant and set $P \leq 0.05$ a priori.

Results: Means, standard deviations, and 95% confidence intervals (CI95) can be found in the Table. The interaction between helmet age and impact location was significant for PLA ($F_{1.54,20.05}=4.87$, $P=0.03$, $\eta^2=0.27$), GSI ($F_{1.38,17.94}=5.18$, $P=0.03$, $\eta^2=0.29$), and HIC-15 ($F_{1.31,17.06}=4.38$, $P=0.04$, $\eta^2=0.25$). Post hoc results revealed significantly higher HIC-15 for used helmets compared to new at the front location ($P=0.04$, mean difference=241.18, mean difference CI95=19.94, 462.42, Cohen's $d=1.22$). No other pairwise differences existed between new and used helmets across impact locations. **Conclusions:** Overall, a single season of impacts and wear history does not appear to negatively influence the impact mitigation capabilities of the examined hockey helmets. However, statistically significant variation in impact performance was observed at the front location. Improving understanding of the effect of end-use of protective helmets can help inform future designs and protective lifespan expectations. Thus, follow up studies are of strong merit.

Funded by a faculty development grant from the University of Lynchburg.

					95% Confidence Interval	
	Location	Helmet Age	Mean	Standard Deviation	Lower Bound	Upper Bound
PLA (g)	Front	New	135.66	19.98	90.10	181.22
		Used	194.04	85.11	145.34	242.75
	Front Boss	New	188.31	39.23	157.97	218.64
		Used	154.13	40.28	121.70	186.56
	Side	New	161.86	17.01	150.42	173.30
		Used	149.78	12.17	137.55	162.01
	Rear	New	123.84	25.74	109.12	138.56
		Used	113.75	5.63	98.01	129.48
GSI (AU)	Front	New	796.50	147.69	240.96	1352.05
		Used	1585.36	1058.67	991.45	2179.26
	Front Boss	New	1140.34	416.69	849.75	1430.93
		Used	824.90	333.23	514.24	1135.55
	Side	New	803.82	129.95	718.92	888.72
		Used	724.77	84.07	634.01	815.53
	Rear	New	469.92	65.67	421.99	517.85
		Used	451.77	59.16	400.54	503.01
HIC-15 (AU)	Front	New	468.89	61.68	317.75	620.02
		Used	710.07	283.54	548.50	871.64
	Front Boss	New	384.71	93.38	307.54	461.88
		Used	374.24	109.29	291.74	456.73
	Side	New	282.43	44.37	253.59	311.27
		Used	259.40	28.14	228.57	290.23
	Rear	New	225.84	29.57	199.70	251.98
		Used	233.41	38.95	205.46	261.35

The Comparison of 2 Different Environments for Baseline Concussion Test in Collegiate Student-Athletes

Lee HR, Jang SH: University of Central Arkansas, Conway, AR, and Indiana State University, Terre Haute, IN

Context: The value of neurocognitive testing in concussion management cannot be underestimated. Assessing a valid baseline of Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) is crucial in concussion management. The testing environment in both laboratory and remote settings has been suggested to influence ImPACT performance. As a result of COVID-19 restrictions limiting in-person contact, concussion baseline testing in a lab setting was prohibited and moved to an online assessment in a remote setting. However, there has been limited research on validating the administration of ImPACT in a remote setting. The purpose of this study was to compare ImPACT baseline performance between a small group in the lab and a remote setting in college student-athletes. **Methods:** A retrospective study was conducted in a laboratory setting. Five hundred-six student-athletes ($n=506$, 18.51 ± 1.15) were divided into two groups; Group A ($n=250$, age 18.50 ± 1.17) was classified as a small group (no more than four subjects concurrently) in the lab setting during the 2016-2019 academic year, and Group B ($n=256$, age 18.51 ± 1.19) was classified as the online remote group during the 2020-2022 academic year. Each individual

was matched by age, gender, sport, and history of concussion between groups. The baseline test for the small groups was conducted at a concussion lab; a total of four computers in the lab are located in each testing carrel. The online group took the baseline test in a remote setting with access to the internet. Both groups were given standardized instructions by the test administrators for each module in the ImPACT; the lab setting group had in-person instruction, and the remote group had a Zoom instruction session before taking the baseline test. MANOVA was used to analyze the difference in the five composite scores (verbal memory, visual memory, visual-motor speed, reaction time, and impulse control), selecting p-value of .05. **Results:** Table 1 presents descriptive statistics of composite scores. There are statistically significant differences between the composite scores of the two groups $F(5,500) = 3.274$, $p = .006$; Wilks' $\Lambda = .968$. Furthermore, there is a statistically significant difference between the two groups on a visual-motor composite score, $F(1,504) = 15.518$, $p < .001$; partial eta squared = .030, and on a reaction time composite score, $F(1,504) = 5.717$, $p = .017$; partial eta squared = .011. **Conclusions:** Although standardized instruction was provided for both groups prior to ImPACT, administering baseline neuropsychological tests in a remote setting may negatively affect ImPACT performance. Clinicians should make every effort to obtain valid and accurate baseline test scores by assessing in a lab setting due to underestimated baseline performance in a remote setting.

Table 1. ImPACT composite scores

Composite score	Group	Observation	Mean (Std. Dev.)
Memory Composite Score – Verbal	Laboratory	250	88.19 (± 9.96)
	Online	256	87.49 (± 10.56)
Memory Composite Score - Visual	Laboratory	250	77.20 (± 12.04)
	Online	256	75.72 (± 13.38)
Visual-Motor Composite Score	Laboratory	250	40.22 (± 5.97)
	Online	256	38.14 (± 5.89)
Reaction Time Composite Score	Laboratory	250	.62 ($\pm .10$)
	Online	256	.65 ($\pm .10$)
Impulse Control Composite Score	Laboratory	250	4.70 (± 3.70)
	Online	256	4.85 (± 3.82)

The Effects of 1 National Collegiate Athletic Association Division I Football Season on Salivary MicroRNA

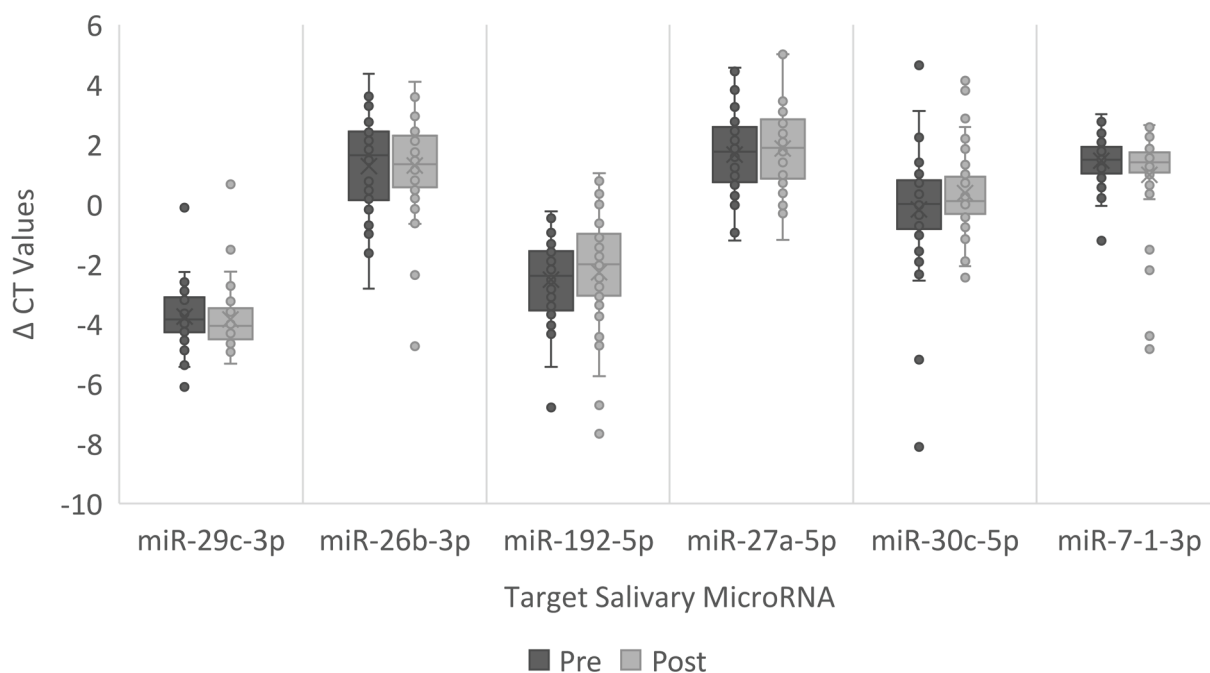
Campbell TR, Zamponi M, Mollica PA, Martinez JC, Hicks SD, Cavallario JM: Old Dominion University, Norfolk, VA, and Penn State Health, Milton S. Hershey Medical Center, Hershey, PA

Context: Despite over two thousand concussions occurring annually, clinicians still experience challenges with concussion care due to the limitations of available management tools and a reliance on subjective input from patients. Recent research has aimed to identify potential biomarkers of concussions, including salivary microRNA. Although promising microRNA targets have been identified, there are still significant limitations that prevent the implementation of microRNA target analysis as a diagnostic tool for concussions. One such limitation includes the potential cumulative effects of one season of contact sport on microRNA targets' expression levels. Understanding the cumulative effects of a contact season may aid clinicians' abilities to interpret microRNA expression following a concussion as compared to expression changes due to natural variations over time. This study aimed to address effects of one NCAA Division I football season on previously identified

salivary microRNA targets which show potential for concussion biomarkers. **Methods:** This prospective, longitudinal study included a convenience sample of 50 active participants (21±1.6 years; 187.5±6.9 cm; 103.1±19.8 kg) on a NCAA Division I Football team. The independent variable for this study was time (NCAA Division I football season). All participants reported for baseline saliva collection prior to the first contact practice of the season. Samples were collected using the ORE-100 ORAcollect-RNA saliva collection kit (DNA Genotek; Ottawa, Canada). Within 72 hours of the final game of the season, a second salivary sample was collected. All samples were stored at -80°C until processed. RNA was isolated and extracted from each sample then quantitative polymerase chain reaction (qPCR) experiments were conducted using the following microRNA targets: miR-29c-3p, miR-26b-3p, miR-192-5p, miR-27a-5p, miR-30c-5p, and miR-7-1-3p. Non-parametric tests (Wilcoxon signed-rank test) were used to compare expression levels of each miRNA target from pre- to post-season collection ($\alpha<0.05$) using SPSS. **Results:** Pre- and post-season salivary miRNA expression levels were compared for all participants (N=50). No significant differences were found between pre- and post-season levels of miR-29c-3p ($P=.34$), miR-26b-3p ($P=.46$), miR-192-5p ($P=.07$), miR-27a-5p ($P=.28$), miR-30c-5p ($P=.30$), and

miR-7-1-3p ($P=.31$). The effect sizes were small for all miRNA targets. (Figure 1) **Conclusions:** The lack of significant findings from this study serve to reinforce previous links between salivary microRNA and concussions. Salivary microRNA remained statistically stable after the season, indicating that time over one NCAA Division I football season has no effect on salivary microRNA expressions. This should reinforce that microRNA expression changes following a concussion are not simply due to natural variations over time. With no change after the course of one season, changes seen in microRNA demonstrated at time of concussion, can be more accurately attributed to the injury. Research should continue to address the potential of salivary microRNAs as concussion biomarkers in hopes to identify an accurate, objective concussion management tool for clinicians.

Figure 1. Comparison of target salivary microRNA expressions over one NCAA division I football season.



Can Brain Functional Network Organization Help Us Understand Associations Between Repetitive Head Impact Exposure and Clinical Measures of Brain Health in Former Collegiate Football Players?

Walton SR, Yin W, Brett BL, Powell JR, Kerr ZY, McCrea MA, Guskiewicz KM, Giovanello KS: University of North Carolina at Chapel Hill, Chapel Hill, NC; Virginia Commonwealth University, Richmond, VA; Medical College of Wisconsin, Milwaukee, WI

Context: Associations between repetitive head impact exposure (RHIE) and worse long-term brain health have been reported in collision-sport athletes, but little is known about the mechanisms underlying these associations. In a sample of former collegiate football players in early midlife, we hypothesized that measures of functional brain network organization would be significantly associated with both RHIE history and clinical outcomes, potentially identifying a measurable biological link between brain trauma and long-term brain health. **Methods:** Forty-eight former collegiate football players (aged 36-41 years; 79.2% white / Caucasian; total years played=12.0±3.2; years since playing=15.3±1.8) participated in this cross-sectional study. Football-related RHIE was estimated with the Head Impact Exposure Estimate (HIEE), a structured interview accounting for playing characteristics (e.g., position, level of play) across their career from high school onward. Participants self-reported depression, anxiety, and somatic symptoms (Brief Symptom Inventory-18 [BSI-18]) alongside cognitive symptoms (Neuro-QoL Cognitive Functioning Short-form). Participants also completed neurocognitive testing, including the Hopkins Verbal

Learning Test-Revised (HVLTR), Verbal Fluency (FAS), Symbol-Digit Modalities Test (SDMT), and the Trail-Making Test Forms A & B (TMTA & TMTB). Resting-state functional MRI was acquired and 2 whole-brain graph measures of functional network organization were investigated using a 300 region-of-interest atlas: Small-Worldness (SW), which measures communication efficiency among functional regions; and Assortativity Coefficient (AC), which measures functional resilience (i.e., ability to withstand disruption to individual functional regions). To test our hypotheses, we first fit multivariable linear regression models to measure the association of HIEE with SW and AC outcomes independently while accounting for lifetime concussion history and age. Next, we fit separate multivariable linear regression models to measure associations of SW and AC with self-reported symptom T-Scores and neurocognitive test raw scores while accounting for age. Standardized effects (β) were calculated for predictors in each model. All models were fit with a priori $\alpha=0.05$. **Results:** Greater HIEE values were associated with lower SW ($\beta=-0.396$; $p=0.004$), but were not significantly associated with AC ($\beta=-0.071$; $p=0.640$). There were no significant associations between SW and the clinical outcomes included in this study, but AC was significantly associated with somatic symptoms (Table 1). **Conclusions:** RHIE was associated with whole-brain communication efficiency in this sample of former football players at early midlife, and this finding warrants further in-depth investigation as RHIE may be related to functional or pathological vulnerability among these players as they age. Inconsistent associations between functional network organization and clinical outcomes in this cross-sectional study suggest that either the effects of these organizational measures manifest later in life, or other underlying mechanisms link RHIE to long-term brain health in former athletes. This study

adds communication efficiency to the list of brain health measures that reflect RHIE as a potential, and modifiable, risk factor for adverse long-term outcomes.

Fellow sponsored by Kevin Guskiewicz, PhD, ATC.

This study was supported, in part, by the National Collegiate Athletic Association (NCAA), in addition to funds provided by the University of North Carolina at Chapel Hill and the Medical College of Wisconsin where the work was performed. All authors also work on a research study funded by the National Football League (NFL), though no party receives direct money from the NFL, and the NFL has no oversight over the work performed by these individuals. Dr. Walton additionally works on research projects supported by the Department of Defense and Department of Veterans Affairs. He is the Chair of Marketing and Promotions for the World Federation of Athletic Training and Therapy, and has received honoraria for conference presentations from the National Athletic Trainers' Association. Dr. Brett reports grants from the National Institute on Aging and National Institute of Neurological Disorders and Stroke, and honoraria for conference presentations. Dr. McCrea receives research funding to the Medical College of Wisconsin from the National Institutes of Health, Department of Veterans Affairs, Centers for Disease Control and Prevention, Department of Defense, National Collegiate Athletic Association, National Football League, and Abbott Laboratories. He receives book royalties from Oxford University Press. He serves as clinical consultant to Milwaukee Bucks, Milwaukee Brewers, and Green Bay Packers, and is Co-Director of the NFL Neuropsychology Consultants without compensation. He is consultant for Neurotrauma Sciences, Inc. He receives travel support and speaker honorariums for professional activities.

Table 1. Associations between whole-brain functional network organization measures and clinical outcomes. BSI-18 = Brief Symptom Inventory-18; Neuro-QoL = Quality of Life in Neurological Disorders; HVLTR = Hopkins Verbal Learning Test; FAS = Verbal Fluency forms F, A, S; SDMT = Symbol-Digit Modalities Test; TMTA = Trail-Making Test form A; TMTB = Trail-Making Test form B. * p -value < 0.05.

	Small Worldness		Assortativity Coefficient	
	β	p -value	β	p -value
BSI-18 depression symptoms	-0.143	0.356	0.256	0.087
BSI-18 anxiety symptoms	-0.068	0.673	0.092	0.548
BSI-18 somatic symptoms	0.022	0.885	0.312	0.039*
Neuro-QoL cognitive function	-0.136	0.407	-0.055	0.723
HVLTR Immediate Recall	-0.154	0.332	-0.173	0.254
HVLTR Delayed Recall	-0.172	0.282	-0.169	0.271
FAS verbal fluency	-0.018	0.910	-0.220	0.154
SDMT	0.253	0.106	0.283	0.060
TMTA time (seconds)	-0.103	0.518	-0.204	0.184
TMTB time (seconds)	-0.082	0.613	0.043	0.784

Something Old, Something New: Convergent Validity of the Sensory Organization Test Between 2 Computerized Dynamic Posturography Units

Georgi AM, Donahue CC, Rosenblum DJ, Resch JE: University of Virginia, Charlottesville, VA

Context: The Sensory Organization Test (SOT) is considered the gold standard for balance assessment before and after sport concussion (SC). The SOT was originally administered on the Natus Smart Balance Master (NSBM) which is no longer manufactured. The SOT is now administered on the Bertec Computerized Dynamic Posturography Unit (BCDP), however, the convergent validity of the SOT as administered on the NSBM and BCDP has yet to be established. Limited data exist regarding the similarities and or differences between the two units. The purpose of this study was to compare SOT outcome scores between the NSBM and BCDP in healthy collegiate athletes. **Methods:** Participants in this cross-sectional study consisted of healthy collegiate athletes (N=494) who were on average 18.9±1.29 years of age. Participants were administered the SOT as part of their baseline in alignment with the university Athletic Department's concussion management protocol. Participants were divided into two groups based on whether they were administered the SOT on the NSBM (n=247[41.3%

female]) or the BCDP (n=247[41.7% female])). Participants were matched on age, height, gender, and sport. Participants were also matched on sport position if possible. Independent t-tests were used to compare group age, height, SOT Equilibrium Score, and Somatosensory, Visual, and Vestibular ratios. Effect sizes were calculated using Cohen's d with 95% confidence intervals. A Chi-squared test was used to compare the proportion of males and females in each group. Bonferroni corrections were performed to account for multiple comparisons. All analyses were performed if alpha = 0.0125. **Results:** Participants were similar in terms of age, height, gender, and sport (all p >0.05) Statistically significant differences were observed between the NSBM and BCDP for all SOT outcome scores (Table 1). Participants scored on average 5.02 points higher on the NSBM compared to the BCDP. Similarly, participants scored on average, 4.93 and 3.03 points higher on the NSBM compared to the BCDP on the Visual and Vestibular sensory ratios, respectively. In contrast, participants in the BCDP group scored on average 1.63 points higher on the Somatosensory sensory ratio compared to participants who completed the SOT on the NSBM. **Conclusions:** Our results suggest that statistically significant differences exist for all SOT outcome scores when administered on the NSBM or the BCDP in healthy collegiate athletes. Provided these differences, caution is warranted when comparing the SOT outcome scores when collected on the NSBM and BCDP.

Outcome	NSBM	BCDP	P	d (95% CI)
Equilibrium Score	83.7 (3.15)	78.7 (4.52)	<.001	1.3 (1.10,1.49)
Somatosensory sensory ratio	96.7 (2.00)	98.3 (2.40)	<.001	-0.74 (-0.92,-0.56)
Visual sensory ratio	93.9 (3.80)	88.9 (4.96)	<.001	1.12(0.93,1.30)
Vestibular sensory ratio	78.4 (6.72)	75.3 (9.03)	<.001	0.38 (0.20,0.56)

Table 1. Mean (SD) values for each outcome score for the Natus Smart Balance Master (NSBM) and Bertec Computerized Dynamic Posturography (BCDP).

**Tandem-Gait Score Differences
Between Contact, Noncontact, and
Collision Sports in Collegiate Athletes**
Dickie SD, Donahue CC, Rosenblum
DJ, Resch JE: University of Virginia,
Charlottesville, VA

Context: The Timed Tandem Gait (TG) test is a valid measure of postural control prior to and following a diagnosed SC. Though the clinical utility of the TG test has been established in collegiate athletes with SC, it has yet to be established if differences exist between collision, contact and non-contact sports on TG test time to completion. The purpose of our study was to determine if differences exist in TG test baseline performance between collegiate athletes in collision, contact, and non-contact sports. We hypothesized that baseline TG test time to completion would be significantly longer for non-contact and contact sport participants compared to those who participate in collision sports. **Methods:** Data were collected from January 2021 to September 2022 in alignment with the university Athletic Department's concussion management protocol. A total of 541(43.3% female) division 1 collegiate athletes, who were on average 19.3 ± 1.2 years of age, were categorized as collision ($n=137[1.4\%$

female]), contact ($n=99[35.4\%$ female]), and non-contact ($n=311[64.3\%$ female]) athletes based on prior research. To complete the TG test, participants were instructed to walk heel-to-toe, down and back, on a 3-meter line without shoes. Participants completed a total of four trials with the fastest time being recorded. Group performance was compared using an analysis of variance. Effect size was calculated using squared (η^2) with 95% confidence intervals. Tukey's test was used for post hoc analysis, if warranted. All analyses were performed with $\alpha=0.05$. **Results:** A significant main effect ($F(2,546)=4.78$, $p=0.009$, $\eta^2=0.017[.001, 0.043]$) was observed between groups for TG test time to completion. More specifically, collision sport athletes (11.9 ± 2.89 seconds) completed the TG test significantly faster ($p=0.01$) than non-contact sport athletes (12.8 ± 2.94 seconds). No other between groups differences were observed. **Conclusions:** When comparing collision, contact, and non-contact athletes, participants in the collision sport group demonstrated significantly faster TG test time to completion than participants in the non-contact sport group. Our findings suggest that clinicians who use the TG test as a clinical measure in their concussion management protocol should conduct baseline assessments to account for between sport variability.

Three Latent Factors Supersede Outcomes From Concussion Baseline and Post-Injury Assessments: Findings From the Concussion Assessment, Research and Education Consortium

Lempke LB, Garcia GP, Boltz AJ, Syrydiuk R, McAllister TW, McCrea MA, Pasquina PF, Broglio SP: University of Michigan, Ann Arbor, MI; Georgia Institute of Technology, Atlanta, GA; Medical College of Wisconsin, Milwaukee, WI; Uniformed Services University of the Health Sciences, Bethesda, MD

Context: Baseline and post-concussion evaluations commonly involve a multidimensional battery of assessments that each theoretically provide unique insights to patient function (e.g., subjective symptoms provide different information than balance assessments). However, the uniqueness or overlap between assessments has not been thoroughly substantiated, and thus redundancy resulting in greater concussion assessment time and effort may be present. Our aim was to examine the factor structure of pre-injury baseline and <48-hour post-concussion assessment battery outcomes separately among collegiate student-athletes. **Methods:** A total of 32,471 unique pre-injury baselines and 1,553 unique <48-hour post-concussion assessments with no missing outcome data were examined from collegiate student-athletes enrolled in the Concussion Assessment, Research, and Education (CARE) Consortium. Student-athletes with seizure, balance, psychiatric, learning, autism, depression, bipolar, hearing, or uncorrected vision disorders, a history of moderate/severe traumatic brain injury, and who were non-varsity military cadets were excluded. Baseline and post-concussion assessments and associated composite outcomes consisted of: symptoms from the Sport Concussion Assessment Tool (SCAT [total symptom score, total symptom severity score]), Brief Symptom Inventory-18 (BSI-18 [global severity index score]), Standardized Assessment of Concussion (SAC [total score]), Balance Error Scoring System (BESS [total errors]), and Immediate Post-Concussion Assessment and Cognitive Test (ImPACT [verbal and visual memory, visual motor speed, reaction time]). Two separate exploratory factor models (baseline and post-concussion) were used with ProMax rotations and maximum likelihood estimation to examine the overarching latent factors. We used Kaiser-Meyer-Olkin (≥ 0.60) and Bartlett

sphericity tests ($p \leq 0.05$) with a priori thresholds to objectively determine sampling and correlation matrix adequacy for the outcomes and models. Scree plots with parallel analyses were used to objectively identify the number of factors to use. All factors required ≥ 0.30 loading to be included, and cross-loading (i.e., ≥ 0.30 loading in ≥ 2 factors) or any factor having < 2 outcomes were excluded from the models. Factor analysis diagrams were generated to visually depict the observed models and titled factors.

Results: A 3-factor model with low-moderate correlation between factors ($r = 0.02$ – 0.57) for baselines independently explained 49.4% total variance: 1) symptomology, 2) cognitive-memory, 3) cognitive-motor (Figure 1a). An comparable 3-factor model with moderate-high correlation between factors ($r = 0.49$ – 0.75) for post-concussion evaluation independently explained 58.2% total variance (Figure 1b). BESS total errors and SAC total score did not load at baseline, and BESS total errors did not load at post-concussion. **Conclusions:** The common 3 factors of symptomology, cognitive-memory, and cognitive-motor were present at baseline and post-concussion, indicating relatively consistent factor makeup regardless of concussion presence or absence. Overlap in assessment composite outcomes indicates potential redundancy in measuring the latent factors, and thus reducing assessment items may be possible to decrease administration time and effort for both patients and clinicians. BESS and SAC not meaningfully loading indicates they potentially represent non-essential outcomes for clinical assessment.

Fellow sponsored by Steven P. Broglio, PhD, ATC.

This study was made possible, in part, with support from the Grand Alliance Concussion Assessment, Research, and Education Consortium, funded by the National Collegiate Athletic Association and the Department of Defense. The US Army Medical Research Acquisition Activity, 820 Chandler Street, Fort Detrick, MD 21702-5014, USA is the awarding and administering acquisition office. This work was supported by the Office of the Assistant Secretary of Defense for Health Affairs through the Psychological Health and Traumatic Brain Injury Program under Award no. W81XWH-14-2-0151. Opinions, interpretations, conclusions, and recommendations are those of the authors and are not necessarily endorsed by the Department of Defense (Defense Health Program funds).

Figure 1. Baseline and <48-Hour Post-Concussion Factor Analyses

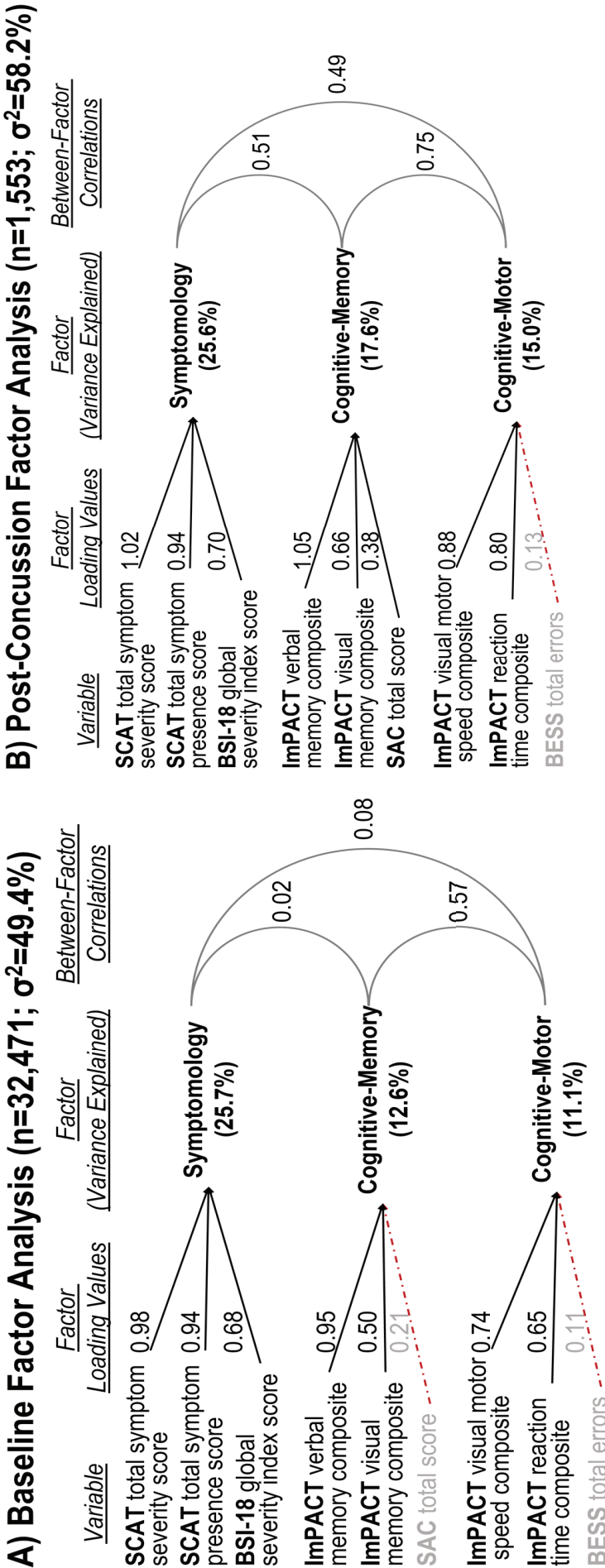


Figure 1 legend. Factor analysis diagrams for A) baseline and B) <48-hour post-concussion. Underlined and italicized headers indicate the information below them. Gray variables and factor loading values with red-dashed lines indicate what factor they most associated with but had insufficient loading, and were thus excluded and ignored.

Free Communications, Rapid Fire Presentations: Physical and Psychological Considerations of the Asymptomatic Athlete

Thursday, June 22, 2023; 11:05 AM-12:00 PM; Room Entry 233

Moderator: Joseph Whitson, MEd, LAT, ATC

Both Music and Metronome Cues Can Increase Step-Rate and Decrease Tibial Acceleration During Running

Lally EM, Ericksen HM, Earl-Boehm

JE: University of Wisconsin-Milwaukee, Milwaukee, WI

Context: Running-related injury (RRI) is often accompanied by long recovery times and high reoccurrence rates. Development of a RRI is a barrier to continuing to run so interventions for prevention and treatment of RRI are imperative. Gait retraining is an effective intervention to prevent or treat RRI, reduce loading, and improve movement deviations. Temporospacial gait retraining includes manipulating step-rate and is exclusively accomplished using a metronome. However, many runners prefer to listen to music and foreknowledge of removal of music can impact the ability to perform exercises. It is possible that step-rate modifications can be achieved with tempo of music but first the feasibility of step-rate modification using music must be established. The purpose of this study was to compare changes in step-rate and running biomechanics between music and a metronome. **Methods:** 10 individuals (age:33±7.37 years; weight:76±13.98 kg; height:1.70±.08 m; average weekly mileage:6.44±9.20 miles)

were assigned to two groups (music auditory cue (MUS) or metronome auditory cue (MET)). Participants completed a pretest treadmill running assessment wearing inertial measurement units (IMUs) while peak positive tibial acceleration (PPA) and peak stance phase hip adduction were collected. The researcher then calculated target step-rate ((preferred step-rate * 5%) + preferred step-rate= target step-rate). The WeavRun phone application allows the tempo of selected music to be adjusted and was used to deliver the auditory cueing. The MUS group self-selected music tracks that were tempo adjusted, and the MET group used an adjusted metronome track only. Auditory cues were set to the target step-rate and participants were instructed to begin running at the same speed used during pretest. The MET group was told to match foot strikes to beats of the metronome and the MUS group was told to match foot strikes to beats of the music. After five minutes, auditory cues were removed, and participants were instructed to continue running at the target step-rate while posttest data was collected in the same manner as the pretest. Step-rate, PPA and peak stance phase hip adduction from the pretest and posttest time points were analyzed using a series of 2 x 2 repeated measures analysis of variance. **Results:** Both MUS and MET groups increased step-rate (p=.001) and decreased PPA

(p=.05) from pretest to posttest. No differences were found for peak hip adduction during stance (Table). **Conclusions:** Both the music and metronome cues were effective to increase step-rate and decrease loading during running. Music is a comparable strategy to change step-rate and decrease loading during running that may provide more psychosocial benefits to runners. More research should be done to determine the long-term effectiveness of using music to increase step-rate and decrease loading.

Fellow sponsored by Jennifer E. Earl-Boehm, PhD, ATC.

To accomplish this project have collaborated with the developers of the Weav Run phone application but did not receive financial compensation for that.

Variable		Pretest	Posttest	Mean Difference
Step-rate (spm)	MUS	156.80 ± 3.99	167.40 ± .4.80	10.60 ± 2.48
	MET	153.60 ± 3.99	163.20 ± .4.80	9.60 ± 2.48
	COMBINED	155.20 ± 2.82	165.30 ± 3.40	10.10 ± 2.01**
PPA (g)	MUS	5.08 ± .56	4.41 ± .73	-.67 ± .89
	MET	4.46 ± .56	3.98 ± .73	-.47 ± .89
	COMBINED	4.77 ± .40	4.20 ± .52	-.57 ± .25*
Peak hip adduction (°)	MUS	11.61 ± 2.79	12.26 ± 1.26	-1.81 ± 2.05
	MET	11.39 ± 2.79	9.59 ± 1.26	-.64 ± 2.05
	COMBINED	11.51 ± 1.97	10.92 ± .90	-.59 ± 1.45

spm = steps per minute; MUS= music group; MET= metronome group; PPA = peak positive tibial acceleration; g = gravitational acceleration; **statistically significant at .001; *statistically significant at .05

Lower Extremity Energy Absorption Between the Penultimate and Final Steps of a 90-Degree Side-Step Cutting Maneuver

Mulligan CMS, Johnson ST, Pollard CD, Hannigan K, Norcross MF: Oregon State University, Corvallis, OR

Context: Non-contact ACL injury often occurs during rapid deceleration and cutting maneuvers that require an athlete to absorb energy to arrest their center of mass and change direction. Previous research has identified that during pre-planned cuts, athletes can decelerate their center of mass through the penultimate step, resulting in decreases to ACL-injury related biomechanics in the final step. However, it is unknown whether individuals demonstrate similar braking strategies through the penultimate step during reactive cutting maneuvers, which better align with the typical sport environment when planning time is limited. Therefore, the purpose of this study was to compare sagittal plane energy absorption during the penultimate and final steps of pre-planned and reactive side-step cuts in healthy females. **Methods:** Thirty-six females (20.9 ± 1.7 years 1.66 ± 0.07 m, 62.4 ± 8.7 kg) completed five pre-planned and five reactive 90-degree side-step cuts off of their dominant limb. Kinematics and kinetics were assessed during the penultimate and final steps using an optical motion capture system interfaced with two force plates. Photoelectric sensors were used to monitor approach velocity under each condition and trigger a light stimulus during reactive trials ~525-700ms prior to the cut that directed the impending maneuver (i.e., side-step cut, cross-over cut, straight). Sagittal plane energy absorption at the ankle, knee and hip was quantified by integrating the negative area under

the joint power curve during the initial-impact (i.e., initial contact through 100ms) and deceleration (i.e., initial contact through peak knee flexion) phases of each step. Total energy absorption was quantified by summing these values across joints. Approach velocity was compared between conditions using a dependent t-test. Separate 2x2 repeated measures ANOVAs were used to assess the potential interaction of step and condition on the magnitude of energy absorption during initial-impact and deceleration phases ($\alpha \leq 0.05$). Tukey-HSD corrections were applied to post-hoc comparisons when applicable. **Results:** Approach velocity did not differ between conditions (Pre-Planned: 3.5 ± 0.3 m/s, Reactive: 3.5 ± 0.3 m/s, $p=0.732$). We identified a significant step*condition interaction for total energy absorption during both initial-impact and deceleration phases ($p < 0.001$). Participants absorbed more energy in the penultimate step during pre-planned cutting compared to reactive cutting, but this was reversed during the final step (Figure 1). **Conclusions:** Less energy absorption in the penultimate step of reactive cutting resulted in the lower extremity absorbing significantly more energy during the final step of reactive cutting in both the initial-impact and deceleration phase. This suggests that greater initial-impact energy absorption, which has been associated with unfavorable ACL-injury related biomechanics, is influenced by planning time and the ability to arrest the center of mass during the penultimate step of reactive cutting. Therefore, identifying ways to improve deceleration during the penultimate step may facilitate more favorable cutting mechanics that reduce ACL injury risk during reactive cutting.

Funded by an NATA Research & Education Foundation Doctoral Grant.

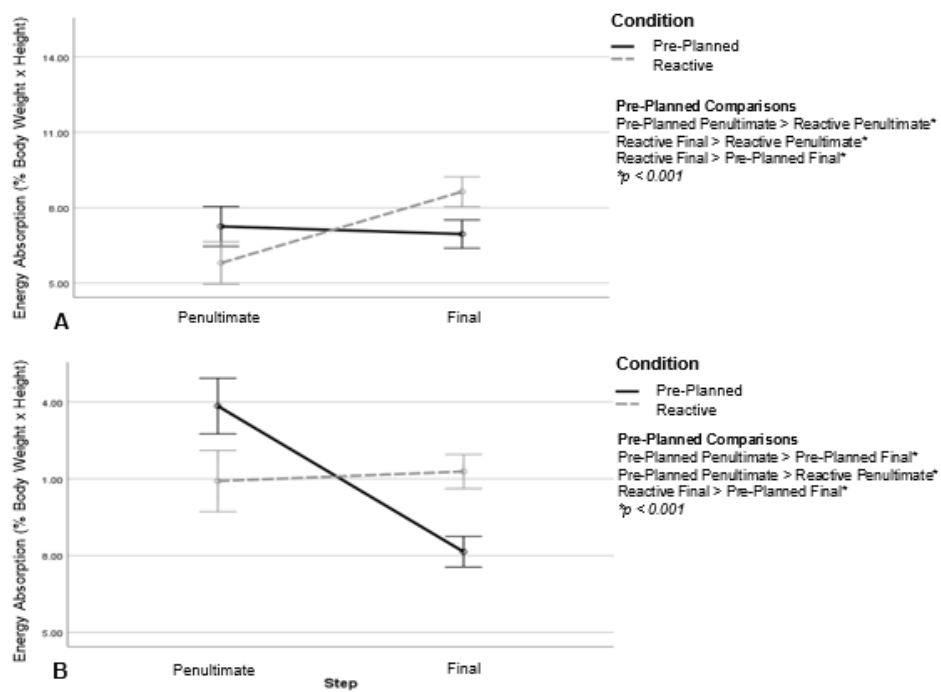


Figure 1. Comparisons of the magnitude of energy absorption during initial-impact (A) and deceleration (B) phases of a 90-degree side-step cut in healthy females.

The Influence of Sport Type on Sensory Organization Test Performance in Healthy Collegiate Athletes

Akard CM, Donahue CC, Rosenblum DJ, Resch JE: University of Virginia, Charlottesville, VA

Context: There are different physical requirements necessary to participate in either collision, contact, or non-contact sports. One of these requirements is postural stability. As deficits in postural stability are well documented following sport concussion (SC) in athletes at all levels of sport, it is important for clinicians to understand if balance differences exist between sport types to inform clinical decision making following a SC. The purpose of this study was to determine if differences in postural stability exist between collision, contact, and non-contact collegiate sport athletes using the Sensory Organization Test (SOT). We hypothesized that collegiate athletes who participated in collision and contact sports would have better balance as measured by the SOT when compared to non-contact sport athletes. **Methods:** Participants consisted of collegiate athletes (N=893[41% female]) who were on average 19.8±1.89 years of age. Athletes were divided into collision (football, wrestling, and cheerleading [n=246]), contact (soccer, volleyball, diving, basketball, field hockey, lacrosse [n=256]), and non-contact (cross country, rowing, track and field, squash, dance, baseball, softball, swimming, tennis, golf [n=391]) groups in alignment with previously accepted

classification criteria. All participants were administered the SOT on the Natus Smart Balance Master System in alignment with the university Athletic Department's concussion management protocol. A one-way analysis of variance was used to compare group SOT Equilibrium score as well as Visual and Vestibular ratios. Due to non-normally distributed data, the group SOT Somatosensory sensory ratio scores were compared using the Kruskal-Wallis test. Post-hoc analyses were performed using Tukey's test when indicated. All analyses were performed with $\alpha=0.05$. **Results:** A significant main effect was observed ($F(2, 890)=8.57, p<0.001$) for the SOT Equilibrium score between groups. More specifically, collision sport athletes had, on average, a higher SOT Equilibrium score (83.7 ± 3.11) than non-contact sport athletes ($83.1\pm3.51[p<0.001]$). Similarly, a significant main effect was observed for the Vestibular sensory ratio ($F(2, 890)=7.12, p<0.001$). On average, contact sport athletes had significantly higher Vestibular sensory ratios (79.9 ± 6.70) than the collision sport ($79.6\pm6.16 [p=0.002]$) and non-contact sport ($78.1\pm6.8[p=0.012]$) groups. No additional significant main effects were observed between groups for any SOT outcome score. **Conclusions:** Our findings suggest that baseline SOT performance differs between collision, contact, and non-contact sports. Our data support the clinical utility of the baseline assessment for the SOT. In the absence of a baseline SOT assessment, caution is warranted when interpreting outcome scores between athletes that participate in varying sport types.

	Collision	Contact	Non-Contact
Equilibrium score (Mean [SD])	83.7(3.11)	84.2(3.10)	83.1(3.51)†
Visual sensory ratio (Mean [SD])	93.1(3.95)	93.7(3.76)	93.5(3.87)
Vestibular sensory ratio (Mean [SD])	79.6(6.16)	79.9(6.70)	78.1(6.81) †‡
Somatosensory Ratio (Median [IQR])	96.5(2.49)	96.8(2.91)	96.4(2.53)

Table 1. Descriptive data for SOT performance for collision, contact, and non-contact athletes. SD = standard deviation, IQR=interquartile range. † Difference compared to collision group
‡ Difference compared to contact group

Change In Subjective and Objective Athlete Monitoring Data Over 2 Competitive Seasons

Pexa BS, Johnston CJ, Taylor JB, Ford KR, Blue MM, Barzak-Scarborough NE: High Point University, High Point, NC; University of North Carolina at Chapel Hill, Chapel Hill, NC; The Henry M. Jackson Foundation for the Advancement of Military Medicine, Bethesda, MD

Context: Athlete monitoring data could be useful to track subjective health¹ and injury risk,² but there is information lacking on how these measures change over the course of two competitive seasons within the same cohort. Therefore, the purpose of this abstract is to determine the changes in commonly used subjective measures of sleep, stress, and overuse injury and objective measures of hip strength in competitive collegiate athletes over the course of 2 competitive seasons at preseason, midseason, and postseason. **Methods:** A prospective cohort study was conducted in 44 collegiate athletes (26F, 18M, height = 175.5±8.6 cm, mass = 71.8±7.9kg). Each athlete was a member of a competitive varsity team over two consecutive

seasons and participated in preseason, midseason, and postseason testing. During testing, participants completed the Perceived Stress Scale (PSS), Pittsburgh Sleep Quality Index (PSQI), and the Oslo Sports Trauma Research Centre Overuse Injury Scale (OSTRC). Additionally, athletes completed strength assessments of the hip abductors and hip adductors, expressed as percentage of bodyweight (%BW). Linear mixed models were used to calculate the changes in outcomes between year (year 1 and 2) and event (preseason, midseason, and postseason) with ID counting as a random effect. For the strength measures, right and left limbs were also used as a predictor variable. **Results:** Model statistics are presented in Table 1. The PSQI and was significantly different between years and within a competitive season, and the PSS was significantly different within a competitive season ($p<0.05$). The PSQI increased by 1.5 survey points between postseason and preseason ($t=3.86$, $p<0.001$) and increased by 0.68 survey points between year 2 compared to year 1 ($t=2.30$, $p=0.022$). The PSS increased by 3.08 survey points at midseason (difference = 3.08, $t=4.7$, $p<0.001$) and 3.15 survey points at postseason (difference = 3.51, $t=3.98$, $p<0.001$) compared to preseason, indicating significantly increased subjective stress. Hip abduction and

adduction strength were significantly different between years and within a competitive season ($p<0.05$). Hip abductor strength increased by 1.8%BW at the postseason time point ($t=2.95$, $p=0.003$) compared to preseason and increased 1.9%BW in year 2 compared to year 1 ($t=4.29$, $p<0.001$). Hip adductor strength increased by 2.5%BW from preseason to postseason ($t=4.27$, $p=0.005$) and by 2.9%BW from year 1 to year 2 ($t=4.27$, $p<0.001$). The OSTRC did not change between years or within the competitive year. **Conclusions:** Sleep quality and stress are altered across a competitive season, indicating a need to monitor these measures in competitive fall sport athletes. Strength scores increase throughout the year and year over year. These changes can be used as benchmarks for patients, and the continued monitoring of this data would provide long-term benchmarks for ATCs who seek to track student-athlete development and injury risk.

Data supported by NATA REF New Investigator Grant #2021NIP01.

Dependent Variable	Independent Variable	F Statistic	p-value
PSQI	Event	7.623	0.001
	Year	5.307	0.023
PSS	Event	14.070	<0.001
	Year	1.107	0.294
OSTRC	Event	2.115	0.124
	Year	0.030	0.862
Abduction Strength	Event	6.761	0.001
	Year	17.970	<0.001
	Direction	1.939	0.165
Adduction Strength	Event	4.646	0.010
	Year	18.254	<0.001
	Direction	2.619	0.107

Table 1. Linear Mixed Models with dependent (outcome) and independent (predictor) variables, along with F-statistic and p-value to indicate statistical significance. PSQI-Pittsburgh Sleep Quality Index, PSS-Perceived Stress Scale, OSTRC-Overuse Injury Scale. Event: Preseason, Midseason, Postseason. Year: Year 1 and Year 2. Direction: Left and Right.

Relationships Between GPS Measured External Load, Internal Load, and Sleep Quality in Collegiate Men's Lacrosse Athletes

Jones YI, Collins SM, Siler CW, Huggins RA, Bowman TG: University of Lynchburg, Lynchburg, VA, and University of Connecticut, Department of Kinesiology, Storrs, CT

Context: Load monitoring is useful in quantifying the demands of sports and can be used to improve training sessions and prevent injury. The study aimed to determine differences in intensity, average heart rate (HR), HR efficiency, sleep time (in minutes), and sleep quality in American collegiate men's lacrosse players. We hypothesized that significant interactions between participant position and session type would be present for all dependent variables.

Methods: Fifty-three National Collegiate Athletic Association (NCAA) division III men's lacrosse athletes (age=20.62±1.40 years; mass=85.03±7.52 kg, height=181.69±6.04 cm) volunteered to participate in our cross-sectional study over the course of 16 weeks during the 2022 NCAA men's lacrosse season (55 practices and 22 games). Participant position (attack, defense, offensive midfielder, defensive midfielder, face-off, and goalie) and session type (training or competition) served as independent variables. We assessed high-speed running density (HSRd) and intensity (proprietary composite metric for overall difficulty of training session) during field sessions using Gametrak SP2 Global Positioning System (GPS) units (10 Hz data collection frequency) and heart rate via Polar H9 HR monitors (5 kHz data collection frequency) which have both been found to be valid and reliable previously. Participants

reported sleep quality before the start of each session by completing the previously validated Karolinska Sleep Diary (KSD). We ran separate 6x2 ANOVAs for each dependent variable (HSRd, GPS intensity, average HR, HR efficiency, sleep time (in minutes), and sleep quality) to determine the effects of participant position and session type with $P \leq .05$ a priori.

Results: We found significant interactions for intensity ($F_{5,2611}=13.99$, $P < .001$, $\eta^2=.03$), average HR ($F_{4,427}=5.04$, $P < .001$, $\eta^2=.05$), and HR efficiency ($F_{4,426}=2.90$, $P=.02$, $\eta^2=.03$). The interaction between participant position and session type was not significant for HSRd ($F_{5,2455}=1.76$, $P=.12$, $\eta^2 < .01$), sleep time ($F_{5,1114}=.85$, $P=.52$, $\eta^2 < .01$), and sleep quality ($F_{5,1113}=2.08$, $P=.07$, $\eta^2=.01$). However, we noted significant main effects for session type ($F_{1,1114}=45.49$, $P < .001$, $\eta^2=.04$) for sleep time as well as participant position ($F_{5,1113}=7.89$, $P < .001$, $\eta^2=.03$) and session type ($F_{1,1113}=6.97$, $P < .01$, $\eta^2=.01$) for sleep quality. The mean and standard deviation for each dependent variable are presented in Table 1. **Conclusions:** Intensity, average HR, and HR efficiency varied significantly across participant position and session type. In most, but not all, situations, intensities and average HRs were higher during competitions compared to training. Utilizing external and internal load metrics during sport participation can allow coaches, sports scientists, and athletic trainers to develop training, reconditioning, and rehabilitation plans that can adequately prepare participants for sport demands, thus decreasing the likelihood of injury or re-injury.

Fellow sponsored by Tom Bowman, PhD, ATC.

Schewel Faculty-Student Research Fund

Table 1. Descriptive statistics (means±standard deviations) for dependent variables across participant position and session type. (*P<.05, **P<.01, ***P<.001)

		HSRd	Intensity	Average HR	HR efficiency	Slep time (in minutes)	Sleep Quality
Attack	Competition	18.67 ± 4.81	31.80 ± 15.85***	138.97 ± 23.27*	1.48 ± 1.25	558.63 ± 72.46	3.74 ± .733
	Training	18.80 ± 8.45	24.20 ± 9.26***	129.25 ± 13.73*	1.47 ± 1.01	475.64 ± 86.14	3.52 ± .681
Defense	Competiton	21.35 ± 13.30	29.28 ± 16.66***	136.13 ± 23.98	1.15 ± .840	552.14 ± 67.50	4.38 ± .865
	Training	21.17 ± 15.40	22.97 ± 8.38***	132.52 ± 13.62	1.49 ± .770	492.32 ± 73.54	3.69 ± 1.028
Offensive Midfield	Competiton	18.67 ± 4.39	19.84 ± 11.77*	98.13 ± 57.79*	.559 ± .222*	569.29 ± 34.69	3.71 ± 1.380
	Training	19.53 ± 14.53	21.87 ± 8.40*	117.80 ± 12.20*	2.80 ± 2.43*	505.49 ± 54.05	3.64 ± .956
Defensive Midfield	Competition	19.69 ± 7.53	29.86 ± 11.99***	139.16 ± 32.91***	1.14 ± .582	534.58 ± 43.46	3.54 ± .779
	Training	28.05 ± 42.03	23.56 ± 8.38***	118.19 ± 13.80***	1.57 ± .986	484.52 ± 53.37	3.60 ± .848
Face Off	Competition	18.91 ± 8.73	16.57 ± 8.26	-	-	540.83 ± 56.78	4.67 ± .816
	Training	24.47 ± 41.08	15.88 ± 6.64	129.37 ± 8.42	1.34 ± 1.26	494.81 ± 47.98	3.84 ± 1.002
Goalie	Competition	22.11 ± 9.48	11.63 ± 4.23	118.70 ± 46.24	1.13 ± .372	530.33 ± 53.87	4.40 ± .632
	Training	19.08 ± 7.42	11.55 ± 3.88	109.84 ± 14.90	1.23 ± 1.41	493.44 ± 59.01	4.36 ± .735

Menstrual Cycle Symptoms Among Female Distance Runners

Golden D, Hertel J: University of Virginia, Charlottesville, VA

Context: The menstrual cycle [MC] normally occurs in reproductively mature females; however, there is little empirical information on MC symptoms reported by female athletes. Our purpose was to identify female distance runners' self-reported MC symptoms under different training and competitive situations. **Methods:** Female distance runners, ages 18-40, were recruited via snowball sampling using email and social media to complete an online survey that queried their MC history and symptoms, training habits, and competition experiences. The novel survey was first reviewed by an expert panel for content validity and piloted on a small group of female runners. Respondents were asked whether MC symptoms ever caused them to modify or discontinue their training, adversely affected their competition performance, or prompted competition withdrawal. Respondents were then asked to report the MC symptoms associated with each affirmative condition. Descriptive statistics were calculated. **Results:** 505 female runners began the survey, with 379 (age=24.1±6.1 years) finishing it [completion rate=75%]. Respondents' running participation level included: professional (n=9, 2.4%), varsity collegiate (n=228, 60.2%), competitive recreational (n=67, 17.6%), and for fun (n=76, 20%). The mode for days run per week was 6 (n=162, 41.4%), mileage per week was 31-40 miles (n=90, 22.9%), and running time per day was 31-60 minutes (n=255, 57%). The average age of menarche was 13.2±1.7 years, 74.1% (n=294) reported that their menstrual

cycle was between 21 and 35 days, and 18.2% (n=77) reported being diagnosed with either oligomenorrhea or amenorrhea. Birth control utilization was reported by 37.1% (n=152), of which 86.2% (n=131) used hormonal birth control methods. Overall, 138 respondents (36.4%) reported that MC symptoms had previously required them to modify their training and 55 (17.9%) had to temporarily discontinue training because of MC symptoms. The most common symptoms reported relating to modified training were cramps (n=105, 76%), fatigue (n=100, 72.5%), feeling weak (n=69, 50%), heavy legs (n=58, 42%), and bloating (n=55, 40%), while those related to discontinued training were cramps (n=36, 65.5%), fatigue (n=33, 60%), feeling weak (n=27, 49.1%), headache (n=18, 32.7%) and heavy legs (n=15, 27.3%). Lastly, 154 respondents (n=40.6%) reported having competition performance affected by MC symptoms and 5 respondents (1.3%) withdrew from a competition because of MC symptoms. The most common symptoms to affect competition performance were fatigue (n=102, 66.2%), cramps (n=95, 61.7%), feeling weak (n=88, 57%), bloating (n=62, 40.3%), and heavy legs (n=61, 39.6%), while those affecting competition withdrawal were cramps (n=4, 80%), muscle ache (n=3, 60%), fatigue (n=2, 40%), and feeling weak (n=2, 40%). **Conclusions:** Our results demonstrate high symptom frequency does affect female distance runners' ability to optimally train and to a lesser extent compete. Cramps, fatigue, feeling weak, and heavy legs were the most common MC symptoms reported among female distance runners.

Fellow sponsored by Jay Hertel, PhD, ATC, FNATA.

Ultrasound-Based Thigh Fat Thickness Is Comparable to Dual-Energy X-ray Absorptiometry for Estimating Total-Body Fat Percentage in Division I Collegiate Female Athletes

Tolzman JE, Collins K, Grozier CD, Keen M, Fajardo R, Triplett A, Kuenze C, Harkey MS: Michigan State University, East Lansing, MI; Lansing Radiology Associates, Lansing, MI; University of Virginia, Charlottesville, VA

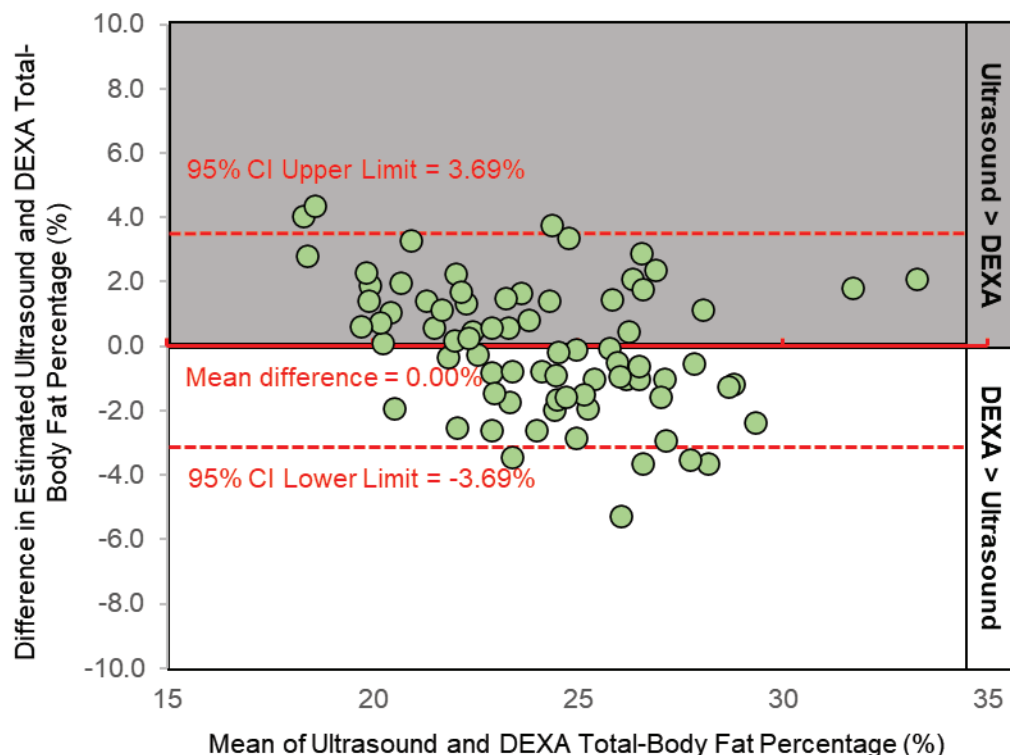
Context: Monitoring total-body fat percentage is beneficial for tracking an athlete's body composition throughout a season. Dual-energy X-ray absorptiometry (DEXA) is the gold standard for assessing total-body fat percentage. However, DEXA machines are not often accessible in athletic training clinics, which may limit their translation to a clinical-setting. Diagnostic ultrasound is a more clinically accessible imaging modality that can quantify subcutaneous fat thickness. However, it is unclear if an assessment of ultrasound fat thickness overlying the quadriceps is related to DEXA total-body fat percentage. Therefore, the aim of this study was to determine if ultrasound fat thickness is related to DEXA total-body fat percentage in Division

I collegiate female athletes. We hypothesized that the two fat measurements will be strongly correlated. We predict that we can create a conversion equation to validly estimate total-body fat percentage using ultrasound fat thickness measurements. **Methods:** A cross-sectional, convenience sample of 77 participants were recruited (age: 20.1 ± 1.5 years, Height: 169.8 ± 7.4 cm, Mass: 66.7 ± 9.0 kg) as part of an ongoing longitudinal study on Division I collegiate female athletes. Each subject completed a full body DEXA scan to determine their total-body fat percentage. Next, an experienced researcher captured three panoramic thigh ultrasound images which included the entire rectus femoris muscle of their left limb at the mid-point of the thigh. Using ImageJ, the subcutaneous fat thickness overlying the rectus femoris was quantified and averaged across 25%, 50%, and 75% of the muscle width. A linear regression model was developed to determine the strength of association between DEXA total-body fat percentage and ultrasound fat thickness in the left thigh. Beta coefficients from the linear regression model were used to create an equation to convert ultrasound fat thickness to DEXA total-body fat percentage. An intraclass correlation coefficient (ICC_{2,k}) and Bland-Altman plot were used to establish the agreement between the estimated

total-body fat percentage based on the ultrasound fat thickness and the DEXA total-body fat percentage. **Results:** Ultrasound thigh fat thickness (0.78 ± 0.24 cm) was significantly associated with DEXA total-body fat percentage ($24.2 \pm 3.5\%$; $F_{1,75} = 146.5$, $p < 0.001$, $R^2 = 0.66$). Using the values from the linear regression model, the following equation was created: Estimated total-body fat percentage = $15.18 + 11.52 \times (\text{ultrasound thigh fat thickness})$. There was high agreement (ICC_{2,k} = 0.89) and minimal mean difference (0.0%; Figure) between the estimated (i.e., from the ultrasound thigh fat thickness) and actual DEXA total-body fat percentage. **Conclusions:** Fat thickness from a single unilateral thigh ultrasound image is significantly associated with DEXA total-body fat percentage in Division I female athletes. This analysis provides evidence that ultrasound may be a clinically accessible tool that can estimate total-body fat percentage compared to DEXA imaging. Therefore, body composition may be estimated from images that are also used to assess the quadriceps muscle.

Dr. Harkey is funded on the following NIH Grant (K01AR081389).

Figure. Bland-Altman Plot Comparing the Estimated Ultrasound and Dual-Energy X-Ray Absorptiometry (DEXA) Total-Body Fat Percentage



Values above 0.0 on the y-axis indicates that the estimated, ultrasound total-body fat percentage was greater than the DEXA total-body fat percentage. Values below 0.0 on the y-axis indicates that the estimated, ultrasound total-body fat percentage was lesser than the DEXA total-body fat percentage.

Therapeutic Alliance: Exploring Bonds, Goals, and Tasks From the Perspective of Collegiate Student-Athletes

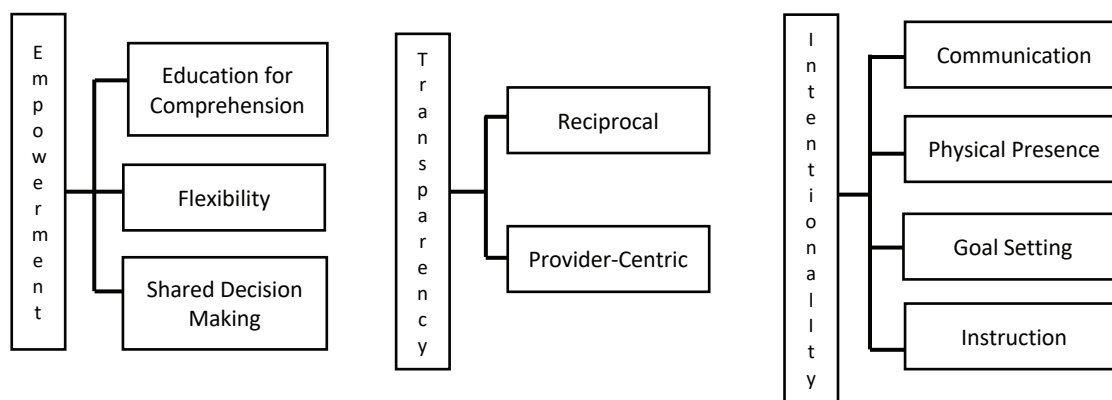
Torres P, Stoepel SM, Young JP, Kiesel JD, Eberman LE, Rivera MJ: Indiana State University, Terre Haute, IN

Context: Therapeutic alliance refers to the relationship between patient and provider, consisting of bonds, goals, and tasks. A positive therapeutic alliance facilitates provision of care as well as demonstrates improved outcomes. Previous research on the therapeutic alliance has been completed in other health care fields, but not within athletic training. This study explored the lived experiences of college student-athletes and development of the therapeutic alliance with athletic trainers. **Methods:** A phenomenological approach was used to explore the therapeutic alliance and lived experiences of 13 collegiate student-athletes (women=10, men=3, age=24±18 years). We used criterion sampling to identify potential participants, who were screened for inclusion using a web-based survey (Qualtrics, Provo, UT): over the age of 18, a student-athlete in the college/university setting, and currently being treated by an athletic trainer (AT) at the time of the study to ensure accurate recall. Participants who met the inclusion criteria engaged in an audio-only, online semi-structured interview (Zoom, San Jose, CA). The research team used best-available literature to develop the semi-structured interview protocol (14 questions), which then underwent internal and external revision. Two lead investigators practiced with the script on several potential

participants and were given feedback to maintain consistency before starting data collection. Recruitment and data collection continued until data saturation occurred. All interviews were audio-recorded and transcribed via artificial intelligence, then checked for accuracy by the primary and secondary investigators. A consensual qualitative research approach was used for analysis with a team of four individuals. The data analysis team completed a multi-phase coding process that included building consensus and internal auditing. The consensus codebook representative of the data was applied across all transcripts. Credibility and trustworthiness in the analysis were ensured through member-checking, multi-analyst review, internal and external auditing. **Results:** We identified three domains regarding collegiate student-athletes' perceptions of the mindset, behaviors, and actions of the athletic trainers that aided in the development of their therapeutic alliance (Figure 1): empowerment, transparency, and intentionality. Actions by the AT that allowed the patient to feel empowered during their care included shared decision making, clinician flexibility, and education for comprehension. During the participants' rehabilitation process, making collaborative decisions, being fully educated regarding the interventions used, and making modifications for their injury empowered the patient. Patients described the ATs as transparent, whereby they felt communication was beneficial when it was reciprocal, equally initiated by both patient and provider, or provider-centric, when the provider initiated communication or shared information. Participants appreciated provider-centric transparency, when the AT was considering more than their physical injury

including their mental health and life outside of sport participation. Reciprocal communication allowed patients to express their feelings and thoughts on certain situations due to the bond established with their AT. Participants felt that when the ATs were intentional in communication, being physically present, goal setting, and instructing, it helped to reinforce the therapeutic alliance. Specifically, when the AT communicated and was physically present to demonstrate and cue patient education, the connection that was developed between patient and provider was strong. Additionally, participants acknowledged goal setting as an important factor in engaging them in their rehabilitation process. **Conclusions:** A positive therapeutic alliance has proven to build trust and openness between clinicians and clients, allowing for better adherence and improved outcomes in allied health settings. Overall, the college student-athletes in this study felt the strong bond with the AT played an important role in facilitating willingness to engage in their care. Participants felt the therapeutic alliance came from the AT being intentional and transparent, while empowering them. ATs are primed to establish a strong therapeutic alliance due to the increase in consistent patient interactions.

Figure 1: Domains and Core ideas



Free Communications, Rapid Fire Presentations: Athletic Training Education

Thursday, June 22, 2023; 7:30 AM-8:25 AM; Room 234-236

Moderator: Ashley Thrasher, EdD, LAT, ATC

Reflective Thinking in Athletic Training Students

Wright SM: University of Maine, Orono, ME

Context: Reflection is an under-researched topic in athletic training, particularly in education. Athletic training students (ATS) are part of the broader health care provider network and thus require continuous updated knowledge and concepts, indicating the need to regularly engage in various levels of reflection. The purpose of this project was to examine athletic training students' use of reflective thinking in their academic programs. **Methods:** We used a cross-sectional survey research design to deliver the validated Reflective Thinking Survey (RTS) in Qualtrics® (sub-scale internal consistency values: 0.58-0.85). Recruitment emails, retrieved from the CAATE website and subsequent program websites, were sent to ATP directors 3 times over 5 weeks. ATPs included in the survey were professional bachelor's (PB), professional master's (PM), post-professional master's (PPM), clinical doctorate (DAT), research doctorate, and residency/fellowship programs; 318 of 328 program director emails were successfully delivered. The 16-item questionnaire is divided into 4 subscales: Habitual Action, Understanding, Reflection, and Critical Reflection. Scoring for the RTS is completed by assigning 5 to strongly agree and 1 to strongly disagree. Due to the non-normality of the data (Shapiro-Wilk test $p < 0.001$), we used non-parametric statistics to analyze the individual Likert scale responses and subscales by current academic program. **Results:** A total of 126 participants completed the survey. We used

the Kruskal-Wallis test to assess individual survey items against the participants' current academic program and found differences between "In this course, we do things so many times that I started doing them without thinking about it" ($H(4)=21.79$, $p < 0.001$) and "This course has challenged some of my firmly held ideas" ($H(4)=15.83$, $p=0.003$). Post-hoc analysis showed differences on "...we do things so many times that I started doing them without thinking about it" between PB and PPM students ($U=20.50$, $p < 0.001$), PB and DAT students ($U=135.0$, $p=0.003$), and PM and PPM students ($U=56.5$, $p < 0.001$). Differences were found between PB and DAT students ($U=131.0$, $p=0.003$) and PM and DAT students ($U=158.0$, $p < 0.001$) on the item "This course has challenged some of my firmly held ideas." We assessed the subscale sums by academic group using Kruskal-Wallis and found significant findings on the Habitual Action subscale ($H(4)=15.74$, $p=0.003$). Post-hoc analysis showed differences between PB and PPM ($U=26.5$, $p < 0.001$). **Conclusions:** The differences between academic groups on the individual survey items show professional level (PB and PPM) ATS agree more that their programs challenge firmly held ideas and disagree that programs do things often enough to support habit formation. The results indicate professional level programs challenge existing student knowledge but may lack reinforcement for habit development. Overall, PPM students show higher engagement with habitual action than the other subscales, especially compared to PB students. Broad implications include educational interventions in programs affect how deeply students are reflect and integrate new knowledge.

Perceived and Actual Rankings of Professional Athletic Training Programs
Branning SE, Neil ER, Voll CA,
Crossway AK, Winkelmann ZK:
University of South Carolina, Colum-
bia, SC; Temple University, Philadel-
phia, PA; Franciscan Health, West
Lafayette, IN; State University of New
York at Cortland, Cortland, NY

Context: The U.S. News college ranking system is used to describe the best graduate programs in the country. Rankings of graduate health programs are based solely on perceived quality ratings by a director and/or dean. Athletic training is not listed by the U.S. News; however, the CAATE reports key metrics such as BOC pass rate and program graduation rate which could be helpful to create actual program rankings. The purpose of this study was to evaluate and rank CAATE-accredited professional ATPs using two different models and comparing the outcomes. **Methods:** To create the perceived ranking, we utilized a cross-sectional, online survey to 310 program directors (PDs) of an ATP. The survey used the same validated methodology as the U.S. News which asked them to rank each program on a 5-point Likert scale (1=marginal, 5=outstanding) when considering the academic quality of each ATP. Participants were instructed to reflect on factors that provided evidence of excellence including curriculum, scholarship, quality of faculty, and graduates. In total, 155 PDs submitted a response to the survey (response rate=50%). To create the actual ranking model, we used publicly available information for each ATP on the CAATE website, including number

of students enrolled, graduation rate, and BOC pass rate (first and overall) between 2018-2021. This data was analyzed using a pre-determined formula considering all variables. A Cohen's κ was run to determine an agreement between the PDs perceived model and the CAATE actual model rankings. **Results:** The average reported rating of the programs was 3.0 ± 0.6 . From CAATE data, 230 total programs (graduating >30 students in 3 years=86, graduating <30 in 3 years=144) were included. Most programs graduated a total of 30 ± 18 students during the 3-year period. The average 1st-time pass rate on the BOC exam was $76 \pm 16\%$ with an overall pass rate of $92 \pm 9\%$. No agreement was found between the perceived and actual ranking models ($\kappa = -0.003$, $P = 0.401$). The perceived top-ranked program by PDs (mean=4.2) was ranked 95th using the CAATE model. The top-ranked programs using the CAATE model (10-way tie; 100% pass rate and 100% graduation rate) were ranked between 29th and 211th on the perceived ranking model. The top 10 ranked programs on the CAATE model were considered small programs graduating between 1-29 students over 3 years. When combining the perceived and actual outcome rankings, the overall top program was ranked 9th on the perceived model and 15th on the actual model. **Conclusions:** Perception by PDs did not align with actual objective data reported by CAATE. The lack of agreement between the two ranking models highlights concerns using the U.S. News system for graduate health programs. We suggest exploring a more robust and comprehensive formula including overall pass rate and graduation rate to identify top-ranked programs in athletic training.

Programmatic Efforts to Ease Transition to Practice Through Progressive Autonomy

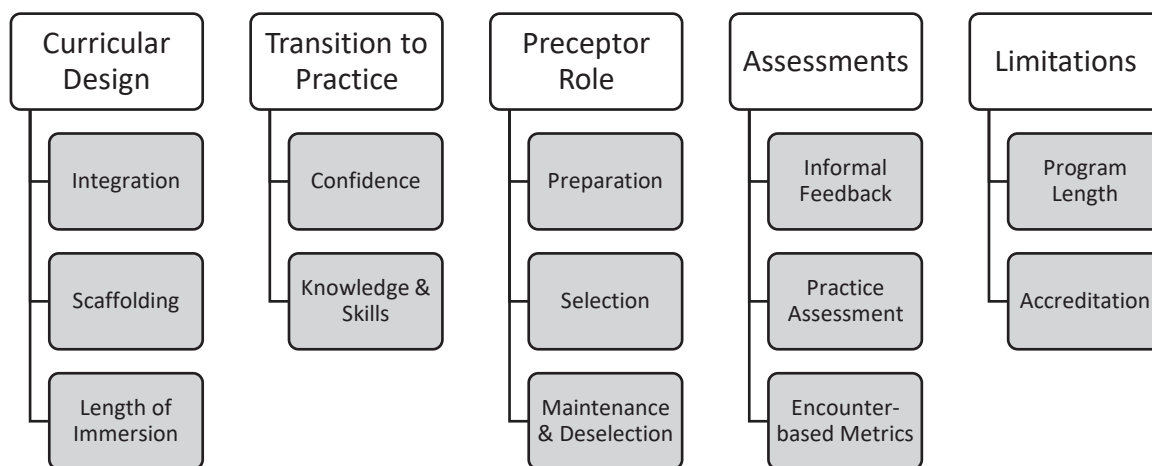
Carlson BE, Young JP, Neil ER, Barrett JL, Eberman LE: Indiana State University, Terre Haute, IN; Temple University, Philadelphia, PA; Springfield College, Springfield, MA

Context: Athletic trainers have identified their professional program as being important to their transition to practice with both formal coursework and clinical education contributing to preparedness; however, the perception of new graduates has been that they lacked the skills needed for autonomous practice including communication, decision making, rehabilitation and more. Previous research has focused on transition to practice from the perspective of the athletic trainer and employers, yet limited investigation has been completed from the programmatic perspective. The purpose of this study was to determine the role of progressive autonomy in clinical education to aid transition to practice. **Methods:** We used a phenomenological approach to explore the experiences of 17 participants representing 16 professional athletic training program administrators. Program directors and clinical education coordinators of CAATE accredited professional master's in athletic training programs were recruited via e-mail. Programs were representative of urban, suburban, and rural communities, institutional type by way of public/private and Carnegie classifications, and program size by way of student enrollment and faculty support. Recruitment and data collection continued until

data saturation was met. The primary investigator conducted an online, semi-structured audio interview (Zoom, San Jose, CA) with each program. Each interview was audio-recorded and transcribed. A data analysis team of 4 individuals used the consensual qualitative research tradition to analyze the data and create a codebook through a multi-phase process. Common ideas were identified and organized into domains and categories. Member checking, multi-analyst triangulation and auditing established trustworthiness and credibility. **Results:** Five domains emerged: 1) curricular design, 2) transition to practice, 3) preceptor role, 4) assessments, and 5) limitations (Figure 1). The curricular design of programs facilitated progressive autonomy through integration, scaffolding, and length of immersion. Programs described intentionally designing curricula to integrate progressive autonomy, while also scaffolding opportunities to build knowledge, skills, and abilities throughout. Programs explained the value of immersion, particularly exceeding the 4-week minimum, aided in the development of progressive autonomy. Participants acknowledged the goal of progressively giving autonomy was specific to transitioning to practice. Clinical experiences that offered progressive autonomy also offered chances to develop knowledge and skills and the confidence to perform them. Preceptors were critical in offering progressive autonomy, but that required the program to intentionally select, prepare, maintain and deselect those that did not provide progressively autonomous experiences. Program's offered variable methods to measure whether progressive autonomy was occurring in the clinical experience and whether students had sufficient opportunities to practice

autonomously before graduation. Participants described the use of practice assessments and informal feedback; some used encounter-based metrics to assess student preparedness. Practice assessments varied from evaluating professionalism to the use of the Athletic Training Milestones. Informal feedback was often described as casual consultation with a preceptor. Encounter-based metrics were quantitative measures of the number and type of encounters (observed, assisted, or independently performed) ensuring sufficient opportunity for autonomy. Perceived limitations or barriers to developing progressive autonomy and preparing students to transition to practice included accreditation and program length following the transition to a two-year professional program. **Conclusions:** Program administrators have identified the importance of progressive autonomy in helping future athletic trainers transition to practice. Limitations appeared to be self-limiting as the ways in which a program designs its immersive experiences and overall curricula are within the purview of each institution. Curricular design and program intentionality relative to preceptors created greater opportunities to ensure progressively autonomous experiences resulting in successful transition to practice. However, programs predominantly used traditional practice assessments and informal feedback to assess student readiness to graduate, which may not effectively measure a student's ability to transition to practice with ease.

Figure 1. Domains and Categories



Athletic Training Students' Perceived Self-Confidence Performing Rectal Thermometry Following Simulated Encounters

Stedje HL, Herzog VW, Kinslow BL, Martin M: Weber State University, Ogden, UT; University of Wisconsin-Stevens Point, Stevens Point, WI; Rocky Mountain University of Health Professions, Provo, UT

Context: Athletic training programs must prepare students to perform rectal thermometry which is best practice for recognizing exertional heat stroke (EHS). Many certified athletic trainers are not utilizing rectal thermometry partially due to low self-confidence. Exertional heat stroke is a high risk, low incidence condition. If certified athletic trainers acting as clinical preceptors are not using rectal thermometry, authentic practice opportunities for students may be limited. Therefore, the purpose of this study was to identify and explore the effect of simulated EHS encounters on athletic training students' self-confidence when performing rectal thermometry. **Methods:** This study used a sequential explanatory mixed methods design. Purposeful sampling was utilized to enroll 6 professional Master of Athletic Training programs. Thirty-nine first-year athletic training students ages 21-42 (23.81 ± 4.31 yr) completed the study. The interventions for this study aligned with Bandura's Social Cognitive Theory. Participants received a 50-minute standardized EHS lesson that included rectal thermometry practice on a task trainer rectum model. An anonymous pre-intervention Athletic Trainer's Self-Confidence Scale (ATSCS) distributed online, via Qualtrics (Provo, UT) was sent to the participants following the EHS lesson. The ATSCS is a 9-item Likert scale questionnaire assessing self-confidence with recognizing and managing

EHS and has validity (Pearson's $r = .19-.79$) and reliability (Cronbach $\alpha = .82$). Within 1-7 days of the pre-intervention ATSCS, participants completed a simulated EHS encounter with a high-fidelity simulation manikin (HFSM) ($n=19$) or a standardized patient (SP) ($n=20$). The post-intervention ATSCS was issued after their simulation encounter with an invitation to volunteer for an individual, semi-structured qualitative interview. An interview guide was developed, and peer reviewed to ensure interview questions aligned with the research question. The phenomenological theory was used to explore the phenomenon of self-confidence. An iterative process of sampling and interviewing continued until data saturation was reached. Eight participants per group ($n=16$) completed an interview over Zoom teleconferencing. All interviews were recorded and transcribed verbatim. Quantitative and qualitative data were initially analyzed separately and then merged to explain the impact the EHS simulation had on students' self-confidence. Inductive, thematic analysis followed the Qualitative Analysis guide of Leuven. To ensure trustworthiness and credibility, transcripts were independently reviewed by the primary author and an external expert in qualitative analysis. Member checking and a reflexivity journal were also utilized. **Results:** A Repeated Measures ANOVA revealed a statistically significant improvement from participants' pre-intervention ATSCS score to the post-intervention ATSCS score regardless of group assignment ($F(1,35)=19.05$, $p=.000$). We identified three major themes as sources of athletic training students' self-confidence that align with the Social Cognitive Theory: 1) past performance, 2) a realistic experience, and 3) imaginal future experiences performing rectal thermometry. Participants shared receiving feedback on past performance, and previous practice in realistic scenarios helped build their self-confidence. Most participants

felt the simulation encounters were realistic to increase their confidence to perform rectal thermometry on an actual patient. Many shared they could perform the steps of rectal thermometry well after practicing in a realistic scenario. Both groups also felt more confident to perform rectal thermometry after their simulation encounter than if they had only practiced on the task trainer. These perceptions agreed with the quantitative results indicating a significant increase in self-confidence following either simulation encounter. **Conclusions:** A simulated EHS encounter with either an SP or a HFSM are equally effective for improving first year athletic training students' self-confidence while performing rectal thermometry. Regardless of simulation technique, students shared perceived improvements in their self-confidence and felt prepared to perform rectal thermometry on an actual patient in the future. Therefore, athletic training programs should add an SP or HFSM encounter after practicing on a task trainer to confidently prepare students to perform rectal thermometry.

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Exploring Faculty Perceptions of Competence Regarding the 2020 CAATE Curricular Content Standards

Rizza KM, Young JP, Rivera MJ, Winkelmann ZK, Welch Bacon CE, Eberman LE: Indiana State University, Terre Haute, IN; University of South Carolina, Columbia, SC; A. T. Still University, Mesa, AZ

Context: The Curricular Content Standards (CCS) subsection of the CAATE 2020 Standards for Accreditation of Professional Athletic Training Programs describes 39 skill-sets that students should be able to perform upon graduation from an accredited ATP. While faculty must didactically teach this material, it is unknown whether these individuals perceive competence in performing these skills themselves. The purpose of this study was to explore faculty perceptions of their own competence in each CCS, particularly regarding content they teach versus content they do not teach. **Methods:** We used a cross-sectional, concurrent triangulation mixed-methods design. Athletic trainers (ATs) who self-reported their primary occupation as education to the NATA (n=1042) received the web-based survey. A total of 160 ATs holding current educational responsibility within an ATP (13±8 years of teaching experience) consented and completed the survey (15.4% response rate). The survey included 4 sections: demographics (8 items), responsibility for teaching CCS (39 yes/no items), perceived level of competence for each CCS (39 items rated on a Likert-scale, modified from the Athletic

Training Milestones), and open-ended questions related to participants' beliefs on the development of competency, proficiency, and expertise (3 items). The open-ended items were designed to contextualize participants' perceived competence rating selections. The instrument was validated by 6 external expert panelists (Content Validity Index; relevance=0.99, clarity=0.95). Descriptive statistical analyses were used for demographics, teaching responsibility, and perceived level of competence. Non-parametric analyses ($p < 0.5$) were used to compare perceived level of competence between groups (those that did and those that did not teach content within a given standard). Open-ended questions were analyzed by a 3-member coding team using a modified Consensual Qualitative Research approach to establish domains and categories. Trustworthiness was ensured through multi-analyst triangulation, internal and external auditing. **Results:** Participants rated no standard below "Competent" by mean or mode. The five highest-rated standards were: practicing ethically, using evidence to guide practice, practicing within BOC standards, interprofessional collaboration, and communication with patients and stakeholders (Table 1). The five lowest-rated standards were: using quality improvement systems, using biometric monitoring, analyzing effect of the social determinants of health, educating patients on pharmacologic use, and using the ICF health model (Table 1). The majority of participants who taught content within a given standard rated themselves significantly higher ($p < .05$) than those who did not. There were no significant between-group differences for only two CCS ('advocating for

health needs', $p=.595$; 'use evidence to inform practice', $p=.080$). Ninety-seven participants responded to open-ended questions. The coding team identified 4 domains (11 categories) that participants believed contributed to the development of competency, proficiency and expertise. Domains included: Educational Preparation (professional-level education, other formal education, continuing professional development), Teaching Responsibility (years of teaching experience, regular content delivery); Scholarship (years of research experience, research mentorship, research-specific content), and Clinical Practice (current clinical practice, years of previous practice experience, practice-specific content knowledge and skills). Respondents most frequently indicated continuing professional development (n=80 / 97, 82%), regular content delivery (n=52 / 97, 54%), and clinical practice experience (n=50 / 97, 52%) as justification for their own proficiency and expertise within the CCS. **Conclusions:** Competence is not fixed or permanent once achieved; it exists on a spectrum that shifts and evolves over a career. Faculty perceived themselves to be competent across all CCS with higher levels of competence in the standards that they teach. Of concern, however, was the perception among some that their expertise was established years ago during their own professional education. Athletic training education and its educators need to adapt to the broader intent of the CCS, embracing and developing in their areas of contemporary expertise and maximizing talents of core faculty.

Post-Professional Terminal Degree Student Winner

Table 1. Percentage of Highest and Lowest Self-Ratings for Curricular Standards

Top 5 Rated Standards (%)						
	Critically Deficient (1)	Novice (2)	Advancing Towards Competent (3)	Competent (4)	Proficient (5)	Expert (6)
St. 65	0	0.6	0.6	10.6	46.3	41.9
St. 62	0	0.6	1.3	9.4	48.8	40.0
St. 66	0	0	2.5	11.9	55.6	30.0
St. 61	0	0.6	0.6	20.0	47.5	31.3
St. 59	0	0.6	3.1	17.0	49.7	29.6
Bottom 5 Rated Standards (%)						
	Critically Deficient (1)	Novice (2)	Advancing Towards Competent (3)	Competent (4)	Proficient (5)	Expert (6)
St. 63	0.6	11.9	13.8	37.5	31.9	4.4
St. 87	1.9	5.2	22.7	38.3	22.7	9.1
St. 57	0.6	11.3	18.2	30.2	31.4	8.2
St. 74	2.6	7.8	13.0	39.0	32.5	5.2
St. 60	3.8	8.8	13.1	35.0	26.9	12.5
Responses marked in bold are the mode score						

**Standardized Patient Encounter Series
Improve Athletic Training Students'
Confidence With Communication
Among Stakeholders**

Frye JL, Clark PR, Armstrong KJ:
James Madison University, Harri-
sonburg, VA; Christopher Newport
University, Newport News, VA

Context: The socialization of athletic training students within a professional program is crucial to setting the foundation for transition to autonomous practice. Newly credentialed athletic trainers have reported a lack of confidence communicating with stakeholders, such as coaches and physicians, as these conversations involve varied opinions and strong emotions. It is imperative for students to have preparation, practice, and repetition of these conversations, which are often missed during clinical education. Thus, professional athletic training programs should seek pedagogical strategies, such as standardized patient (SP) encounters, to build these skills. Therefore, the purpose of this investigation was to examine the impact of a series of SP encounters on confidence and communication. **Methods:** We used a mixed-method design. A convenience sample of 12 first-year professional master's students (2 men, 10 women, age = 21.47 ± 1.726) completed a series of three communication SP encounters with various stakeholders (i.e., patient, physician, coach) and a structured debrief. Immediately before and after the series of SP encounters, each participant completed a 14-item confidence survey. Cronbach's alpha determined internal consistency, $\alpha = 0.971$. Descriptive statistics were computed for all survey items. Wilcoxon signed-ranks tests were used to compare pre- and post-encounter confidence survey ratings.

Alpha levels were set at 0.05. An interpretive coding method was used to analyze respondents' debrief comments. **Results:** Overall, athletic training students reported an increase in their confidence after completing the SP encounters series emphasizing communication with various stakeholders, noting an increase in 12 of 14 survey items (See Table). Specifically, a significant increase in confidence was noted in determining the amount of rest a patient needs, generating responses to a coach's follow-up questions, and communicating with a difficult coach. Though overall mean confidence increased from pre- to post-encounter, this increase was not statistically significant ($Z=1.492$, $P= 0.136$). Three themes emerged from the qualitative debrief data. The first theme, student expectations, included comments regarding the differences between preconceived expectations and the reality of the conversation that occurred with each stakeholder. The second theme, self-reflection, included comments regarding the participants' ability to self-reflect on the evaluation process and interpret findings to support clinical decisions when communicating with each stakeholder. The final theme, importance of using a collaborative approach, included self-reflection emphasizing collaborative communication with varying stakeholders to optimize patient care. **Conclusions:** Our SP encounter series was a positive socialization activity for athletic training students to demonstrate full autonomy in clinical decision-making and practice communication with various stakeholders. The utilization of SPs improved confidence and stimulated self-reflection. Athletic training educators should use these types of encounters to allow students to navigate communication with various stakeholders in a safe and independent learning environment to supplement experiences missed during clinical education.

MSAT Students Perceived Confidence

Confidence Rating Item	Standardized Patient Encounter Pre-Encounter $M \pm SD^*$	Post-Encounter $M \pm SD$	Wilcoxon Signed Rank (Z, P)
Overall Mean Scores	3.76 \pm 0.284	4.03 \pm 0.372	$Z = 1.492, P = 0.136$
Formulate Diagnosis (n = 12)	4.00 \pm 0.426	4.00 \pm 0.426	$Z = 0.000, P = 1.000$
Determine Rest Needed (n = 12)	3.17 \pm 0.389	3.75 \pm 0.622	$Z = 2.111, P = 0.035^\dagger$
Formulate Treatment Plan (n = 12)	3.50 \pm 0.522	3.75 \pm 0.452	$Z = 1.134, P = 0.257$
Providing Coach Education (n = 12)	3.58 \pm 0.793	4.00 \pm 0.739	$Z = 1.127, P = 0.260$
Generate Follow Up Answers (n = 12)	3.33 \pm 0.651	4.17 \pm 0.835	$Z = 2.153, P = 0.031^\dagger$
Communicate Difficult Coach (n = 12)	3.25 \pm 0.452	4.08 \pm 0.515	$Z = 2.486, P = 0.013^\dagger$
Relay Relevant Information (n = 12)	3.92 \pm 0.515	4.08 \pm 0.515	$Z = 0.707, P = 0.480$
Diverse Coaches (n = 12)	4.17 \pm 0.577	4.17 \pm 0.577	$Z = 0.000, P = 1.000$
Using Verbal Communication (n = 12)	4.08 \pm 0.515	4.25 \pm 0.452	$Z = 0.816, P = 0.414$
Using Non-Verbal Communication (n = 12)	3.75 \pm 0.452	3.92 \pm 0.515	$Z = 1.000, P = 0.317$
Using Professional Language (n = 12)	4.00 \pm 0.426	4.42 \pm 0.515	$Z = 1.890, P = 0.059$
Selecting Communication Methods (n = 12)	4.25 \pm 0.622	3.92 \pm 0.515	$Z = -1.256, P = 0.206$
Reasoning in RTP Decision (n = 12)	4.00 \pm 0.603	3.92 \pm 0.515	$Z = -0.333, P = 0.739$
Abilities as AT (n = 12)	3.75 \pm 0.622	4.00 \pm 0.603	$Z = 1.000, P = 0.317$

* 1 = Strongly Disagree; 5 = Strongly Agree

† = Statistically Significant

Transition to Practice: Perceptions on Mentorship From Athletic Training Programs Administrators

Young JP, Carlson BC, Neil ER, Barrett JL, Eberman LE: Indiana State University, Terre Haute, IN; Temple University, Philadelphia, PA; Springfield College, Springfield, MA

Context: Educational and organizational impacts on transition to practice (TTP) have been investigated in early career athletic trainers. Mentorship has been identified as an educational mechanism, for successful TTP. Previous literature has described the perceptions of mentorship from the learner and early career athletic trainer perspective but no investigation has observed the perception of mentorship from the ATP perspective. The purpose of this study was to investigate ATP administrator perceptions on mentorship and its role in learners' TTP. **Methods:** We used a phenomenological approach, with a semi-structured interview protocol to meet the study's purpose. To be included in the study, participants had to have at least one year of experience in their current position and the program must have matriculated one cohort through graduation, at the time of the study. Seventeen Program Directors (PD) or Clinical Education Coordinators (CEC), representing 16 CAATE-accredited professional-level masters ATPs met inclusion and chose to participate. Participants were primarily PDs (n=12, 70.5%), representing urban institutions (n=8, 50.0%), at R1 Carnegie Classified institutions (n=6, 37.5%) with an average of 7.4±6.4 years of experiences in their current role, and 11.3±6.9 years of experience

as an athletic trainer. Recruitment and data collection were continued until data saturation was observed. One investigator conducted virtual semi-structured interviews, which were audio-recorded, transcribed, and saved to cloud storage (Zoom, San Jose, CA). We used a multi-phase, multi-analyst Consensual Qualitative Review (CQR) approach to analyze the transcripts. Through CQR we established, finalized, applied, and confirmed a codebook that organized commonly observed participant responses into domains. Trustworthiness, accuracy and credibility were established through member-checking, multi-analyst triangulation, and internal and external auditing. **Results:** Four domains emerged from the data: 1) Mentorship as a positive influencer for TTP, 2) Trust as an important factor for mentor-mentee relationships, 3) Programmatic intentionality regarding integrating mentorship, and 4) Preceptors as mentors (Table 1). PDs and CECs typically acknowledged the critical role mentorship plays in a student's ability to TTP. They also occasionally noted trust between a mentor and mentee, as an important factor for the development and maintenance of the mentor-mentee relationship. ATPs frequently discussed programmatic intentionality related to mentorship. A few ATPs (5 / 16, 31.2%) described intentionally enhancing mentee experiences for their learners through strategies like providing mentor training beyond standard preceptor training for their preceptors or intentional preceptor-matching. Despite this, there was a typical assumption that preceptors were inherently mentors based on their preceptor status, regardless of mentorship training, experience, or interest of the preceptor or assigned

student. The assumption that preceptors were automatically mentors led to a majority of programs (11 / 16, 68.8%) lacking an intentional plan for training, facilitating, and evaluating mentorship relationships. **Conclusions:** PDs and CECs confirmed the beliefs of learners and early career athletic trainers, agreeing programmatic mentorship is important for effective TTP, but, outside of preceptor matching or training, programs demonstrated limited, formal intentionality toward the development and facilitation of mentee experiences for learners. As mentorship is believed to be a facilitator for TTP, ATPs should establish formalized mentorship programs and facilitate beneficial mentor-mentee relationships for their learners. A theoretical model has recently described the TTP experience within athletic training. The model established that individuals first encounter educational and professional norms, self-doubt, and fear before seeking support, learning coping strategies, and eventually finding rhythm in clinical practice. Establishing formalized mentoring relationships during education, outside of preceptors or programmatic faculty, may further assist with professional socialization so learners better understand norms, and can seek support sooner through established mentors, to more quickly and effectively find their rhythm and TTP.

Table 1. Frequency Counts for Domains

Domain	Frequency (N=16)	Commonality
Transition to Practice	81.3% (N=13)	Typical
Trust	43.8% (N=7)	Variant
Preceptor as Mentors	81.3% (N=13)	Typical
Programmatic Intentionality	100.0% (N=16)	General

Frequency counts were calculated for each domain and category based on participant responses as general (n=15-16), typical (n=8-14), or variant (n=3-7), or rare responses (n=1-2).

The Effect of Immersive Clinical Experiences on Athletic Training Students' Confidence in Performing Tasks Associated With Patient Care and the Domains of Practice

Walker SE, Pribesh SL, Cavallario JM:
Ball State University, Muncie, IN; Old
Dominion University, Norfolk, VA

Context: Immersive clinical experiences were implemented to provide each student with opportunities to experience the totality of patient care and the day-to-day job of an athletic trainer to address deficiencies, such as lack of confidence. The purpose of this study was to examine the influence of immersive and non-immersive clinical experiences on the confidence of students in implementing skills associated with patient care and the domains of practice.

Methods: A longitudinal, time-diary survey design was used. A group of athletic training education researchers developed the time-diary survey, which was then reviewed by content experts for content validation. Piloting occurred with four students and their data were not included in the final analyses. Recruitment occurred through snowball sampling by emailing program directors who were asked to forward the recruitment information to students. A total of 53 students (39 women, 14 men) participated from 21 different CAATE-accredited professional master's athletic training programs. During two-years (Summer 2020 through Spring 2022) of their education participants received 196 survey prompts via text. Each text survey required participants to identify the setting at which their experience occurred, whether the experience was immersive, non-immersive, or if they did not attend clinical that day. Participants were then asked to rate their associated confidence in patient care, administrative, facilities management, and communication tasks. Specifically, we examined 17 tasks

with a response scale that ranged from 1=Not at all confident to 5=Extremely confident. An independent samples t-test was used to determine statistically significant differences using an a-priori significance level of $p<0.05$. **Results:** Participants submitted 6054 surveys (58% response rate). Participants reported attending an immersive clinical experience for 13% ($n=759$) of responses, a non-clinical immersive experience for 21% ($n=1265$) of responses, and did not attend clinical for the remainder of the responses 66% ($n=4030$). We found three tasks that showed significant differences. Participants in an immersive clinical experience felt more confident on integrating best business practices ($p=0.037$), providing appropriate communication with other healthcare providers ($p=0.049$), and providing appropriate communication with administrators ($p=0.021$). There were no significant differences with any of the other tasks.

Conclusions: Students who engaged in immersive clinical experiences felt more confident in providing appropriate communication with other healthcare providers and administrators, likely because they were at their clinical site at times when preceptors encouraged their involvement in these types of skills. The influence on confidence with business practices could possibly be attributed due to increased communications with other healthcare providers in various administrative tasks or even involvement with documentation associated with billing practices. Immersive clinicals did serve to improve students' confidence in communication and business strategies, but notably missing was any significant differences in confidence in performing patient care tasks.

Fellow sponsored by Stacy E. Walker, PhD, ATC, FNATA.

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Sudden Cardiac Arrest With Seizure-Like Symptoms – Type 3 Case Study

Bartholomew LM, Steele ND: Lubbock Independent School District, Lubbock, TX, and Texas Tech University Health Sciences Center, Lubbock, TX

Background: Sudden Cardiac Arrest (SCA) occurs when the heart fails to beat sufficiently to maintain organ perfusion and life. SCA resulting in death is termed sudden cardiac death (SCD). SCD is the leading cause of death among athletes. Prompt intervention is critical in the treatment of SCA and can be a determinative factor in the survival of the athlete. Recognition of SCA can occasionally be obscured by myoclonic jerks and other seizure-related symptoms due to lack of brain blood flow, thus leading to a delay in treatment due to a possible misdiagnosis of a seizure. This Type 3 case study reports a young high school athlete who suffered acute SCA that presented with seizure-like symptoms. **Patient:** The patient is a 14-year-old high school male football student-athlete. He had a known preexisting history of synoptic episodes with myoclonic jerks that had been diagnosed and reported to the high school athletic training team as seizures. Following a freshman football game, the patient took a knee during a post-game huddle and subsequently fainted. The athletic training staff quickly attended to the patient and noted the presence of myoclonic jerks, a distended neck, and proptosis. During the assessment, the patient went limp and pulseless. The athletic trainer quickly recognized the patient was in SCA and intervened promptly. **Intervention & Treatment:** The patient's football pads were quickly removed, an AED was attached, and a shock was delivered. CPR was then administered until the patient regained consciousness. Shortly after the patient regained consciousness, EMS arrived and transported the patient to a local hospital. AED data analysis showed the patient experienced

ventricular fibrillation during the synoptic event and further demonstrated that the athletic trainer utilized proper CPR techniques. An angiogram and ECG were performed at the hospital and diagnosed the patient with left main coronary artery stenosis. This presentation of SCA presents with several typical SCA symptoms, such as syncope, lack of pulse, and apnea, but also includes the atypical symptoms of myoclonic jerks, distended neck, and proptosis. **Outcomes or Other Comparisons:** Without prompt intervention, SCA often leads to SCD. In this case, the administration of an AED shock and CPR saved the patient's life and allowed them to receive proper medical treatment for a previously undiagnosed heart condition. The patient is not cleared to return to strenuous activity and wears a defibrillator vest pending heart surgery to remediate the stenosis. **Conclusions:** This presentation of SCA with seizure-like symptoms illustrates a challenging situation to athletic trainers and demonstrates a potentially fatal complication in the treatment of SCA. Seizure symptoms are easily discernible which predisposes the athletic trainer to initially conclude that the patient is suffering from a seizure. Because SCA treatment requires immediate intervention with an AED, CPR, and immediate notification of EMS, and seizures commonly do not require these interventions, a misdiagnosis of seizures can lead to a delay in life-saving treatment for SCA. This delay leads to an increased chance of SCD. Athletic trainers need to be aware of this potential complication and need to constantly monitor vital signs in the presence of seizure-related symptoms so that prompt cardiac care can be initiated if necessary. **Clinical Bottom Line:** SCA is a dangerous event that can quickly lead to death among athletes. Within the stressful environment that surrounds a seizure or SCA event, athletic trainers must recognize that a patient presenting with seizure-like symptoms may be experiencing SCA, must continually monitor vitals, and be prepared with an AED to provide lifesaving treatment.

Athletic Staff Management of NCAA Collegiate Athletes Who Test Positive for Sickie Cell Trait

Kucera KL, McDonald MA, Schmid L, Yang Y, Robbins PA, Marean DL, Agans RP, Royal CDM: National Center for Catastrophic Sport Injury Research, University of North Carolina at Chapel Hill, Chapel Hill, NC; Department of Exercise & Sport Science, University of North Carolina at Chapel Hill, Chapel Hill, NC; Center on Genomics, Race, Identity, Difference, Duke University, Durham, NC; Social Science Research Institute, Duke University, Durham, NC; Department of Human Development and Family Studies, Purdue University, West Lafayette, IN; Carolina Survey Research Laboratory, University of North Carolina at Chapel Hill, Chapel Hill, NC

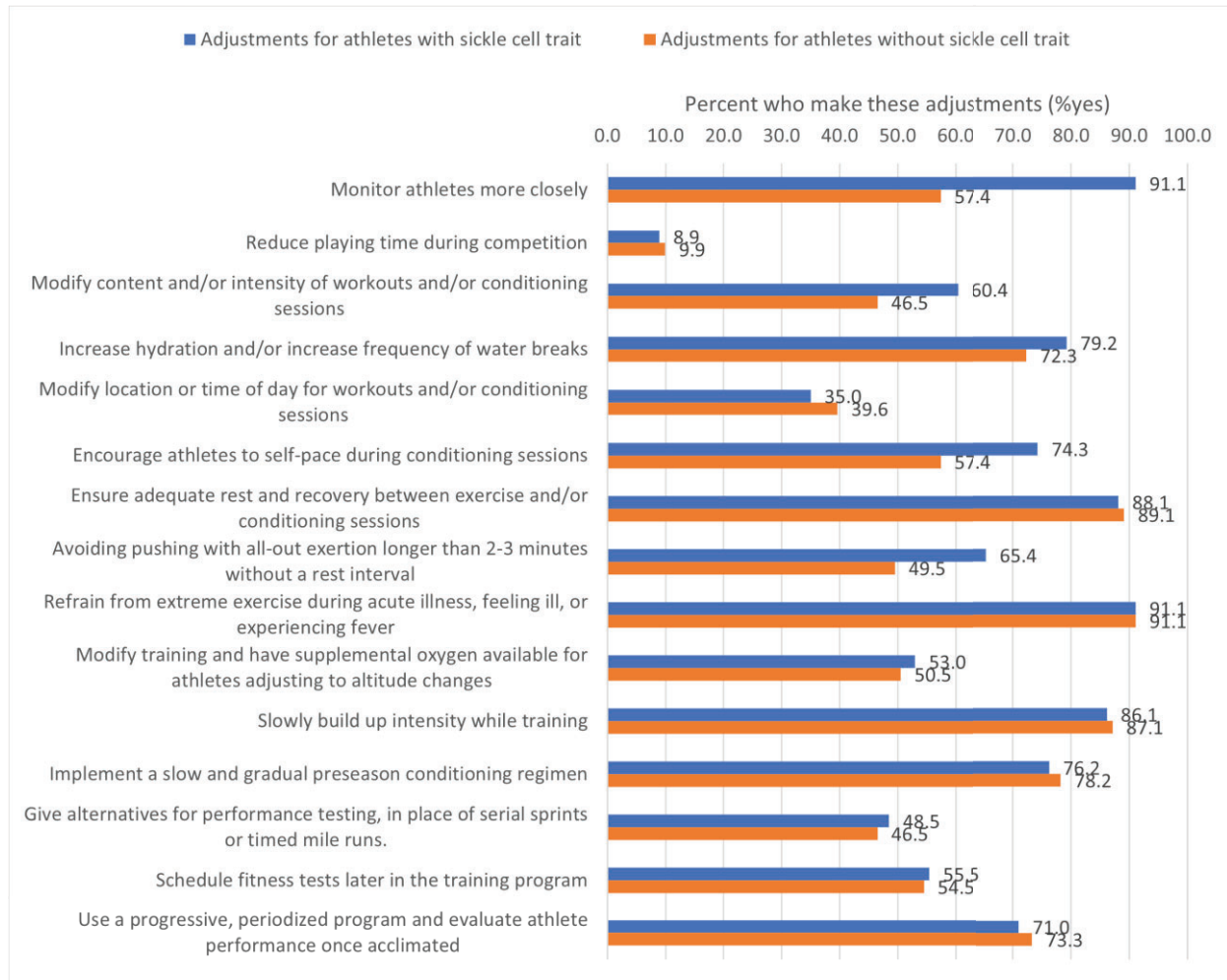
Context: Since the 2010 adoption of the NCAA SCT screening policy, NCAA athlete exertional sickling-related deaths declined from 10 in 2001-2010 to 2 in 2011-2020 (Buchanan et al. 2020). Screening is one form of primary prevention for exertional sickling-related deaths; however, other measures include evidence-based prevention and management strategies outlined by the NATA and NCAA. This study described athletic trainer (AT) and coach management of NCAA athletes with SCT. **Methods:** This analysis utilized cross sectional survey data examining NCAA SCT screening policy implementation. All NCAA head ATs were invited in 2020 and 2021 by email, postal letter, and phone to participate in an online survey. Those who consented (n=120/1071 schools, 11%) forwarded survey links to staff ATs and coaches from 2 randomly selected sports (football or the following men's and women's sports: basketball, soccer, lacrosse, or track and field). Staff were asked about screening policy knowledge, experience working with athletes with SCT, and adjustments for athletes with and without SCT. Chi-square tests identified differences in factors by staff role (AT vs coach). McNemar's test assessed differences in proportions of staff who made adjustments for athletes with and without SCT. **Results:** A total of 128 staff ATs and 140 coaches completed the survey and had the following demographics: 54.1% male,

83% White, 94% non-Hispanic/Latino, mean age 34.5 (22-75), and mean years in current position 9.5 (1-44). The majority of staff were from DIII (41.0%) followed by DI (31.0) and DII (28.0); 85% were employed by the athletics department and 59.7% had a master's degree. ATs had higher knowledge about the NCAA SCT policy compared to coaches (65.2% vs 21.0% knowledgeable/very knowledgeable, $p=0.0251$). ATs acquired knowledge from AT staff at their college (48.4%), their AT academic program (37.5%), and NCAA education materials (8.6%), whereas coaches acquired knowledge from AT staff at their college (73.9%) and NCAA education materials (10.9%). Thirty-nine percent of staff (n=104) had previously worked with an athlete with SCT at their college: 47.7% ATs and 31.2% coaches ($p=0.006$). Of these 104 staff members, 39.5% routinely modified workouts and conditioning programs for athletes with SCT; coaches were more likely to modify workouts for athletes with SCT compared to ATs (52.9% vs 28.8%, $p=0.0224$). Staff were more likely to make the following adjustments for athletes with SCT compared to athletes without SCT (Figure): monitor athletes more closely (91% vs 57%, $p<0.001$); modify content/intensity of sessions (60.4% vs 46.5%, $p=0.024$); encourage athletes to self-pace (74.3% vs 57.4%, $p=0.001$); and avoid pushing with all-out exertion >2-3 minutes (65.4% vs 49.5%, $p<0.001$). **Conclusions:** Evidence-based management strategies for athletes with SCT are not universally applied among athletic staff and application and type of modification varied between ATs and coaches. Management of athletes with SCT is important for preventing death and serious injury.

The study was funded by the National Human Genome Research Institute (Grant # R01HG010364) at the National Institutes of Health. Kristen Kucera is the Director of The National Center for Catastrophic Sport Injury Research (NCCSIR) which is supported by the American Football Coaches Association (AFCA), the National Collegiate Athletic Association (NCAA), the National Federation of State High School Associations (NFHS), the National Athletic Trainers' Association (NATA), the American Medical Society for Sports Medicine (AMSSM), and the National Operating Committee on Standards for Athletic Equipment (NOCSAE). Presenting Author (Kucera) is the Director for NCCSIR.

Athletic Staff Management of NCAA Collegiate Athletes Who Test Positive for Sick Cell Trait

Figure. Adjustments staff (n=101) make for athletes who test positive (blue) and athletes who test negative (orange) for sickle cell trait



Pneumonia and Septic Shock in a Young Healthy Football Player: A Level 4 Clinical CASE Study
Stonerook LG, Galloway DA, Crothers S, Howard JS: Appalachian State University, Boone, NC

Background: The patient was an 18-year-old male football player in his freshman season with no pertinent medical history. While traveling for an away competition, he presented with a minor cough that began approximately a week before the detailed event. Following a team meal, the patient reported to the athletic trainer complaining of nausea and proceeded to vomit five times within an hour. He was administered ondansetron and acetaminophen by the team physician, which decreased symptoms. He then woke up in the middle of the night due to severe pain in his right side and a rigid abdomen. The patient was taken to the hospital by the athletic trainer and team doctor and was found to have a blood pressure of 90 / 40mmHg, a temperature of 102°F and a heart rate of 120 bpm. **Differential Diagnosis:** Prior to diagnostic testing, gastroenteritis was suspected due to the patient's vomiting. Additionally, appendicitis was tested for, as the pain was in the right lower quadrant. A CT scan, blood culture test, and urine test were performed to rule out appendicitis or an infection. **Intervention & Treatment:** The CT scan demonstrated that the patient had a severe case of pneumonia in his right lung. The pressure of the infection was so great that it was causing the abdominal pain. The blood culture test came back clear, while a pneumococcal pneumonia urine antigen test was positive. A final diagnosis of community acquired pneumonia was given.

After approximately 6 hours, the patient went into septic shock and critical illness related renal insufficiency. A central line was placed, and vasopressors were administered to increase the patient's blood pressure. Intravenous doses of a steroid (prednisone) and antibiotics (azithromycin and cefdinir) were given to clear the infection. The patient responded well to the treatment and was discharged from the hospital 3 days later. A gradual return to play protocol was followed. The patient was withheld from exercise for 1 week until cleared by the team physician. He then was allowed to lift with the team 3 days a week and progressed to running, then full contact practices within 2 weeks post hospital discharge. The patient's blood pressure and oxygen saturation were taken daily by the athletic training staff during his return to play protocol, with minimum thresholds for continued activity progression set at 108 / 60 mmHg and 95% O₂. **Uniqueness:** This case is unique as the patient was a young, healthy, active individual who had no prior medical history predisposing him to developing pneumonia and rapid onset sepsis. **Conclusions:** There was no definitive cause of the patient's rapid deterioration following admission to the hospital. He did not have any predisposing factors, such as malnutrition, high blood pressure, and obesity, nor did he have any prior symptoms of disease beyond a mild cough. After a gradual return to play plan, the patient has been able to return to the field at his prior abilities. While this scenario is not common in the athletic population, it is an important reminder for sports medicine providers. It is recommended that athletic trainers take subtle signs of infection seriously, including a fever and rigid abdomen.

Spear Tackler's Spine in a Collegiate Athlete: A Type 4 Clinical CASE Study
Powers MR, Garcia NA, Odai ML,
Linforth J: Florida International
University, Miami, FL

Background: A 22-year-old male football player presented to the Athletic Trainer (AT) with loss of sensation in his right arm following impact during practice. The AT's evaluation noted that it took more than 5 minutes for sensation to return but no tenderness to palpation along the cervical spine and no obvious deformities. MMT of trapezius, trapezoid, sternocleidomastoid, and biceps were within normal limits. The athlete has a history of "stingers" in previous seasons. Discussion with the athlete revealed he was experiencing neurological signs and symptoms including tingling, numbness, and sharp pain radiating down his right arm for one month prior. The neurological symptoms were experienced throughout all extremities outside of sport specific activity. Due to the previously unreported symptoms and delayed time for sensation to return, the AT referred the athlete to a team physician. **Differential Diagnosis:** Brachial Plexopathy, Herniated Disc. **Intervention & Treatment:** Physician evaluation noted no signs of obvious deformities, no tenderness to palpation along the cervical spine and neck, normal range of motion, and no loss of sensation in the upper extremity. MMTs of the biceps, triceps, deltoid, and rotator cuff were all graded 5/5. Despite lack of presentation during the evaluation, the team physician ordered diagnostic imaging. Results

of the MRI and consultation with spine specialist determined bulging annulus at four levels of the cervical spine, C3 through C7. At C5 and C6 there is slight narrowing of the right neural foramen and compression of the thecal sac at C6-C7. The physician diagnosed the patient with cervical spine stenosis (Spear Tackler's Spine), recurring cervical radiculopathy, and brachial plexopathy. Due to this diagnosis the team physician declared medical disqualification of all contact sports due to increased risk of injury. When receiving the medical disqualification, the patient sought out two other professional opinions. Second opinions declared that the patient did not have any dynamic instability and would be able to return to play with little to no increased risk of injury. However, the team physician's medical disqualification was accepted. **Uniqueness:** Physician evaluation presented no clinical findings; however, patient history provided a basis for further examination. Although stingers are common in football, they typically subside quickly with no lasting symptoms. Prior to the patient informing AT of symptoms, he continued to play without impact on his athletic performance. **Conclusions:** According to the NATA position statement, athletes with signs of cervical stenosis, ongoing neuropraxia, or Spear Tackler's Spine should be considered for medical disqualification. AT and physician collaboration led to the diagnosis, although symptoms first appeared normal. Serious consequences including permanent neurological damage could have occurred if the athlete was not properly referred and diagnosed. It is important for the AT to not disregard common occurrence such as stingers in the football population.

Catastrophic Exertional Heat Stroke Trends in Secondary School Sports From 1982–1983 Through 2021–2022

Stearns RL, Kucera KL, Hosokawa Y, Filep EM, Grace A, DeLong R, Cantu R, Casa DJ: Korey Stringer Institute, Department of Kinesiology, University of Connecticut, Storrs, CT; National Center for Catastrophic Sport Injury Research, University of North Carolina at Chapel Hill, Chapel Hill, NC; Department of Exercise & Sport Science, University of North Carolina at Chapel Hill, Chapel Hill, NC; Waseda University, Saitama, Japan; Department of Kinesiology and Military Science, Texas A&M University-Corpus Christi, Corpus Christi, TX

Context: Though preventable, exertional heat stroke (EHS) fatalities remain among the top causes of athlete deaths. While rule changes and policy modifications have reduced injuries, deaths continue each year. Understanding trends in sport-related death is the first step in understanding if these occurrences are changing and identifying athletes at greater risk for these events. Therefore, this analysis aimed to describe EHS deaths in secondary school athletes since the 1982 / 1983 academic year. **Methods:** Catastrophic sport-related EHS deaths in secondary school sports in the last 40 years (from 7 / 1 / 1982 through 6 / 30 / 2022)

captured in the National Center for Catastrophic Sports Injury Research (NCCSIR) database were included in this descriptive epidemiological study (n=67). Any non-sport-related deaths were excluded. Event details were captured through systematic media searches of publicly available news reports and reports submitted directly to the NCCSIR. Characteristics of the sex, age, sport, geographic region, month, and event type (competition/game, conditioning, practice, scrimmage, strength/weight session, or other) were summarized. A 5-year rolling average was provided over the 40-year period, see figure. A Chi-Square test of goodness of fit was performed for the four 10-year blocks of deaths ($\alpha=0.05$) to examine any significant differences between decades. **Results:** Of the 67 deaths, 66 (98.5%) were male. Ages ranged from 13-18 years old, with 16 (n=20) and 17 (n=19) years old making up 58.3% of all deaths. Football accounted for 63 (94%) of deaths, while basketball (n=2), soccer (n=1), and track and field (n=1) accounted for the remaining cases. The southern region had the largest number of deaths, n=50 (74.6%). The month of August accounted for the greatest deaths (n=35), with July (n=15) and September (n=9) following. Official school practice represented most cases, n=56 (83.6%). When broken into four 10-year blocks, the Chi-Square analysis demonstrated that the proportion of EHS deaths was significantly different across time, $\chi^2(3, n=67) = 8.72$, $p=0.0326$. The block from 2002-2011 had the highest number of EHS deaths (n=26), while both 1992-2011 and 2012-2021 had 16 deaths.

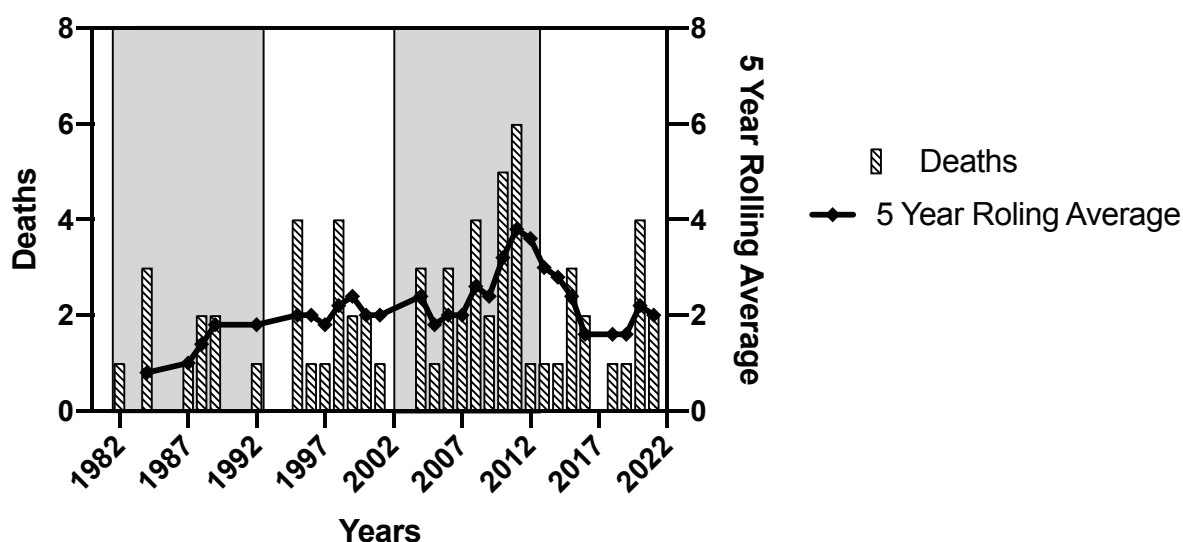
See figure. **Conclusions:** Overwhelmingly, football had the highest (94%), and almost exclusive cases of EHS-related death. Other factors predominantly characterizing EHS deaths included males (98.5%), those between the ages of 16-17 (58.3%), the southern region (74.6%), and the month of August (52.2%). The most recent 10-year decade shows a 38% reduction from the peak decade (2002-2011, n=26). While the cause of these trends was not explored, targeted prevention strategies for EHS, emergency planning that includes coordination of care, and emergency equipment are necessary to prevent catastrophic sport-related death due to EHS.

Established Career Winner

Fellow sponsored by Douglas James Casa, PhD, ATC, FNATA.

The National Center for Catastrophic Sport Injury Research (NCCSIR) is supported by the American Football Coaches Association (AFCA), the National Collegiate Athletic Association (NCAA), the National Federation of State High School Associations (NFHS), the National Athletic Trainers' Association (NATA), the American Medical Society for Sports Medicine (AMSSM), and the National Operating Committee on Standards for Athletic Equipment (NOCSAE).

High School Exertional Heat Stroke Deaths



Note: 5-year rolling average represents the average yearly deaths based on previous 5-year numbers. Gray blocks distinguish separate decades.

Core Temperature Afterdrop Following Cold Water Immersion of Hyperthermic Individuals Is Independent of Clothing Worn

Pryor RR, Fitts T, Haboian K, Nance K, Schwob J: Center for Research and Education in Special Environments, University at Buffalo, Buffalo, NY

Context: To expedite cooling initiation, exertional heat stroke patients may be placed in and later exit cold water immersion while wearing clothing they were wearing upon heat stroke commencement, including a shirt and socks in addition to shorts. Anecdotal evidence indicates that some exertional heat stroke patients wearing additional clothing have required hospital transport for hypothermia due to substantial post-immersion core temperature (Tc) afterdrop. The purpose of this study was to test the hypothesis that individuals wearing additional wet clothing would have a greater post-immersion Tc afterdrop and a sustained reduction in Tc following cold water immersion egress compared to individuals wearing minimal wet clothing. **Methods:** This randomized clinical trial had a volunteer sample of 8 male and 7 female participants (Age: 22 ± 4 y, Height 1.71 ± 0.11 m, Weight: 71.2 ± 16.3 kg, Body Fat: $14.3 \pm 6.1\%$) complete treadmill exercise in a hot chamber until Tc reached $39.5 \pm 0.6^\circ\text{C}$, followed by cold water immersion ($15 \pm 1^\circ\text{C}$) until Tc reached 38.0°C . Following immersion, participants lightly towel dried to remove dripping water, then rested on a cot in a supine position for 45 min while a fan provided a slight breeze (0.8 km / h) in a temperate room ($28 \pm 3^\circ\text{C}$, $65 \pm 4\%$ relative humidity). Participants wore either 1) wet shorts and sports bra (in females) (MINIMAL; N=8) or 2) a wet long-sleeved shirt and long socks in addition to wet shorts and sports bra

(in females) (ADDITIONAL; N=7). Tc was measured using a validated ingestible gastrointestinal pill. The primary variables were Tc afterdrop (start of post-immersion Tc - Tc nadir (lowest Tc) and Tc rise after nadir, analyzed using a 2-way group x time analysis of variance. Secondary variables were time to nadir and nadir cooling rate, analyzed using independent-samples t-tests. Analyses were performed in SPSS statistical software and presented as Mean \pm SD.

Results: Start of post-immersion Tc was similar between MINIMAL ($37.5 \pm 0.4^\circ\text{C}$) and ADDITIONAL ($37.4 \pm 0.4^\circ\text{C}$, $p=0.76$) and decreased to the nadir in each group ($36.6 \pm 0.5^\circ\text{C}$, $p < 0.01$; $36.4 \pm 0.7^\circ\text{C}$, $p < 0.01$), respectively, with no between group difference ($p=0.71$) or interaction effect ($p=0.79$). Time to nadir and nadir cooling rate were not different between MINIMAL (25.1 ± 12.0 min, $0.04 \pm 0.02^\circ\text{C} / \text{min}$) and ADDITIONAL (27.6 ± 13.8 min, $p=0.72$; $0.05 \pm 0.03^\circ\text{C} / \text{min}$, $p=0.91$), respectively. Tc rise after nadir was similar between MINIMAL ($0.0 \pm 0.0^\circ\text{C}$) and ADDITIONAL ($0.0 \pm 0.0^\circ\text{C}$, $p=0.37$). End of post-immersion Tc remained lower than pre-exercise Tc in each group ($37.3 \pm 0.3^\circ\text{C}$, $p=0.03$; $37.4 \pm 0.2^\circ\text{C}$, $p < 0.01$), respectively, with no between group difference ($p=0.98$) or interaction effect ($p=0.52$).

Conclusions: Tc remained reduced 45 min following cold water immersion compared to pre-exercise and was not impacted by type of wet clothing worn. Practitioners may not need to remove excess patient clothing upon water egress, as post-immersion Tc afterdrop was not different between those wearing minimal and additional wet clothing.

This study was a secondary analysis of a study funded by the National Athletic Trainers' Association Research and Education Foundation Master student grant (1920MGP03).

Correlations Between High School Specific Wet Bulb Globe Temperature and Local National Weather Service Heat Index Readings

Wilkins SJ, Vogel CM, Mark T, Rosen AB, Meredith TJ: University of Nebraska at Omaha, Omaha, NE

Context: Wet Bulb Globe Temperature (WBGT) is considered best practice for monitoring heat stress for outdoor activities. If access to WBGT measurements is not available, schools may utilize National Weather Service (NWS) reports for heat index data to assist in clinical decision making. While these NWS reports may provide less accurate, non-specific recommendations, the relationship between NWS data and location specific WBGT readings have not been fully explored. Therefore, the purpose of this study was to determine the relationship in WBGT readings at high schools and the nearest NWS station. Additionally, this study compared site specific WBGT readings and activity modifications reported by each site with stated recommendations. **Methods:** Cohort design. Secondary school athletic trainers in the state were asked to record daily the pre-event WBGT readings, highest recorded WBGT readings during activity, associated modifications made to outdoor activity, and number of heat illness cases from August 8-September 16, 2022. WBGT data was collected using Kestral 5400 devices. Recorded data from the athletic trainers was submitted electronically to the research team

daily if outdoor activities were scheduled at their school. Recorded data was date and time matched with heat index data from the nearest NWS weather station to the school. Data were summarized using means (SD), and frequencies and percentages. Pearson r correlations were calculated to determine relationship with pre-event WBGT reading and NWS heat index values, highest WBGT readings during the event and NWS heat index values ($p < 0.05$).

Results: Twenty-four athletic trainers from different locations in the state participated in the study, recording a total of 447 unique data entries (mean pre-event WBGT: 78.92 ± 6.31 , highest WBGT reading during activity 80.5 ± 5.6 , NWS Heat Index: 88.27 ± 4.44). A positive moderate correlation was calculated between pre-event WBGT reading and heat index reading ($r = 0.515$, $p < 0.001$) and highest WBGT reading during activity and heat index reading ($r = 0.517$, $p < 0.001$). Three total pre-event WBGT readings were reported in the “black” range, however, the schools did not report cancelling activities as recommended as a result of those readings. **Conclusions:** Both pre-event and highest WBGT reading during activity were moderately correlated with NWS heat index calculations. Using WBGT temperature is the most accurate method for measuring heat stress for outdoor activities. Even when secondary school ATs measured WBGT values in the “black” category, outdoor activities were not cancelled. More education is needed on how to measure and interpret WBGT values for ATs.

A Descriptive Study of Emergency Preparedness in Youth Sports

Boergers RJ, Bowman TG, Hiltz D, Blitzer R, Genao G, Gould J, Wallace S: Seton Hall University, South Orange, NJ; University of Lynchburg, Lynchburg, VA; Code One Training Solutions, East Hartford, CT

Context: A large number of youth athletes participate in sports as a form of socialization and to maintain a healthy lifestyle. With increased sport participation comes increased risk of injury. Sudden cardiac arrest is the leading cause of death among youth athletes in the United States. Intervention using a well-designed EAP, by trained individuals and expedient use of an AED greatly increases the survival rate of sudden cardiac arrest in youth athletes. The purpose of this study was to evaluate the level of preparation, training of personnel, and availability of AEDs for responding to emergencies in youth sports organizations. **Methods:** We recruited adults ($n=357$, age= 29.55 ± 8.65 yrs) who were parents ($n=204$, 45.2%), coaches ($n=77$, 17.1%), administrators ($n=34$, 7.5%), athletic trainers ($n=14$, 3.1%) or other ($n=28$, 7.8%) of youth sport athletes from 36 states to complete a questionnaire regarding emergency planning in youth sport. Twenty-two different sports were represented with the largest response for girl's soccer ($n=46$, 10.2%). The authors collaborated on a questionnaire draft and had it peer reviewed ($n=1$). Following peer review, we completed 2 iterations of expert review where panelists ($n=3$) scored question clarity, importance, and relevance to the research questions on a 4-point Likert scale. Final questions included

had average scores ≥ 3 . Following expert review, we completed pilot testing with 10 participants meeting inclusion criteria before finalizing the questionnaire. Participants were recruited via purposive, convenience, and snowball sampling methods. We posted recruitment scripts to various social media accounts and sent emails to administrators of youth sport organizations asking them to forward study information to respective stakeholders between March and October 2022. Participants agreed to the terms of the consent form and completed the online questionnaire via Qualtrics. The questionnaire contained demographic questions and specific questions related to the existence of written and publicly available EAPs, CPR/AED training of coaches and personnel, and expedient access to AEDs. We used question logic to ask follow-up questions. We analyzed frequency data of the responses. **Results:** Responses for EAP availability, expedient access to AEDs, and confidence in management of cardiac emergencies are provided in Table 1. When asked if coaches were required to be CPR/AED certified, participants responded with varying responses ("yes"=97, 38.6%; "no"=79, 31.5%; "unsure"=75, 29.9%). Participants mostly thought AEDs were available at home practice venues ($n=136$, 54.8%), while fewer responded "no" ($n=56$, 22.6%) or "unsure" ($n=56$, 22.6%). **Conclusions:** Overall, results suggest lack of knowledge in whether or not there are EAPs publicly posted and accessible, whether coaches are CPR/AED certified, and whether AEDs are expediently accessible during youth sport participation. Therefore, we urge youth sport administrators to have clearly defined policies and procedures regarding safety measures during sport participation and clearly articulating them to all youth sport stakeholders.

Table 1. Responses for emergency preparedness questionnaire [frequency, (%)].

	Always	Almost Always	Most of the Time	Some of the time	Almost Never	Never	Unsure
Is the EAP for the <i>home practice venue</i> written and publicly accessible?	35, (12.4)	20, (7.1)	14, (5)	22, (7.8)	44, (15.6)	55, (19.5)	92, (32.6)
Is the EAP for the <i>home competition venue</i> written and publicly accessible?	33, (12.1)	17, (6.3)	13, (4.8)	19, (7.0)	31, (11.4)	52, (19.1)	107, (39.3)
Can the AED be retrieved and brought to patient's side within 1-3 min at the <i>home practice venue</i> ?	79, (59)	24, (17.9)	14, (10.4)	4, (3)	2, (1.5)	2, (1.5)	9, (6.7)
Can the AED be retrieved and brought to patient's side within 1-3 min at the <i>home competition venue</i> ?	77, (59.2)	25, (19.2)	9, (6.9)	3, (2.3)	2, (1.5)	2, (1.5)	12, (9.2)
Are you confident that a cardiac emergency would be handled appropriately?	29, (13.4)	29, (13.4)	41, (19)	42, (19.4)	18, (8.3)	9, (4.2)	48, (22.2)

Disparities in Sickle Cell Trait Care: An Examination of Policies and Resources
Meyer CM, Hirschhorn RM, Lane AD, Arent SM, Buono KM, Yeargin SW:
University of South Carolina, Columbia, SC, and Louisiana State University, Baton Rouge, LA

Context: Comprehensive safety policies can prevent exertional sickling through prescribed work-to-rest ratios from strength and conditioning coaches (SCC) and treatment from athletic trainers (ATs). However, disparities may be present regarding sickle cell trait (SCT)-related policies and SCC or AT staffing between types of institutions. This study aimed to: 1) describe current SCT-related policy variables and staffing at NCAA institutions; and 2) determine if associations between university designation (Historically Black College or University [HBCU] vs. Non-Historically Black College or University [Non-HBCU]) or NCAA Division (I/II/III) and SCT-related policy variables exist. **Methods:** Cross-sectional surveys were emailed to ATs at NCAA institutions using REDCap. The survey collected self-reported university designation, NCAA division, number of student athletes (SAs), number of full-time ATs, number of full-time SCCs, existence of SCT-related policy variables (yes/no/unknown), and SCCs

policy involvement (Helped Develop/Sign-to-Acknowledge Policy/ Trained-Annually/Unknown). AT:SA and SCC:SA ratios were calculated by taking the number AT or SCC and dividing by total number of SA and multiplying by 100 (reported as staff per 100 SA). A Mann Whitney-U test compared AT:SA and SCC:SA ratios by university designation whereas a Kruskal-Wallis H-test with post hoc Dunn's Test evaluated NCAA divisions. Chi Square analyses with cross-tabulations determined differences in SCT-related policy variables and involvement between designations and divisions. **Results:** A total of 76 ATs responded: 76.3% from Non-HBCUs (n=58) and 71.0% from NCAA DI (n=27) or DII (n=27) institutions. The majority reported they had a policy on exertional sickling (n=42, 71.2%) and did not know if SCCs were educated annually on the policy (n=40, 52.6%). Existence of SCT-related policy variables and involvement with policies were associated with division (table), but not between designations (p>0.05). The mean ratio of AT:SA was 2.00 for DI, 1.10 for DII, and 0.92 DIII. The division significantly affected the ratio across divisions, with differences between DI and II ($\chi^2 (2)=18.3$, p<0.001) and DI and III ($\chi^2 (2)=24.6$, p<0.001). The mean ratio of SCC:SA was 0.94 for DI, 0.32 for DII, and for 0.33 DIII. The division significantly affected the ratio across divisions, with differences between DI and II ($\chi^2 (2)=25.0$,

p<0.001), and DI and III ($\chi^2 (2)=21.1$, p<0.001). There was no significant difference in AT:SA or SCC:SA ratio between HBCU and Non-HBCU institutions (p>0.05). **Conclusions:** Although most institutions have an exertional sickling policy, it is concerning that most SCCs lacked training on exercise prescriptions for SCT athletes especially at DII and III levels where ATs are not required to be present for training sessions. Differences between HBCU and Non-HBCU resources and policies were not significant; instead discrepancies in care between divisions were identified as it relates to personnel. SCT education, and policy collaboration between AT and SCC, should be a priority of NCAA institutions to reduce exertional sickling events.

Dr. Susan Yeargin, Dr. Lane, and Dr. Arent, received \$13,960 from an internal University of South Carolina ASPIRE: Racial Disparities grant to fund this study aim in addition to a second aim.

Table. University Sports Medicine Sickle Cell Trait (SCT) Policy Variables by National Collegiate Athletic Association (NCAA) Division

Variables (survey respondents n=76)	DI %(n)	DII %(n)	DIII %(n)
Existence of Comprehensive Exertional Sickling Crisis Policy	51.9 (14)*	55.6 (15)	61.9 (13)
Supplemental oxygen present in <u>all</u> athletics facilities	18.5 (5)	11.1 (3)	4.8 (1)
Policy requiring ATs are present for strength and conditioning sessions	51.9 (14)*	22.2 (6)	14.3 (3)
Strength and conditioning coaches (SCCs) helped to develop SCT policy	0 (0)	0 (0)	0 (0)
SCCs sign to confirm implementation of the policies	96.3 (26)	92.6 (25)	85.7 (18)
SCCs re-educated annually on SCT policies	51.9 (14)	51.9 (14)	52.4 (11)
Athletic Trainers are trained to identify exertional sickling crisis	70.4 (19)	85.2 (23)	81.0 (17)
SCCs are trained to identify exertional sickling crisis	55.6 (15)	48.1 (13)	38.1 (8)
ATs are trained to develop exercise protocols/prescriptions SCT positive athletes	59.3 (16)	63.0 (17)	66.7 (14)
SCCs are trained to develop exercise and training protocols for SCT positive athletes	44.4 (12)	29.6 (8)	28.6 (6)

*proportion differed at p<0.05

Free Communications, Rapid Fire Presentations: In It For the Long Haul:

Treating Chronic Musculoskeletal Conditions and Pain

Thursday, June 22, 2023, 7:30 AM-8:25 AM; Room 237-239

Moderator: Brian Bratta, PhD, ATC

Lower Extremity Muscle Volume Differences Between Individuals With and Without Patellofemoral Pain

Glaviano NR, Kim S: University of Connecticut, Storrs, CT

Context: Patellofemoral pain (PFP) is a prevalent orthopedic condition, with females being twice as likely to develop PFP than males. Although the etiology of PFP is indecisive, neuromuscular impairments such as lower extremity muscle weakness seem to play a crucial role. Lower extremity muscle weakness is limited to major muscle groups, preventing a more specific assessment of individual neuromuscular impairments. Muscle volume is one possible measurement for individual muscles; however, current PFP literature is limited to the quadriceps muscle. Therefore, the aim of this study was to compare lower extremity muscle volume in females with PFP compared to a database of pain-free individuals. **Methods:** Thirteen females with PFP (age: 22.4 ± 3.9 years; height: 164.4 ± 5.9 cm; mass: 65.2 ± 13.5 kg; symptom duration: 38.5 ± 52.6 months; pain severity: 6.0 ± 1.5 cm in visual analog scale; self-reported function: 72.8 ± 5.1 points in Anterior Knee Pain Scale) completed this cross-sectional laboratory study. We quantified lower extremity muscle volume via magnetic resonance imaging, with the raw muscle volume (cm³) of each muscle being normalized to the product of the participant's mass and height (cm³ / kg*m) and compared to the normative database from 24 pain-free individuals. Independent t-tests were used to assess group comparisons while

Cohen's d effect sizes quantified the magnitude of difference. All statistical analyses were performed using SPSS (version 28.0; IBM Corp., Armonk, NY) with an alpha level set a priori at $P < .05$. **Results:** Compared to pain-free individuals, females with PFP had smaller muscle volume of the anterior hip muscles ($P < .0025$; $d=1.23-1.65$), deep external rotators ($P < .0013$; $d=1.0-1.5$), adductors ($P < .069$; $d=0.80-1.35$), and knee flexors ($P < .05$; $d=0.70-1.20$). Females with PFP had smaller muscle volume of the rectus femoris (PFP: $1.70 \pm .29$, Pain-free: $2.2 \pm .3$ cm³ / kg*m; $P < .001$; $d=1.67$) and vastus intermedius (PFP: $1.72 \pm .26$, Pain-free: $2.2 \pm .3$ cm³ / kg*m; $P < .001$; $d=1.60$); however, there was no difference in muscle volume of the vastus lateralis (PFP: 6.47 ± 1.10 , Pain-free: $6.8 \pm .8$ cm³ / kg*m; $P=.302$; $d=0.41$) or vastus medialis (PFP: $3.41 \pm .71$, Pain-free: $3.5 \pm .4$ cm³ / kg*m; $P=.623$; $d=0.23$) compared to pain-free individuals. Additionally, there was no difference in muscle volume of the gluteus maximus (PFP: $6.73 \pm .76$, Pain-free: $6.9 \pm .7$ cm³ / kg*m; $P=.498$; $d=0.24$) and gluteus medius (PFP: $2.47 \pm .42$, Pain-free: $2.6 \pm .4$ cm³ / kg*m; $P=.36$; $d=0.33$). **Conclusions:** Females with PFP present with smaller muscle volume of the anterior hip, deep external rotator, hip adductors and knee flexor muscle groups. While previous PFP literature supports muscle weakness of the quadriceps, gluteus medius, and gluteus maximus, we did not find smaller muscle volumes compare to a pain-free cohort. Heterogenous lower extremity volumetric profiles exist, suggesting individualized impairment-based interventions are warranted when treating females with PFP.

Musculotendinous Changes Among Adolescent Runners With Exercise-Related Lower Leg Pain

DeJong Lempke AF, Jackson S, Straccioli A, d'Hemecourt PA, Meehan WP, Whitney KE: School of Kinesiology, University of Michigan, Ann Arbor, MI; Department of Orthopedics, Boston Children's Hospital, Boston, MA; Harvard Medical School, Boston, MA

Context: Exercise-related lower leg pain (ERLLP) is one of the most common injuries incurred among adolescent runners. To date, there is limited information available on lower extremity morphological characteristics as they relate to ERLLP to guide rehabilitation efforts. Ultrasound imaging has previously been used to identify musculotendinous structural changes among adults with chronic lower limb injuries; similar measurement approaches may be adopted to determine the extent of musculotendinous change in injured adolescent runners. Therefore, the purpose of this study was to compare ultrasound-derived lower extremity musculotendinous thickness and echogenicity, and extrinsic ankle muscle pennation angles between adolescent runners with and without ERLLP. **Methods:** Twenty-eight adolescent runners participated in this study, including 14 adolescent runners with ERLLP (sex: 11F, 3M; age: 15±2 years; BMI: 21.6±1.9 kg/m²), and 14 healthy adolescent runners (sex: 6F, 8M; age: 16±1 years; BMI: 20.5±2.7 kg/m²). Standardized ultrasound imaging assessments were conducted for all participants by a single experienced sports medicine researcher. Following a five-minute rest period, patients were placed in a supine position to obtain bilateral ultrasound images of the tibialis anterior, abductor hallucis, and flexor digitorum brevis at the mid-belly of each structure. Participants then were positioned in prone with a neutral ankle to obtain bilateral ultrasound images of the medial gastrocnemius and the Achilles tendon. Musculotendinous thickness measures were obtained by measuring a vertical line between the superior and inferior borders of each structure, and were subsequently normalized to participant

mass. Echogenicity measures were obtained by a computerized histogram analysis (0-255 scale) for each structure. Lower echogenicity values (darker hues) are more favorable for muscle tissue, while higher echogenicity values (brighter hues) are more favorable for tendinous structures. Pennation angles were calculated for the medial gastrocnemius and tibialis anterior muscles by measuring the angle between the muscle fibers and deep aponeuroses. Separate 2x2 multivariate analyses of variance (MANOVA) with Cohen's d effect sizes were used to compare groups (ERLLP, healthy) and limbs (involved, uninvolved) for all ultrasound-derived measures. Alpha was set a priori to .05 for all analyses. **Results:** Adolescent runners with ERLLP had reduced muscle size for the intrinsic foot muscles and the medial gastrocnemius to the healthy group (p-range: 0.002-0.05), but not the tibialis anterior muscle (p=0.37; Table). The ERLLP also presented with reduced medial gastrocnemius pennation angles on their involved limb compared to their contralateral limb and to the healthy group (p<0.001; Table). Runners with ERLLP had reduced Achilles tendon size (p=0.03), and lower tendon echogenicity compared to healthy counterparts (p=0.02; Table). **Conclusions:** Adolescent runners with ERLLP exhibited morphological musculotendinous changes that may occur either as a result of or as a contributing factor to pain and persistent dysfunction. Our findings highlight key targets for rehabilitation for young, injured runners, particularly intrinsic foot muscle strengthening.

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Table. Between-group Comparisons for Ultrasound-derived Musculotendinous Measures.

Musculotendinous Structure	Outcome Measure	Exercise-Related Lower Leg Pain (N=14)			Healthy (N=14)		Between-Group Comparison
		Involved Limb	Uninvolved Limb	Limbs Combined	Involved Matched Limb	Uninvolved Matched Limb	
Medial Gastrocnemius	Mass-Normalized Thickness (mm/kg)	2.84 ± 0.55	2.84 ± 0.52	2.84 ± 0.53	3.50 ± 0.82	3.16 ± 0.77	p=0.01* d=0.72
	Echogenicity (0-255)	53 ± 25	51 ± 22	60 ± 23	58 ± 17	62 ± 17	p=0.99 d<0.2
	Pennation Angle (°)	23.1 ± 2.2 ^a	26.8 ± 3.5	24.9 ± 3.4	29.5 ± 3.9	26.5 ± 3.9	p<0.001* d=0.81
Tibialis Anterior	Mass-Normalized Thickness (mm/kg)	3.48 ± 0.53	3.52 ± 0.53	3.50 ± 0.71	3.70 ± 0.76	3.59 ± 0.68	p=0.37 d=0.21
	Echogenicity (0-255)	65 ± 40	64 ± 35	64 ± 36	63 ± 20	62 ± 20	p=0.80 d=0.07
	Pennation Angle (°)	11.9 ± 2.9	14.4 ± 1.8	13.1 ± 2.7	13.9 ± 3.5	12.7 ± 2.9	p=0.85 d=0.07
Abductor Hallicis	Mass-Normalized Thickness (mm/kg)	0.88 ± 0.24	0.89 ± 0.24	0.88 ± 0.24	1.11 ± 0.25	1.06 ± 0.25	p=0.002* d=0.86
	Echogenicity (0-255)	51 ± 19	47 ± 17	55 ± 14	56 ± 14	54 ± 15	p=0.16 d=0.37
Flexor Digitorum Brevis	Mass-Normalized Thickness (mm/kg)	1.07 ± 0.23	1.13 ± 0.24	1.10 ± 0.23	1.26 ± 0.24	1.18 ± 0.24	p=0.05* d=0.64
	Echogenicity (0-255)	61 ± 26	59 ± 25	66 ± 15	67 ± 15	65 ± 16	p=0.30 d=0.29
Achilles Tendon	Mass-Normalized Thickness (mm/kg)	0.99 ± 0.20	1.03 ± 0.24	1.01 ± 0.22	1.22 ± 0.27	1.10 ± 0.28	p=0.03* d=0.61
	Echogenicity (0-255)	89 ± 31	90 ± 29	89 ± 27	109 ± 29	105 ± 19	p=0.02* d=0.70

Mean and standard deviation of ultrasound-derived musculotendinous thickness and echogenicity on a 0-255 scale for all structures, and pennation angles for the medial gastrocnemius and tibialis anterior muscles.

*signifies statistically significant difference between groups at p≤0.05.

^asignifies statistically significant difference between limbs at p≤0.05.

Abbreviations: mm, Millimeters; kg, Kilograms; d, Cohen's d Effect Size.

Self-Efficacy and Physical Activity Are Related in Patients With Hip-Related Pain

Jochimsen KN, Murro M, Derrico D, Nguyen AD, Mancinelli CA: West Virginia University, Morgantown, WV; University of Delaware, Newark, DE; Boston University, Boston, MA

Context: Physical activity reduces chronic musculoskeletal pain; however, many individuals with chronic pain decrease their physical activity in an attempt to manage their symptoms. In patients with hip-related pain (HRP) (non-arthritic, intra-articular pathologies), self-efficacy and kinesiophobia are related to patient-reported function; however, the relationship to physical activity is unknown. Understanding this relationship will help identify treatment targets for improving physical activity as a means to reducing chronic hip pain. Therefore, we aimed to evaluate the relationships between self-efficacy, kinesiophobia, patient-reported hip function and physical activity [sedentary time and moderate to vigorous physical activity (MVPA)] in individuals presenting to an outpatient physical therapy clinic for HRP. We hypothesized that lower kinesiophobia and higher self-efficacy would be related to higher patient-reported function, lower sedentary time and higher MVPA. **Methods:** Participants reported their duration of symptoms (months) and completed the 11-item Tampa Scale for Kinesiophobia (TSK-11), the Self-Efficacy for Physical Activity Scale (SEPA),

and the 12-item International Hip Outcome Tool (iHOT-12) to assess patient-reported hip function. To assess physical activity, participants wore an ActiGraph accelerometer (wGT3X-BT) (60Hz) on a waistband centered over the painful hip for 7 consecutive days, of which 4 days (3 weekdays, 1 weekend day) were analyzed. Pearson's product-moment correlations were used to evaluate the relationships between TSK-11, SEPA, iHOT-12, sedentary time and MVPA ($P \leq 0.05$). **Results:** In 25 participants (18F/7M, 32.3 ± 9.7 years, 24.8 ± 6.7 kg/m²) presenting to an outpatient physical therapy clinic with HRP, the average patient-reported scores were: symptom duration 23.6 ± 26.6 months, TSK-11 26.1 ± 5.7 , SEPA 17.3 ± 4.6 , and iHOT-12 45.9 ± 18.5 . The average sedentary time was 28.3 ± 8.0 min/hr and the average MVPA was 3.1 ± 1.8 min/hr. iHOT-12 scores were related to TSK-11 scores ($r = -0.40$, $P = 0.05$) and MVPA ($r = 0.50$, $P = 0.02$), such that lower patient-reported hip function was related to higher levels of fear and a lower MVPA. SEPA scores were related to MVPA ($r = 0.52$, $P = 0.01$), such that higher self-efficacy was related to a higher MVPA. **Conclusions:** Higher patient-reported function is related to lower kinesiophobia and higher MVPA in patients with HRP. Likewise, higher self-efficacy is related to higher MVPA. Clinicians should screen patients' psychosocial health, including kinesiophobia and self-efficacy, as these measures could influence physical activity and patient-reported function.

Ultrasound Imaging of Collegiate Gymnasts Achilles Tendons Offers Insight Into Potential Risk Factors for Tendinopathy: A Pilot Study

Thompson Murray S, Chambers M, Cortes DH, Wadlinger R, Miller SJ: Department of Kinesiology, Pennsylvania State University, University Park, PA; Department of Mechanical Engineering, Pennsylvania State University, University Park, PA; PennState Health Primary Care Sports Medicine, Pennsylvania State University, University Park, PA

Context: Seventeen percent of collegiate women's gymnasts will rupture their Achilles tendon during their career. Previous literature suggests that tendon thickness and abnormalities are associated with Achilles tendinopathy and rupture; however, no studies have attempted to connect Achilles tendon morphological measurements with the development of tendinopathy. The objective of this study is to examine the potential relation between structural morphology of Achilles tendons and various subjective predictive measurements in the development of tendinopathy in a group of Division 1 collegiate women's gymnasts. **Methods:** This descriptive epidemiology study was conducted in a collegiate gymnastics facility. Power calculation with an alpha of 0.05, effect size of 0.80 at 80% power revealed the need for 15 subjects. A convenience sample of 15 collegiate women's gymnasts (age: $19.4 \pm 1.28y$), cleared to compete by the team physician, with no history of Achilles tendon rupture and no history of lower extremity injury in the past 3 months. Previous medical history, past career characteristics, leg dominance, VISA-A scores, and all ultrasound measurements (Acuson P300, 5-12 MHz) were

obtained at the beginning of the competitive season. Ultrasound imaging sites for thickness measurements included the calcaneal notch, midtendon and musculotendinous junction. Three images were obtained at each location, and the mean thickness (mm) was recorded (RadiAnt DICOM Viewer). Neovascularization and echogenicity were assessed in real time. Descriptive analysis included group means and standard deviations for the dependent variables of interest. The incidence of sonographic abnormalities was calculated. Paired t tests were used to analyze the continuous data. Two-tailed tests were chosen to evaluate significance. Cohen's d was set to 0.02, 0.05 and 0.08 for a small, medium, and large effect respectively. Forward stepwise multiple linear regression analysis was used to assess the relation between appropriate quantitative variables. **Results:** Comparing gymnastics dominant and nondominant Achilles tendon thickness, significant mean limb differences (MLD) were found at the midtendon (MLD = 0.67mm, $p < 0.001$; $d = 1.682$, 95% CI [0.87, 2.46]). History of low back injury ($\beta = 1.298$, $p = .001$), participation in floor exercise ($\beta = 1.233$, $p = .003$) and hours of training in high school ($\beta = 0.090$, $p = .050$) significantly predicted gymnastics nondominant midtendon thickness ($R^2 = 0.725$, $F(3,14) = 9.656$, $p = .002$). History of low back injury significantly predicted gymnastics dominant midtendon thickness ($\beta = 1.052$, $p = 0.026$), ($R^2 = 0.328$, $F(1,14) = 6.336$, $p = .026$). **Conclusions:** The gymnastics dominant leg Achilles tendon was found to be thicker than the nondominant leg indicating possible adaptive thickening or development of tendinopathy. A history of low back injury was a consistent significant predictor of tendon thickness. While additional research is needed, these findings reveal the potential for objective, clinical predictors of Achilles tendinopathy in collegiate women gymnasts.

Walking Kinematics, Kinetics, and Muscle Activation With and Without Femoroacetabular Impingement

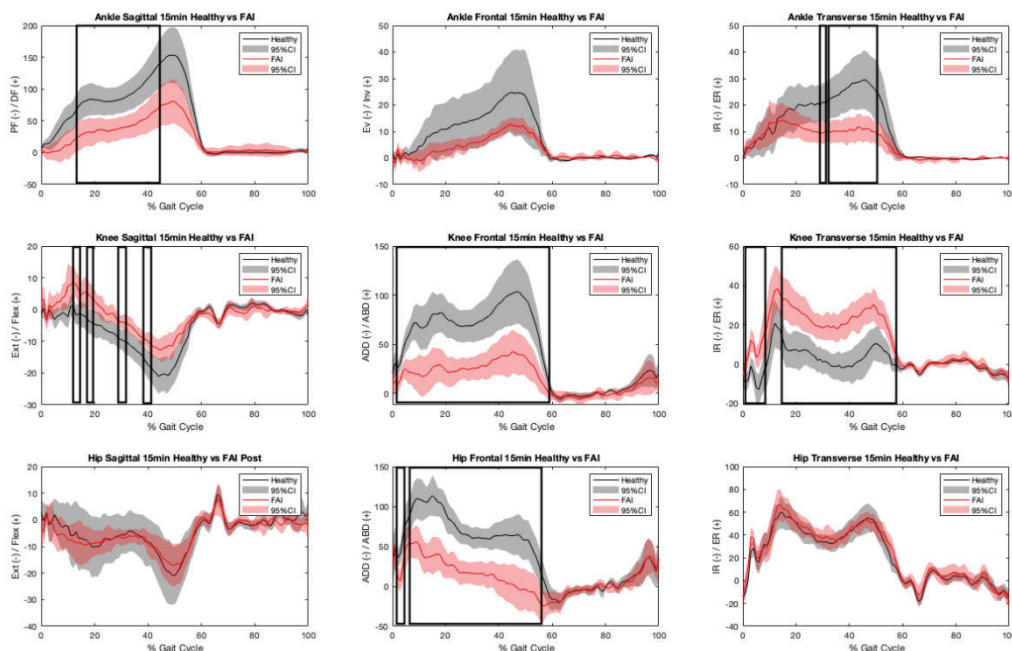
Swaim EM, Rodriquez K, Knudson D, Li Y, Koldenhoven RM: Department of Health and Human Performance, Texas State University, San Marcos, TX

Context: Approximately 60% of individuals that present with hip pain symptomology are diagnosed with Femoroacetabular Impingement (FAI). These individuals have demonstrated gait biomechanical deficits; however, current research presents inconsistent findings, limited motion analysis paired with surface electromyography (sEMG), varying gait speeds, and minimal timeframe for gait adjustment with FAI. The purpose of this study was to simultaneously analyze walking gait kinematics, kinetics, and muscle activity in individuals with and without FAI over a 15-minute bout of walking. **Methods:** Twenty-four adults (12 FAI, 12 Healthy) were recruited to participate in this study (FAI: sex (female, male) = 8,4, age = 22.3±3.9, height = 1.70±0.09 m, mass = 68.1±13.2 kg; Healthy: sex (female, male) = 8,4, age = 22.5±2.5, height = 1.68±0.08 m, mass = 73.9±11.9 kg). Participants completed walking trials on a treadmill at 1.3 m/s for 15 minutes. Three-dimensional kinematics and

kinetics were recorded simultaneously for the ankle, knee, and hip joints. sEMG amplitude was measured for the gluteus medius, gluteus maximus, tensor fascia latae, semitendinosus, and rectus femoris muscles. Ten consecutive strides from the beginning of each walking trial at each timepoint (5-minutes, 10-minutes, 15-minutes) were analyzed for the test limb using statistical parametric mapping (SPM). SPM t-tests were used to compare group differences between FAI and healthy groups ($p < 0.05$). The Holm-Bonferroni method was implemented to correct for potential inflation of type I errors due to the considerable number of potentially correlated variables assessed. **Results:** The healthy group demonstrated a significantly greater ankle dorsiflexion moment during the stance phase (0-11%, 13-48%; $p < 0.001$). The healthy group demonstrated higher knee abduction moments during the stance phase during the 5-minute (0-11%, 17-39%), 10-minute (6-9%, 16-17%, 18-30%), and 15-minute time point (6-9%, 16-36%; $p < 0.001$ for all timepoints). The healthy group demonstrated significantly less knee external rotation moments at the 15-minute time interval during the stance phase (1-7%, 15-37%; $p < 0.001$) (Figure 1). Hip abduction moments were significantly greater in the healthy group during the stance phase (2-4%, 6-39%) at the 5-, 10-, and 15- minute timepoints. No other significant differences were identified

for kinematics, kinetics, or sEMG amplitude measures. **Conclusions:** Individuals with FAI showed significant differences in ankle sagittal, knee frontal, and hip frontal moments throughout the gait cycle. The FAI group demonstrated lower ankle dorsiflexion moments and lower abduction moments within the frontal plane for the knee and hip. There were no differences in kinematic or muscle activity between the groups. Additional research is needed to further understand the compensatory mechanisms that may be adopted by individuals with FAI. These alterations could potentially be addressed during rehabilitation using gait training strategies by clinicians and practitioners, thus improving patient outcomes.

Figure 1.
Group Comparison of Mean \pm 95% CI Mass Normalized ($N \bullet m/kg$) Joint Moments at 15-minute Time Interval. (Significant differences highlighted by boxes).



Is Lower Extremity Strength Associated With Clinical Outcomes in Individuals With Patellofemoral Pain? A Systematic Review and Meta-Analysis

Kim S, Zuk EF, DiStefano LJ, Briani RV, Glaviano NR: University of Connecticut, Storrs, CT, and São Paulo State University, Presidente Prudente, SP, Brazil

Context: Patellofemoral pain (PFP) is a challenging condition, affecting up to one in four individuals with knee-related disorders. Multiple PFP consensus statements provide clinical recommendations that support exercise therapy with the ultimate goal of improving pain and function; however, the direct association between lower extremity strength and clinical outcomes is still uncertain. We aimed to (1) evaluate the association of lower extremity strength with pain or patient-reported outcomes in individuals with PFP and (2) conduct a meta-analysis to assess the effects of muscle contraction type and patient-reported questionnaire tools via inclusive data analysis of the available literature. **Methods:** We conducted a literature review adhering to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement via PubMed, Scopus, and SPORTDiscus. The search strategy included a combination of key search terms related to population (PFP or anterior knee pain) and outcome measures (lower extremity strength, pain, or patient-reported outcomes). Peer-reviewed studies published in English were included if they evaluated the association of lower extremity strength with pain or patient-reported outcomes in individuals with PFP. Methodological quality was determined by the modified Downs and Black checklist. For quantitative synthesis,

we pooled data across studies using the random-effects model and calculated pooled point estimates and 95% confidence interval (CI) using Comprehensive Meta-Analysis software. We quantified heterogeneity with the I² statistic, with significance set as I²>50% and P<.05. Correlation coefficients were interpreted as ‘weak’ (<0.4), ‘moderate’ (0.4–0.7), and ‘strong’ (>0.7). We used the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach to assess the overall quality of the evidence. Levels of certainty were defined as follows: ‘very low’, ‘low’, ‘moderate’, and ‘high’. **Results:** Thirteen cross-sectional studies were included, ten moderate quality and three high quality. Moderate evidence indicated no association between isometric hip abduction, hip extension, hip external rotation, and knee extension strength with subjective measures of pain. Low-to-moderate evidence indicated a weak positive association between isometric hip extension and Anterior Knee Pain Scale (AKPS) (r=0.35, 95% CI 0.04, 0.60, P=.027) and isometric hip external rotation with both the AKPS (r=0.38, 95% CI 0.07, 0.61, P=.017) and the Activities of Daily Living Scale (ADLS) (r=0.23, 95% CI 0.04, 0.41, P=.020). Low-to-moderate evidence indicated isometric knee extension strength has a weak positive association with the ADLS (r=0.21, 95% CI 0.02, 0.39, P=.032) but not with the AKPS. No data pooling was possible for any association related to isokinetic strength. **Conclusions:** Contrary to our expectations, there is low-to-moderate evidence that lower extremity strength has a weak or no association with clinical outcomes in individuals with PFP. Future research should evaluate if strength may have an indirect association with pain and function through other potential mediators following strengthening-based interventions for PFP.

The Effect of Myofascial Decompression and Cupping to Increase Hamstring Range of Motion: A Critically Appraised Topic

Riesgo R, Ostrowski JL, Saba-Whitermore B: Moravian University, Bethlehem, PA; Harkness Center for Dance Injuries, New York, NY

Context: Cupping and myofascial decompression (MD) are commonly used to treat muscular injuries by manipulating the soft tissue. Negative pressure pulls the skin and soft tissue into the cup, creating a localized stretch and fascial release designed to increase range of motion. Clinical question: In collegiate student-athletes, do cupping and MD increase hamstring range of motion (ROM), as compared to alternate therapy or a control group? **Methods:** The literature was searched for randomized control trials (RCT) and cohort studies investigating the relationship between MD and cupping on hamstring ROM. CINAHL, PubMed, and Google Scholar were searched in September 2021 for terms including hamstring pathologies, myofascial decompression, cupping, range of motion, and flexibility. The search returned 3 studies that met inclusion criteria and were published within the past 5 years: 1 cohort study and 2 RCTs. The cohort study was appraised using the STROBE scale (16/22) and was considered Level 2 evidence. The RCTs were appraised using the

PEDro scale (7/10, 8/10) and were considered Level 1 evidence. **Results:** Our search initially returned 23 studies; 16 were excluded after examination of the title and abstract and an additional 4 were excluded after full-text review, resulting in 3 articles used for critical appraisal. These studies included college student-athletes with and without hamstring pathology. All studies used MD or cupping for 3-7 minutes as the intervention, as compared to control, stretch, or self-myofascial release (SMR). Outcomes were measured post-treatment in each study using an inclinometer. Cupping and MD increased hamstring ROM when compared with passive stretching (MD mean = 11.4 ± 8.46 ; stretching mean = 10.2 ± 7.62 , $p < .001$) and SMR (MD mean = 3.68 ± 7.22 , SMR mean = 4.42 ± 3.55 , $p=0.19$), but there was no significant difference compared to a control group (MD mean = 4.35 ± 6.90 , control mean = 1.93 ± 5.61 , $p=0.35$). We found Grade “D” evidence to support cupping and MD as a beneficial option to increase hamstring ROM. The Center for Evidence Based Medicine recommends a grade of “D” for troubling inconsistent findings. **Conclusions:** Cupping and MD may be beneficial for increasing hamstring ROM, however a firm conclusion could not be drawn due to contradictory evidence and a limited volume of research. Future research should look to standardize cupping application and the amount of pressure in cups in order to compare results across studies.

The Effectiveness of Extracorporeal Shockwave Therapy on Reducing Pain and Improving Function in Athletes With Patellar Tendinopathy: A Critically Appraised Topic

Zwart MB, Gunnerson M: South Dakota State University, Brookings, SD

Context: Patellar tendinopathy is a common musculoskeletal disorder for which Extracorporeal Shockwave Therapy (ESWT) may be used to decrease pain and stimulate tissue regeneration. PICO clinical question: (P) In 18-25-year-old physically active individuals with patellar tendinopathy, (I) is extracorporeal shockwave therapy (O) effective in reducing pain and improving function? **Methods:** A search was conducted from August 2021 to December 2021 using PubMed, MEDLINE, ScienceDirect, Google Scholar, and hand searching reference lists. Key terms included patellar tendinopathy, anterior knee pain, shockwave, placebo, strengthening, injection therapy, decreased pain, and enhanced function. Studies included were level 3 evidence or higher, investigated shockwave therapy in individuals with patellar tendinopathy, measured pain and function, published in the last 5 years, and written in the English language. Studies were excluded if they investigated anterior knee pain due to acute injuries and utilized adolescent and/or geriatric populations. Evidence quality was appraised using the PEDro scale, STROBE guidelines, and PRISMA guidelines. Outcome measures included VAS, VISA-P, and EQ-5D. **Results:** The literature search returned five possible studies. Based on inclusion criteria, one systematic review, one randomized controlled trial, and

one prospective cohort study were appraised. Of the three studies appraised, only one study described statistically significant results in reducing pain (VAS score significantly reduced over time T0: 52.83 ± 20.86 , T24: 21.88 ± 25.42 ; $p < 0.0001$ and VISA-P scores significantly improved over time T0: 49.33 ± 18.7 , T24: 75.63 ± 21.90 ; $p < 0.0001$), and improving function (EQ-5D pain/discomfort scores T0: 1.98 ± 0.27 , T24: 1.25 ± 0.46 ; $p < 0.0001$, and EQ-5D usual activities scores T0: 1.72 ± 0.50 , T24: 1.25 ± 0.46 ; $p = 0.0001$). Two studies reported ESWT to be no different than placebo intervention in reducing pain and improving function (Intervention group increased VISA-P scores from 54.5 ± 15.4 to 70.9 ± 17.8 , whereas the placebo group increased from 58.9 ± 14.6 to 78.2 ± 15.8 ; between-group change: -4.8% , 95% CI: -12.7 to 3.0 ; $p = 0.150$). Moderate-level evidence suggests no difference between focused ESWT and placebo ESWT at short-term (3 months) and mid-term (5-6 months) follow-up in pain or function. **Conclusions:** There is a lack of evidence supporting ESWT for reducing pain and improving function in athletes with patellar tendinopathy. Clinicians should consider a multi-faceted approach including therapeutic exercise, injection therapy, pharmaceutical intervention, and therapeutic modalities to improve patient outcomes. Clinicians who have access to ESWT should acknowledge the lack of standardized treatment protocols. Protocols ranged from three sessions of ESWT at 48–72-hour intervals to three sessions at 1-week intervals. Dependent upon patient's tolerance, energy dose fluctuated between 0.02 to 0.58 mJ/mm², for a total of 1,000–2,500 impulses at a frequency of 4 Hz. With a financial burden of purchasing a unit, clinicians should consider other financially viable treatment options.

Free Communications, Rapid Fire Presentations: Contemporary Rehabilitation and Therapeutic Modality Paradigms to Improve Patient Outcomes

Thursday, June 22, 2023, 11:05 AM-12:00 PM; Room Entry 239

Moderator: Susan Saliba, PhD, PT, ATC

Leader-Follower Roles in Female Soccer Players: Interpersonal Coordination Within a Collision-Avoidance Task

Fernandes CA, Norte GE, Gokeler A, Schwab S, Sherman DA: University of Toledo, Toledo OH; Boston University, Boston, MA; Paderborn University, Paderborn, Germany; University of Cincinnati, Cincinnati, OH; Harvard University, Cambridge, MA; Live4 Physical Therapy and Wellness, Acton, MA

Context: Determining return to sport readiness following injury historically relies upon highly controlled and uniplanar assessments—e.g., hop testing. These tests are often critiqued for failing to replicate the chaotic demands of sport. Return to sport assessments that incorporate on-field dynamics may better assess patients within chaotic sport-like environments. We investigated interpersonal dynamics between female soccer athletes during a collision avoidance task through exploration of leader-follower roles in the context of injury history and whether external perturbations influenced coordination stability. **Methods:** In this cross-sectional study, nine dyads ($n=18$, nine individuals with history of lower extremity injuries paired with uninjured controls) completed 20 trials of an externally paced collision-avoidance agility task with an unanticipated change of direction (e.g., perturbation). Figure 1a-d depicts how participant trajectories were digitized using high-speed motion capture and analyzed using non-linear time-series analysis—cross recurrence quantification (CRQA). CRQA maximum lag was used to split trials into self-determined leader-follower groups—i.e., trials where leader was the participant with history of injury and trials where leader was the control participant. CRQA determinism (DET) and maximum line (MAXLINE) length were examined to explore dyadic coordination and task stability during early, perturbation, and late phases of each trial. Separate two-way

repeated measures ANOVAs were used to compare between groups (leader, follower) during three time points within each trial (early, perturbation and late phase). Cohen's d effect sizes are reported with 95% confidence intervals for significant findings. **Results:** All dyads demonstrated a high value of DET throughout all trials ($\geq 90\%$), indicating highly stable, coordinated behavior. The uninjured control participant was identified as the leader 65% in all trials and led for the majority of trials performed in 7 of 9 dyads. We observed a group-by-time interaction for DET ($F_{2,334}=3.5$, $p=0.03$) and MAXLINE ($F_{2,334}=3.8$, $p=0.02$, Figure 1e). When individuals with a history of injury were the follower, they demonstrated lower DET during the perturbation ($d=-0.31$ [-0.58, -0.04]) and late ($d=-0.26$ [-0.53, 0.01]) compared to the early phase. In contrast, when control participants were the follower, they demonstrated lower DET only during the perturbation compared to both early ($d=-0.47$ [-0.83, -0.11]) and late ($d=-0.44$ [-0.80, -0.08]) phases. DET was lower in the late phase when individuals with a history of injury were the follower compared to controls ($d=-0.34$ [-0.66, -0.02]). **Conclusions:** Participants successfully coordinated behavior during a collision-avoidance agility task. The stability of their coordination was negatively affected by external perturbation, regardless of injury history status. Interestingly, individuals with a history of injury were unable to recover stability in the later phase of the task when assuming a follower role. Although speculative, diminished ability to recover stable, coordinated behavior following an unanticipated perturbation may contribute to higher risk of re-injury seen in those with previous lower extremity injury.

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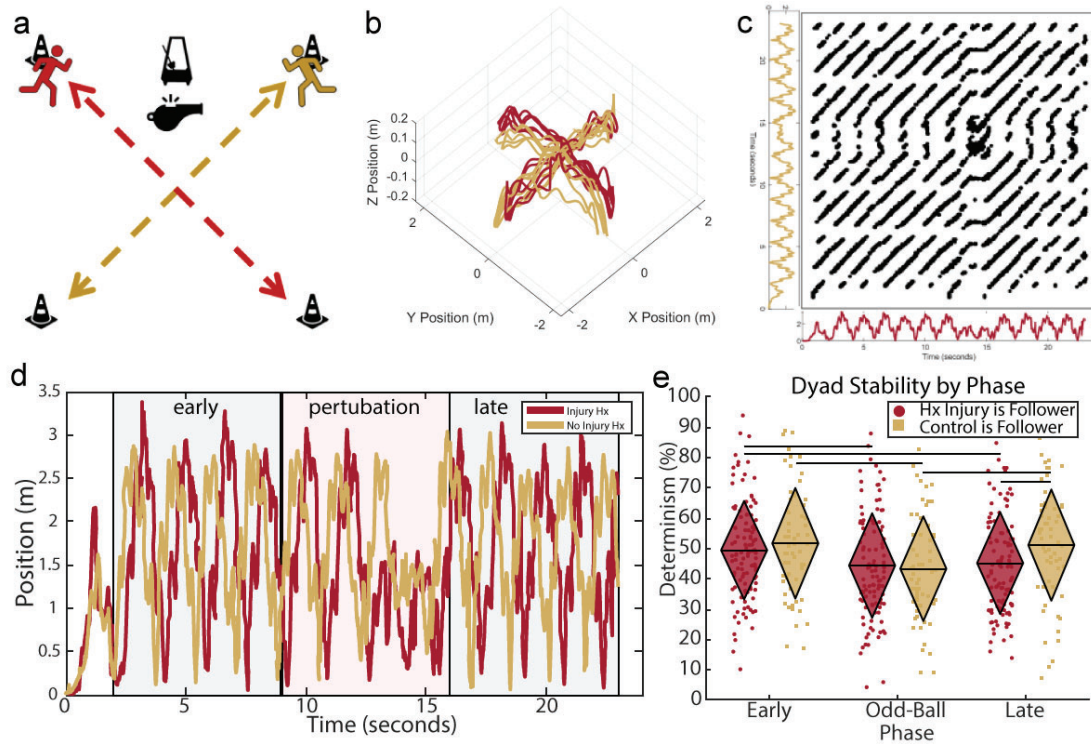


Figure 1. (a) Schematic of collision-avoidance task paced by metronome with oddball tone (whistle) occurring once. At oddball tone, participants would make a 90 degree turn at the center and continue the task—e.g., red would then take on path of gold and vice versa. (b) Raw cartesian position of the dyad movement (d) transformed into an overlaid time series of the overall Euclidean displacement. (c) The time series then subjected to CRQA analysis, producing the cross-recurrence plot. (e) Windowed analysis by leader-follower status through each stage of the collision-avoidance task for outcomes of DET. Diamond heights depict standard deviation. Individual trials are shown as red circles (History of Injury) and gold squares (Control) for each stage. Statistically significant differences are present for comparisons with horizontal lines.

Improving Patient-Based Outcomes in Individuals With a History of ACL Reconstruction: A Pilot Randomized Control Trial

Hoch JM, Baez SE, Kleis RR, Hoch MC, Dlugonski D: University of Kentucky, Lexington, KY; University of North Carolina at Chapel Hill, Chapel Hill, NC; University of Wisconsin-Eau Claire, Eau Claire, WI

Context: Many patients who sustain an ACL injury undergo ACL reconstruction (ACLR) and complete post-operative rehabilitation to return to pre-injury activities. However, individuals with a history of ACLR often have residual impairments after formal rehabilitation has ceased. A home-based rehabilitation program targeting residual impairments may improve patient-based outcomes following ACLR. The purpose of this pilot randomized controlled trial was to determine the effects of an 8-week home-based rehabilitation program on patient-based outcomes in individuals with a history of ACLR. **Methods:** Twenty participants (13 females; age: 23±3.2 years; time since surgery: 5±2.7 years) who injured their knee playing or training for sports, and had a unilateral ACLR without additional ligamentous reconstruction were enrolled. Participants reported to the laboratory pre-intervention and completed patient-based outcome measures. Participants were then randomized into the control (CON, n=9) or intervention (INV, n=11) groups. The control group was asked to continue daily activities. The intervention group received an 8-week home-based rehabilitation program designed to target lower extremity and core strength and balance. Participants were asked to complete the exercises 3-times per week, with a bi-weekly progression. All participants returned to the laboratory for two follow-up testing sessions

to complete the patient-based outcomes. The independent variables were group (CON, INV) and Time (pre-intervention, post-intervention, 1-month post-intervention). The dependent variables were scores on the Fear-Avoidance Belief Questionnaire (FABQ), the Knee Self-Efficacy Scale (KSES) and Tampa Scale of Kinesiophobia (TSK-11). Changes in patient-based outcomes were examined via separate linear mixed models. LSD post-hoc comparisons were performed in the presence of a significant time effect or group-by-time interaction. Intention-to-treat analyses were performed for participants that were lost to follow-up. Alpha was set a-priori at $p<0.05$. **Results:** Descriptive statistics can be found in Table 1. There was a significant interaction ($p=0.032$) for the TSK-11. The INV group had lower kinesiophobia 1-month post-intervention compared to 1-week post-intervention ($p=0.029$). No changes were identified in the CON group. There was a significant interaction ($p=0.006$) for the KSES-Future. The CON group reported less knee self-efficacy 1-month post-intervention compared to 1-week post-Intervention ($p=0.015$). No changes were identified in the INV group. No other significant interactions or main effects were detected. **Conclusions:** In this pilot study, the home-based supervised rehabilitation program did not appear to create significant improvements in patient-based outcome measures. However, the pre-intervention scores for both groups may have prohibited large improvements from pre-intervention to post-intervention. While we may not have improved patient-based outcomes in this group, this could be largely due to a pilot sample size of relatively healthy individuals with a history of ACLR. Future research should explore the effectiveness of this 8-week home-based rehabilitation in participants with a history of ACLR who report decreased patient-based outcomes.

Table 1. Descriptive statistics (mean (standard deviation)) for all patient-based outcomes.

Patient-Based Outcome	Control Group			Intervention Group		
	Pre-Inv	Post-Inv	1-month	Pre-Inv	Post-Inv	1-month
FABQ-Physical Activity	4.8(5.3)	4.9(5.8)	4.6(5.5)	4.8(3.5)	4.5(2.8)	3.5(4.1)
FABQ- Sport	6.9(7.2)	5.8(7.8)	7.3(8.2)	7.1(7.0)	5.4(6.1)	3.9(6.4)
TSK-11	18.0(6.5)	16.3(5.5)	16.6(5.4)	14.6(2.4)	15.8(2.9)	14.2(2.5) ^a
KSES-Daily Activities	9.8(0.3)	9.8(0.2)	9.7(0.4)	9.9(0.2)	9.9(0.1)	9.9(0.1)
KSES-Sport and Leisure	9.0(1.0)	9.1(1.1)	9.0(1.2)	9.6(0.4)	9.6(0.4)	9.5(0.4)
KSES-Physical Activities	9.1(1.0)	9.2(0.9)	9.0(1.0)	9.1(0.7)	9.2(0.6)	9.4(0.7)
KSES-Future	7.3(3.0)	7.8(2.8)	6.8(3.6) ^a	8.7(1.0)	8.4(1.1)	8.8(1.1)

Notes: ^a indicates significantly lower than post-intervention scores.

Use of Motor Imagery to Increase Muscle Strength in Lower Extremities of Healthy Individuals: A Critically Appraised Topic

Pearson B, Tierney RT, Russ AC, Mansell JL: Temple University, Philadelphia, PA

Context: Motor imagery (MI) is shown to boost performance by using an individual's own memories and experiences to create mental images of personalized and realistic situations without movement. Increased focus on psychological methodologies may encourage motor learning, potentially leading to improvement in injury prevention or rehabilitation outcomes. In healthy individuals, does the use of motor imagery increase muscle strength in lower extremities? **Methods:** PubMed, CINAHL and SPORTDiscus were searched in June 2022 using the Boolean phrase: "imagery or motor imagery" AND "muscle strength or increased muscle strength". Studies were included if they were randomized control trials using motor imagery intervention and outcome measures of strength in lower extremity. Articles were excluded if they included other modalities or upper extremity exercises or injured participants. Only studies from the past 5 years were considered. Article titles were reviewed for relevance, then abstracts, then full texts. The Physiotherapy Evidence Database (PEDro) Scale worksheet was used to critically appraise each article. Outcome measures were effect sizes (ES) of changes in maximal voluntary contraction for lower extremity compared across interventions. **Results:** The search returned 126 articles; 3

were selected. All studies showed an increase in muscle strength using MI compared to a control. Bougurtch et al assessed 3 muscles- the Soleus (ES=0.88), medial gastrocnemius (ES=1.16), and lateral gastrocnemius (ES=1.03). Dello Iacono et al. reported increased muscle strength in the MI group compared to control (ES=1.54). Grosprete et al. examined motor imagery in relative 1 repetition maximum (RM) back squat and a relative mean propulsive power back squat, both at 85% of 1 RM and optimum power load. For the 1 RM back squat, the participants using motor imagery in both 85% 1 RM and the optimum power load groups increased over controls (E =0.74 and 0.33, respectively). For the relative mean propulsive power, the participants using motor imagery in both 85% of 1 RM and the optimum power load group increased over controls (ES=0.76 and 1.11, respectively). All but one of the associations across the three studies demonstrated a large effect size (i.e., 0.5 and above). **Conclusions:** There is consistent but limited evidence supporting the use of MI to increase muscle strength in lower extremities. Two of the three studies used similar methodology, with all participants imagining completing a motion while one study had the groups imagine performing a complete activity. All articles received a 6/10 on the PEDro Scale. None used randomized controlled trials nor were the participants or investigators blinded to the study group assignment. SORT grade B. Studies revealed that MI is a successful modality to prevent loss of muscle strength in healthy individuals during a detraining period. Clinicians should consider using MI to improve neuromuscular function without involving training load.

Balance Exercise on Unstable Objects: A Descriptive Survey of Practice Patterns Among Healthcare Professionals

Cheatham SW, Baker R, Batts W, Ambler-Wright T, Sutton B: California State University Dominguez Hills, Dominguez Hills, CA; University of Idaho, Moscow, ID; California University Pennsylvania, California, PA; National Academy of Sports Medicine, Gilbert, AZ

Context: Balance training on unstable objects is a popular intervention used by healthcare professionals for a variety of purposes such as sport performance, injury or fall prevention, fitness, and rehabilitation. The research is mixed with no consensus on the optimal program. Understanding different professional beliefs and practice patterns may provide insight for future research and development of evidence-based guidelines. The purpose of this survey study was to document the beliefs and professional practice patterns for balance training on unstable objects among healthcare professionals in the United States. **Methods:** This was a cross-sectional survey of healthcare professionals. A 30-question online survey was emailed to members of the National Athletic Trainers Association and Academy of Orthopedic Physical Therapy. Professionals were also informed through a recruitment post in different private healthcare and fitness Facebook groups. Survey descriptive data was calculated including total responses, frequency count, and percentages. Data were treated conservatively, any respondents who failed to answer an item were removed from the data set. **Results:** A

total of 1,129 professionals began the survey. Six hundred and eighteen (N=618) respondents completed the survey and were included in the analysis. Forty-seven percent (n= 290) reported having a physical therapy license, 17% (n=105) reported being a certified athletic trainer, and 36% (n=223) reported also having some other healthcare related credentials. Most respondents used balance training with unstable objects for musculoskeletal post-injury rehabilitation (72%), athletic and sports performance (66%), and fall prevention (66%). Most believed the main therapeutic effects were enhanced motor control (88%), balance (85%), and somatosensory (85%) function. Most reported using the foam pad (80%), BOSU® (83%), air-filled stability disc/s (56%), and wobble board (54%). The most used subjective outcome was the Activities-specific Balance Confidence scale. Most respondents used single limb stance (85%) to measure static balance performance and the single leg squat assessment (51%) for dynamic balance. Respondents used variables such as dynamic movement, repetition and sets, and time-based training to challenge clients during training. Respondents considered recent injury or surgery, neurological or vestibular conditions, and impaired or altered sensation as the top three precautions. Respondents considered acute injury or surgery, neurological or vestibular conditions, and poor mentation as the top three contraindications. **Conclusions:** This is the first survey study to document practice patterns among healthcare professionals for balance training on unstable objects. This survey provides insight into how healthcare professionals use these devices and highlights different practice patterns and gaps between research and practice.

Blood Flow Restriction Resistance Exercise Performed to Failure Acutely Reduces Pain

Proppe CE, Rivera PM, Gonzalez-Rojas DH, Hill EC: University of Central Florida, Orlando, FL

Context: Pain is a commonly cited limitation during rehabilitation or as a reason that reduces engagement in physical activity. Exercise can acutely reduce pain (exercise-induced hypoalgesia, [EIH]) but typically high-intensity or long-duration exercise is required to elicit this response.¹ Alternatively, low-load resistance exercise (30-40% of 1 repetition maximum), combined with blood flow restriction (BFR), may induce EIH but there is little evidence that has evaluated different BFR protocols on EIH.² Therefore, the purpose of this study was to evaluate the effects of two commonly implemented BFR exercise protocols on EIH. **Methods:** Thirteen women (mean age \pm SD= 22 \pm 3 years, height= 162.7 \pm 4.4 cm, weight= 71.0 \pm 14.2 kg) and eleven men (mean age \pm SD= 22 \pm 4 years, height= 178.7 \pm 8.2 cm, weight= 78.8 \pm 11.3 kg) volunteered to participate in this study. One leg was randomly assigned complete 75 repetitions (1 \times 30, 3 \times 15) and the other to complete 4 sets to failure of isokinetic, unilateral, concentric-eccentric leg extensions at 30% of maximal strength. Exercise was completed during the same visit separated by 15 minutes and BFR was applied at 60% of total arterial occlusion pressure using an 11 cm wide cuff. Repetitions completed were analyzed using a 2

(Sex [male, female]) \times 2 (Protocol [75 repetitions, 4 sets to failure]) mixed factorial repeated measures ANOVA. To quantify EIH, pain pressure threshold (PPT) of the rectus femoris was measured before and immediately after exercise then examined using a 2 (Sex [male, female]) \times 2 (Protocol [75 repetitions, 4 sets to failure]) \times 2 (Time [Pre-test, Post-test]) mixed factorial repeated measures ANOVA. **Results:** For repetitions completed, there was no significant ($p = 0.485$, $\eta^2 = 0.022$) Sex \times Protocol interaction, but there was a significant main effect for Protocol ($p = 0.006$, $\eta^2 = 0.293$), but not sex ($p = 0.650$, $\eta^2 = 0.010$). Specifically, more repetitions were completed during the 4 sets to failure protocol (92.0 \pm 31.9) than the 75-repetition protocol (73.1 \pm 3.7). For PPT, there was no significant ($p = 0.072$, $\eta^2 = 0.140$) three-way interaction but there was a significant ($p = 0.024$, $\eta^2 = 0.211$) Protocol \times Time interaction. Follow-up analyses of simple main effects indicated that PPT increased from pre-test (3.3 \pm 1.9 kpf) to post-test (3.8 \pm 2.3 kpf) for the 4 sets to failure protocol ($p = 0.013$), but there was no change in PPT for the 75-repetition protocol ($p = 0.382$). **Conclusions:** There was an EIH effect for low-load BFR exercise when performing sets to failure that was not affected by sex. Completing low-load resistance training with BFR to failure, but not a 75-repetition protocol, might be a potent enough stimulus to acutely reduce pain during rehabilitation or exercise sessions. Collectively, these findings indicated that both men and women can achieve acute EIH when performing 4 sets to failure of low-load BFR exercise.

Acute and Residual Effects of IASTM and Percussion Massager on Hamstring Range of Motion and Patient Satisfaction

Choi H, Kinouchi Y, Stedje H, Herzog V: Weber State University, Ogden, UT

Context: Instrument-assisted soft tissue mobilization (IASTM) and percussion massagers are myofascial release techniques that have shown acute and residual effects for improving lower extremity ROM. However, no research has compared the effects of percussive massage vs. IASTM on hip PROM. The purpose of our study was to evaluate the acute and residual effects of these two treatments on passive hip flexion and compare patient satisfaction. **Methods:** This was a randomized controlled trial in a university laboratory. Participants were 60 (30M,30F) recreationally active individuals (age=24.52±4.26 yrs, ht=171.20±9.42 cm, wt=78.93±26.28 kg) with a deficit of hamstring flexibility, randomly assigned to one of three groups (10M,10F per group): IASTM (using Graston instruments - \$2395), Percussive massager (Theragun Elite - \$399), and control group. Exclusion criteria included lower extremity injury or surgeries in the last 6 months. Participants warmed up on a stationary bike for 5 minutes and then a researcher blinded to the treatment type measured their passive hip flexion ROM with the ankle at 90 degrees on day 1 pre- and immediate post-treatment, day 3 pre- and immediate post-treatment, and on day 8 using an Acumar digital inclinometer. For treatment groups, IASTM or percussion massager were applied to the dominant posterior low leg and hamstring muscles for 5 minutes each on days 1 and 3. The control group laid prone for 10 minutes.

Following each treatment, we assessed patient satisfaction for the IASTM and percussion massager groups. The dependent variables were passive hip flexion ROM and patient satisfaction (0-10 Visual Analog Scale). Data were analyzed using a two-way mixed ANOVA and ANCOVA for PROM and a two-way repeated measures ANOVA for patient satisfaction ($p < 0.05$). **Results:** There were no differences between groups over time for hip PROM ($F(8,228)=1.96, p=.068, n2=.064, \text{observed power}=0.737$), but there was a simple main effect for time ($F(4, 228)=11.01, p<.001, n2=.162, \text{observed power}=1.000$). The ANCOVA showed a significant difference in PROM at post-Day 1 treatment between groups ($F(2, 56)=3.771, p=.029, n2=.119, \text{observed power}=.665$), showing that percussive massager ($59.78 \pm 9.05^\circ$) produced a greater immediate increase in PROM compared to the control group ($56.28 \pm 10.87^\circ$); (difference= $3.38 \pm 1.26^\circ$; $p=.029$). None of the other timepoints showed significant differences between groups. The participants were equally satisfied ($F(2,76)=0.130, p=.850, n2=.003, \text{observed power}=0.068$) with the IASTM ($9.23 \pm .27$) and the percussion massager ($9.08 \pm .27$). **Conclusions:** There was an immediate improvement in hip PROM pre to post on Day 1 for the percussion massage group when compared to the control group. There were no residual effects on hip PROM over time for either treatment. Percussion massagers may be more effective, more affordable, and easier for novice users than IASTM instruments which may require formal training. Two treatments may not be sufficient to improve a ROM deficit; future research should include more treatments if ROM is measured with the ankle in 90 degrees of dorsiflexion.

The Response of Photobiomodulation on Muscle Fatigue When Applied at Different Time Points

Fisher SR, Martillaro JM, Rigby JH:
Texas State University, San Marcos,
TX, and University of Utah, Salt Lake
City, UT

Context: Photobiomodulation (light and laser) therapy (PBMT) can increase resistance to skeletal muscle fatigue when applied before exercise. However, there is limited evidence on how early PBMT can be applied before exercise. This study aimed to determine the optimal time between PBMT application and a knee extensor exercise to resist fatigue. **Methods:** A total of 60 participants (gender: F=29, M=31, age=21.0 y, BMI=24.7) were randomized into four different treatment groups (N=15 per group): (1) PBMT applied 0 h, (2) PBMT applied 5 h, (3) PBMT applied 24 h, and (4) sham PBMT at 0 h before exercise. We applied 4 PBMT LED patches (450 & 640 nm, irradiance=2.5 mW/cm², fluence=4.5 J/cm²) over the anterior thigh for the active treatment. The sham device had the same functionality as the active device, but no power was supplied through the device.

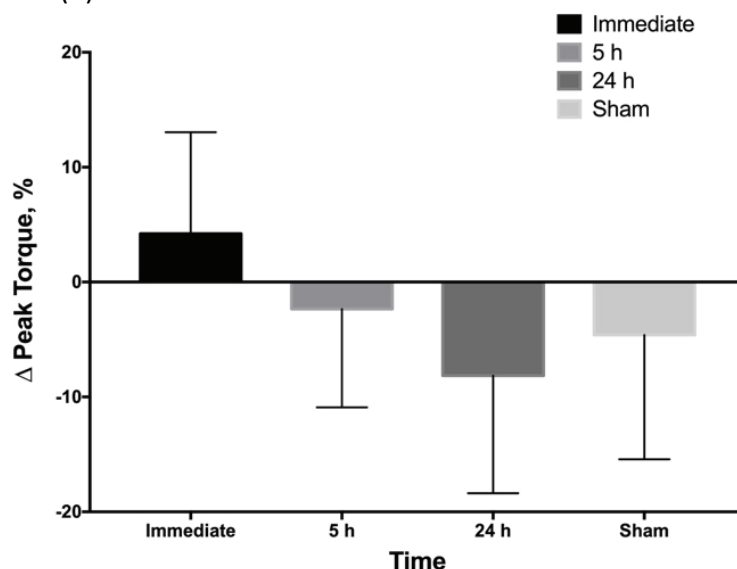
Participants made two visits to the research laboratory. During the first visit, we measured the participants' baseline knee extension isometric maximum voluntary contraction (MVC) at 60° on an isokinetic dynamometer. We used the peak torque of 3 repetitions. During the second visit, we applied the assigned treatment to the participant. At the assigned time after the treatment, the participant completed another isometric MVC test. We used this MVC peak torque to calculate the fatigue exercise thresholds of 50% and 45% MVC. We used 50% MVC as the target value participants tried to maintain during the fatigue exercise. Participants would perform isometric knee extension repetitions of 20 s with a 2 s rest for as many repetitions as possible until they could not maintain the 45% MVC threshold for longer than 2 s. Immediately after, participants completed a post-exercise MVC test. We provided verbal encouragement, and participants had visual torque feedback during all tests and fatigue exercise. We calculated the percent change between baseline and post-fatigue exercise peak torque for descriptive statistics. We used a repeated measures mixed models ANOVA to determine if there was a change in peak torque between the pre- and post-fatigue exercise. **Results:** The active 0 h treatment

group improved their mean percent change of peak torque (4.2 ± 16.0), while all other groups had more fatigue (Figure). However, there was no significant interaction between the treatment groups from the pre- to post-fatigue exercise MVC ($F_{3,55}=1.92$, $P=0.137$, effect size=0.49). There was no significant difference between the number of repetitions each group performed during the fatigue protocol ($F_{3,117}=0.89$, $P=0.451$). **Conclusions:** Though not statistically significant, there was a trend that PBMT applied immediately before helped reduce fatigue during an isometric knee exercise. Continued research and larger sample size are needed to confirm these PBMT effects when delivered immediately before an exercise bout. Investigators can then apply those findings to sport-specific movements.

Post-Professional Advanced Clinical Track
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Figure. Percent change peak torque means and 95% CI of the four treatment groups: (1) PBMT applied 0 h, (2) PBMT applied 5 h, (3) PBMT applied 24 h, and (4) sham PBMT at 0 h before exercise.



Effects of Short-Term Knee Immobilization on Quadriceps Structure and Function

Venegas LA, Perkins RK, Padovich MR, Avila J, Gabler CM: Weber State University, Ogden, UT

Context: Quadriceps muscle dysfunction after knee surgery has a rapid onset in patients and is an obstacle during rehabilitation. The cause of this dysfunction is multifactorial and difficult for clinicians to discern. In addition to pain, inflammation, and joint trauma, the disuse of the limb after surgery further contributes to the dysfunction observed in the quadriceps. Therefore, the objective of this study was to investigate the singular impact of short-term knee immobilization on the neuromuscular function and structure of the quadriceps in healthy adults. **Methods:** Thirteen, healthy male adults (age=23.8±5.6 years, height=177±5.8cm, weight=74.8±11.5kg) volunteered to participate in this prospective cohort study conducted at a university research laboratory. The participants' left knees were immobilized for a period of 7 days in a fiberglass cast. The cast was applied from 10 cm above the lateral malleolus to 50% of the distance between the ASIS and the superior pole of the patella. The knee was fixed in 45° of flexion. Unilateral isometric knee extension torque (KET) via isokinetic dynamometry, quadriceps percent activation (PA) via interpolated twitch technique, and cross-sectional area of vastus medialis (VMCSA) and lateralis (VLCSA) via musculoskeletal ultrasound were

measured in participants before and after immobilization. KET, VMCSA, and VLCSA were all normalized to body weight (per kg). Paired t-tests were performed to assess for significant differences between pre-and post-immobilization ($\alpha=0.05$). **Results:** Isometric KET of the involved limb was significantly decreased after immobilization when compared to baseline (2.08 ± 0.53 vs. 2.79 ± 0.75 Nm/kg, $p<0.001$). Likewise, both VMCSA and VLCSA in the involved limb were significantly smaller after immobilization when compared to baseline (VMCSA = 0.227 ± 0.061 vs. 0.258 ± 0.078 cm²/kg, $p=0.002$; VLCSA = 0.300 ± 0.053 vs. 0.327 ± 0.061 cm²/kg, $p=0.027$). The mean quadriceps PA was observably lower after immobilization when compared to baseline (79.44 ± 10.61 vs. $84.71 \pm 10.18\%$), but this difference was not statistically significant ($p=0.057$). **Conclusions:** A knee immobilization period of only 7 days elicited significant disuse atrophy and weakness in the quadriceps. However, immobilization did not significantly hinder an individual's ability to voluntarily activate their quadriceps, which suggests that knee immobilization affects quadriceps morphology more than its neural functioning. The short-term impact of joint immobilization emphasizes the importance of early mobilization and optimal loading in post-surgical rehabilitation. Furthermore, therapeutic interventions should be compared to determine the most effective and safest methods to implement during the acute phase of post-surgical rehabilitation.

Free Communications, Rapid Fire Presentations: Who? What? Where? When? Health Informatics of Injuries and Treatments Across Physically Active Populations

Friday, June 23, 2023; 7:30 AM-8:25 AM; Room 231-233

Moderator: Kristen Kucera, PhD, MSPH, ATC

Injury and Treatment Characteristics of Middle School-Aged Patients Under the Care of Athletic Trainers From 2010-2022: A Report From the Athletic Training Practice-Based Research Network

McCarthy M, Sigmon T, Marshall AN, Lam KC, Koldenhoven RM: Texas State University, San Marcos, TX; Appalachian State University, Boone, NC; A.T. Still University, Mesa, AZ

Context: An understanding of sports-related musculoskeletal injuries and treatment characteristics in middle school sports may inform patient care decisions such as appropriate medical coverage. Recently, there has been increased participation in youth sports, yet very few studies have identified the types of injuries and treatments related to middle school-aged athletes. While study findings involving high school and collegiate athletes may be used to infer injury and treatment characteristics in middle school athletes, a study of middle school athletes specifically would be most informative. Our objective was to describe injury and treatment characteristics of middle school-aged patients receiving care from athletic trainers within the Athletic Training Practice-Based Research Network (AT-PBRN). **Methods:** We retrospectively analyzed electronic patient records from the AT-PBRN. Patient records were completed by 59 athletic trainers (female=36, years certified=4.9±9.4, years employed at site=2.3±5.1) practicing in 36 athletic training clinics (middle school-high school grades combined=17, preparatory=9, middle=4, other=4) across 14 states between 2010-2022. We used summary statistics (frequency, percentages, median, interquartile ranges [IQR]) to describe injury (age at injury, sex, sport, body part, diagnosis) and treatment characteristics (type of treatment, number of visits, number of procedures per visit). Diagnosis and type of treatment were

recorded, respectively, using the International Classification of Diseases Version 10 (ICD-10) and Current Procedural Terminology (CPT) codes. **Results:** A total of 1,011 sports-related injuries were documented during the study period for middle school-aged athletes (age in years: 10=45, 11=135, 12=273, 13=558; sex: male=503, female=506, declined to answer=2). Football (17.7%, n=179), basketball (17.6%, n=178), and soccer (14.9%, n=151) reported the highest number of injuries. Ankle (17.1%, n=173), knee (16.5%, n=167), and head (14.1%, n=143) were the most common injury locations. Concussion (ICD-10=S06.0X0XA; 12.3%, n=124), ankle strain/sprain (ICD-10=S93.409A; 9.4%, n=95), and sprain/strain of the thigh/hip/groin (ICD-10=S73.109A; 7.4%, n=75) were the most reported diagnoses. A total of 3,870 treatments were recorded during the study period, with hot/cold packs (CPT=97010; 17.2%, n=665), therapeutic exercise (CPT=97110; 15.4%, n=595), athletic trainer re-evaluation (CPT=97006; 12.9%, n=501), athletic trainer evaluation (CPT=97005; 11.8%, n=456), and manual therapy (CPT=97140; 9.3%, n=358) being the most recorded services. Patients attended a median of 2 visits (IQR=1-4) with a median 2 procedures per visit (IQR=1-2). **Conclusions:** Middle school-aged athletes participating in football, basketball, and soccer reported the most musculoskeletal injuries, with concussions as the most frequent diagnosis, followed by ankle sprains/strains. Our findings concur with previous investigations at the high school and collegiate levels. Treatments at the middle school level were also similar to those that have been previously reported at the high school level with hot/cold packs and athletic trainer evaluation being the most common. This information provides insight for athletic trainers and parents/guardians that may impact care and safety of middle school-aged athletes.

Fellow sponsored by Kenny Lam, ScD, ATC.

Descriptive Epidemiology of Collegiate Student-Athletes for Acute, Overuse, Time-Loss, and Non-Time-Loss Spine Injuries From 2018-2019 to 2020-2021

Choe S, Bovbjerg VE, Soucy M, Fredericson M, Simon JE, Brown CN: Oregon State University, Corvallis, OR; Stanford University, Stanford, CA; Ohio University, Athens, OH

Context: Spine injuries comprise approximately 15% of all sports-related injuries and are more likely than most injuries to be associated with debilitating or life-threatening conditions. However, there is limited information about the occurrence of spine injuries by mechanism, type, time-loss (TL) status, and associated healthcare utilization. The purpose was to describe the occurrence of cervical (CS), thoracic (TS), and lumbar spine (LS) injuries and associated athletic training services (ATS), physician encounters (PE), and other healthcare utilization stratified by TL and non-time-loss (NTL) in collegiate student-athletes. **Methods:** De-identified electronic medical records authorized by student-athletes for research use were collected from August 2018 to July 2021 from a Division I conference. The data represent a total of 701 team seasons (308 men's and 393 women's) with 15 men's and 16 women's sports. Spine injuries

were reported by anatomical regions (CS, TS, LS), mechanism (acute or overuse), injury type, and stratified by TL/NTL. Frequencies of healthcare utilization were calculated for the occurrence of PE, prescribed medication, test, procedure, and surgery, and ATS provided per team per season. **Results:** A total of 1640 injuries (CS n=247; TS n=252; LS n=1141) occurred with acute-TL LS representing the highest frequency (n=393, 24%) followed by acute-NTL LS (n=351, 21%). By type, the occurrence of muscle strain was greatest for both men's (n=448, 27%) and women's (n=384, 23%) sports as well as ATS provided by gender (n=2241, 14%; n=3583, 21%, respectively). However, disc degeneration had the highest occurrence within procedures (men's n=12/51, women's n=7/51) and surgeries (men's n=5/14, women's n=4/14) for both genders. Football (12.4) and women's rowing (5.4) had the highest occurrences of overall spine injuries per team season, with the majority being LS injuries (Table 1). However, of the 17282 ATS provided, football (102.9) and women's gymnastics (59.9) had the highest ATS per team season, led by acute-TL LS in football (41.4) and overuse-NTL LS in women's gymnastics (20.3) (Table 1). Acute-TL LS injuries required the greatest number of PE (n=217), medication (n=74), tests (n=123), procedures (n=25), and surgeries (n=6). **Conclusions:** LS injuries accounted for 70% of all spine injuries

and required the majority of healthcare provided. Across all spine injuries, NTL and TL frequencies were similar within 1-3% by mechanism and location. Together, acute-NTL and overuse injuries accounted for over half of ATS provided, demonstrating substantial clinician workload and treatment burden. Further, the healthcare utilization per team season demonstrated that 'low-risk' sports required frequent ATS, particularly for NTL and overuse injuries. Better documentation of spine injuries including the mechanisms and TL status may improve injury prevention/management strategies as well as depict a more accurate estimate of clinician burden and workload.

Fellow sponsored by Cathleen N. Brown Crowell, ATC.

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Table 1. Lumbar Spine Injury Occurrence and ATS per Team Season for Selected Sports

Sports	Occurrence per Team Season				ATS per Team Season			
	Acute		Overuse		Acute		Overuse	
	TL	NTL	TL	NTL	TL	NTL	TL	NTL
BASEBALL (M)	0.84	0.16	0.32	0.13	15.55	0.29	5.35	2.23
SOFTBALL (W)	0.44	0.44	0.16	0.40	8.80	3.68	4.32	7.00
BASKETBALL (M)	0.59	0.56	0.06	0.06	3.24	1.88	0.62	0.21
BASKETBALL (W)	0.29	0.76	0.18	0.24	8.06	9.47	8.82	4.24
FOOTBALL (M)	3.79	2.56	0.76	1.06	41.35	21.26	9.91	8.26
GYMNASTICS (M)	0.83	0.83	0.67	1.00	7.33	4.50	8.17	2.83
GYMNASTICS (W)	0.45	0.41	0.73	1.32	16.86	3.64	12.82	20.32
LACROSSE (W)	0.22	0.72	0.06	0.28	9.11	13.50	0.00	4.89
ROWING (M)	0.54	0.13	0.67	0.38	2.04	1.08	3.33	0.21
ROWING (W)	1.29	0.52	0.86	0.62	25.33	1.95	15.48	3.43
SKIING (M)	0.00	0.00	0.67	0.00	0.00	0.00	2.67	0.00
SKIING (W)	0.50	0.33	0.33	0.33	1.50	1.50	9.33	0.33
SOCCER (M)	0.13	0.33	0.00	0.07	0.20	0.80	0.00	0.00
SOCCER (W)	0.24	0.44	0.12	0.24	4.09	11.62	4.41	12.82
SWIM/DIVE (M)	0.38	0.31	0.06	0.13	2.75	0.63	4.88	0.94
SWIM/DIVE (W)	0.43	0.91	0.22	0.13	8.00	9.57	19.35	5.43
TRACK & FIELD (M)	0.50	0.36	0.32	0.14	5.68	1.14	4.68	1.64
TRACK & FIELD (W)	0.59	0.71	0.47	0.56	5.71	7.85	6.94	6.03
VOLLEYBALL (M)	1.22	0.78	0.11	0.56	38.22	9.67	0.00	2.67
VOLLEYBALL (W)	0.41	0.38	0.18	0.35	5.32	4.18	6.53	5.03
BEACH VOLLEYBALL (W)	0.24	0.48	0.28	0.40	4.08	2.40	4.44	6.44
WRESTLING (M)	0.78	1.11	0.11	0.78	11.33	2.33	0.44	1.78

ATS: Athletic Training Services; TL: Time-loss; NTL: Non-time-loss

Epidemiology of Patients With Shoulder Dislocations Presenting to Emergency Departments in the United States, 2007-2020

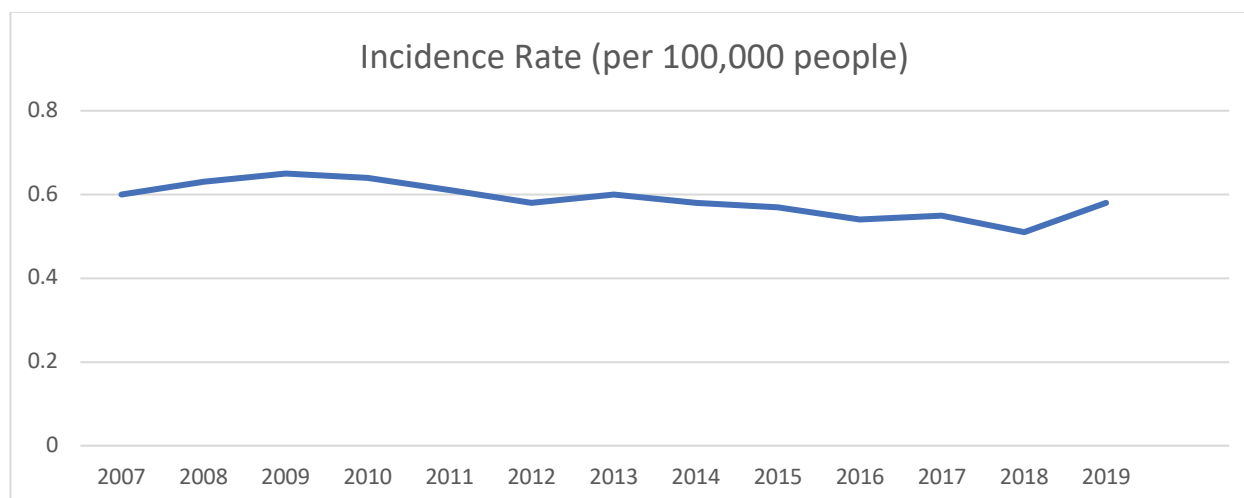
Rodriguez RR, Lam KC: A.T. Still University, Mesa, AZ, and Pacific University, Hillsboro, OR

Context: Shoulder dislocations are the most common type of joint dislocation treated in emergency departments (EDs) in the U.S. Shoulder dislocations can cause long-term pain, dysfunction, and decreased quality of life. A previous epidemiological study of patients with shoulder dislocations included ED visits from 2002-2006 with no subsequent follow-up investigation. Our aim was to provide an updated epidemiological report of ED visits for shoulder dislocations from 2007-2020. **Methods:** We extracted data from the U.S. Consumer Product Safety Commission's National Electronic Injury Surveillance System (NEISS) in September 2021. The NEISS database contains publicly available, de-identified patient data and represents a national population estimate based on a probability sample of 100 EDs in the U.S. Our query was limited to the body part code of "shoulder" and diagnosis code of "dislocation" and included the following variables: year, sex, age, location of injury, disposition, and a narrative description of the injury. We reviewed each narrative to identify glenohumeral joint dislocations specifically, the mechanism of injury (MOI), and other dislocation characteristics (directionality, laterality). We used descriptive statistics to summarize our findings. For incidence rate (IR) calculations, we abstracted U.S. population estimates for males and females from the U.S. Census Bureau for 2007-2019

by age group and calculated IR as the number of cases per 100,000 people. **Results:** A total of 26,203 patient cases (male=18,722, 71.4%) were recorded between 2007-2020. Injuries most frequently occurred at home (n=9,101, 34.7%) or a place of recreation (n=6,925, 26.4%). Sports or recreational participation was the most reported MOI (n=12,735, 48.6%) followed by falls (n=7,693, 29.4%) and other (n=3,457, 13.2%). Of the reported sport-related injuries, basketball (n=2,307, 18.1%), football (n=1,954, 15.3%), and biking (n=1,239, 9.7%) were the most common activities recorded. Of the cases in which directionality (n=1,323) and laterality (n=12,069) of dislocation were reported, most cases were classified as anterior dislocations (n=1,235, 93.3%) occurring in the right shoulder (n=6,597, 54.1%). Most patients were treated and released from the ED (n=25,052, 95.6%) with a small percentage being admitted for additional care (n=816, 3.1%). In general, IR did not change over time (range=0.5-0.6). When accounting for sex and age, males between 15-34 years old demonstrated the highest IR (range=1.1-2.9) when compared to other groups (Figure 1). **Conclusions:** Our findings suggest that incidence rates of shoulder dislocations have remained relatively consistent over the past 19 years. Young males, especially those participating in recreational activities such as basketball, football, and biking, are at the highest risk for a shoulder dislocation. Future research should aim to identify effective shoulder dislocation prevention strategies to limit the long-term dysfunction following this injury and to decrease the burden on the U.S. healthcare system.

Fellow sponsored by Kenny Lam, ScD, ATC.

Figure 1. Incidence Rate of Shoulder Dislocations in the United States from 2007-2019



Joint Injury and Osteoarthritis Are Associated With Cardiovascular Disease Risk Factors in Former NFL Athletes: An NFL-LONG Study

Kuenze C, Pietrosimone B, Currie KD, Walton SR, Kerr ZY, Brett BL, Chandran A, DeFreese JD, Manix R, Echemendia RJ, McCrear M, Guskiewicz KM, Meehan WP: University of Virginia, Charlottesville, VA; University of North Carolina at Chapel Hill, Chapel Hill, NC; Michigan State University, East Lansing, MI; Medical College of Wisconsin, Milwaukee, WI; Datalys Center for Sports Injury Research and Prevention, Indianapolis, IN; Boston Children's Hospital, Boston, MA; University Orthopedics Center Concussion Clinic, State College, PA

Context: Lower extremity osteoarthritis (OA) is associated with a 25% greater risk of cardiovascular disease (CVD) compared to those without OA. The prevalence of traumatic joint injuries among National Football League (NFL) players exposes these athletes to an elevated risk for OA and potentially a greater risk of cardiovascular risk factors (CRF) and CVD. Therefore, the

purpose of this study was to examine the association between a history of lower extremity joint injury, lower extremity OA, and the prevalence of CRFs and CVD among former NFL athletes. **Methods:** In this cross-sectional study, former NFL players completed a general health questionnaire via online or paper interface. Over 15,000 former NFL players were contacted via mailing, and a subset of these same individuals (n = 11,645) were also contacted via electronic mail if their email address was available. Former players were eligible to participate if they had played one or more full season in the NFL. Recruitment took place from 01/01/2019 to 02/14/2020 and data analysis took place from 08/11/2020 to 05/17/2021. A sub-sample of 1,738 former players reported lifetime medical diagnoses including CVD or CRFs such as hypertension, hypercholesterolemia, diabetes mellitus—type II, and sleep apnea. This survey acquired information about former players' personal demographics, football playing history, medical history, musculoskeletal injury and surgery history, self-reported functioning, health-related quality of life, current substance use, and health-related behaviors. Crude and adjusted prevalence ratios (PR) characterized the association between CVD or CRF with injury and/or OA diagnosis among athletes who reported 1) no history of lower extremity joint injury or surgery and no diagnosed OA, 2) athletes

with a history of lower extremity joint injury or surgery and no OA diagnosed OA, and 3) athletes with a history of lower extremity joint injury or surgery and diagnosed OA. **Results:** Neither history of lower extremity joint injury (PRadj=1.34, CI95=0.86, 2.07) nor history of lower extremity joint injury and diagnosed OA (PRadj=1.41, CI95=0.89, 2.25) were significantly associated with CVD (Table 1). However, CRFs were 30% and 53% more prevalent in former players with lower extremity joint injury and no diagnosed OA (PRadj=1.30, CI95=1.12, 1.50) and those with lower extremity joint and diagnosed OA (PRadj=1.53, CI95=1.31, 1.78) when compared to athletes with no history of either condition. **Conclusions:** Our findings indicate that after accounting for demographic factors, isolated lower extremity joint injury and post-traumatic OA significantly predict the prevalence of risk factors for cardiovascular disease among former NFL athletes. The prevalence of CRFs was highest among former NFL athletes with a history of lower extremity joint injury and diagnosed OA. These findings provide insight regarding the potential pathways to chronic diseases that may be initiated by joint injury early in life.

Work was funded by the National Football League.

Table 1. Prevalence Ratios (PRs) for Predictors of Cardiovascular Disease (CVD).

Predictor/Covariate	Prevalence Ratio (95% CI)		
	Full Sample n = 1,686	Participants ≥ 50 years of age (n = 914)	Participants < 50 years of age (n = 772)
Crude Model			
Injury, surgery, osteoarthritis history group			
No history of injury or surgery and no Osteoarthritis	1.0	1.0	1.0
History of injury or surgery without Osteoarthritis	1.29 (1.10, 1.51)	1.08 (0.93, 1.25)	1.66 (1.17, 2.34)
History of injury or surgery and osteoarthritis	1.85 (1.57, 2.18)	1.21 (1.04, 1.41)	3.24 (2.26, 4.67)
Adjusted Models			
Injury, surgery, osteoarthritis history group			
No history of injury or surgery and no Osteoarthritis	1.0	1.0	1.0
History of injury or surgery without Osteoarthritis	1.30 (1.12, 1.50)	1.10 (0.95, 1.28)	1.53 (1.11, 2.11)
History of injury or surgery and osteoarthritis	1.53 (1.31, 1.78)	1.20 (1.03, 1.41)	2.46 (1.72, 3.51)
Age (continuous; 1-year increase)	1.02 (1.02, 1.03)	1.01 (1.00, 1.01)	1.05 (1.04, 1.07)
Race/Ethnicity			
Identifies as White/non-Hispanic	1.0	1.0	1.0
Does not identify as White	1.23 (1.13, 1.35)	1.10 (1.00, 1.20)	1.46 (1.21, 1.77)
Obesity status			
Not obese (BMI < 30)	1.0	1.0	1.0
Obese (BMI ≥ 30)	1.26 (1.16, 1.37)	1.20 (1.10, 1.31)	1.25 (1.03, 1.52)
Liver & kidney disease			
No liver or kidney disease	1.0	1.0	1.0
Diagnosed with liver and/or kidney disease	1.10 (0.93, 1.30)	1.03 (0.87, 1.22)	2.09 (1.53, 2.86)
Smoked ≥ 100 Lifetime Cigarettes			
No	1.0	1.0	1.0
Yes	1.17 (0.85, 1.60)	1.14 (1.04, 1.26)	0.97 (0.71, 1.32)

Adjusted models consisted of the injury, surgery, osteoarthritis history contrast variable as the predictor while controlling for age, racial/ethnic identity, obesity status, diagnoses of liver and/or kidney disease, and smoking history. Significant PR values are those that do not include the value of 1.00 in their 95% confidence intervals (CIs).

Initial Concussion Evaluation Documentation Completeness Among ATs in the Collegiate Setting

Stratmoen EK, Johnson MM, Decoster LC, Hollingworth AT, Welch Bacon CE, Valovich McLeod TC, Beltz EM: New Hampshire Musculoskeletal Institute, Manchester, NH; A.T. Still University, Mesa, AZ; Northern Vermont University, Johnson, VT

Context: Medical documentation serves numerous purposes, including meeting professional standards, recording patient medical history, facilitating continuity of care, and minimizing malpractice exposure. Evidence suggests athletic training documentation is deficient. Objective assessment of documentation completeness is critical to documentation quality improvement efforts. The Concussion Documentation Audit Tool (CDAT) is a valid and reliable tool to assess the completeness of initial concussion evaluation documentation. The purpose of this study was to assess the completeness of initial concussion evaluation documentation among athletic trainers (ATs) in the collegiate setting. **Methods:** Ten de-identified initial concussion evaluation notes from a convenience sample of 6 collegiate institutions (60 notes total) were audited for this cross-sectional study. Initial evaluation was operationally defined as all encounters from the day a patient reported a concussion to the AT. Three certified ATs (1-36 years' experience) audited the notes using the CDAT. The

CDAT details 38 items essential to complete documentation in 4 clinically-relevant sections: history (7 items), presentation (13), physical exam (9), and assessment and plan (9). Three items are scored "present" or "absent" (scored 1 and 0, respectively), and the remaining items are scored 0-2, indicating criteria are fully (2 points), partially (1), or not met (0). Items with mean scores of < 0.5 and ≥ 1.5 were categorized as "low," and "high", respectively. Total score and scores for each section were divided by total possible points to determine mean completeness percentage. Descriptive analyses of CDAT score were performed by item, section, and total score. Results are presented mean \pm standard deviation. **Results:** CDAT total and section completeness were all below 60% (Figure). Six items had low completeness: concussion-related medical conditions (0.4 ± 0.8 points), current medications (0.2 ± 0.6), vital signs (0.00 ± 0.00), upper-extremity coordination (0.41 ± 0.81), differential diagnosis (0.06 ± 0.23), and patient understanding (0.19 ± 0.59). Five items had high completeness: mechanism of injury (1.7 ± 0.5), time elapsed between injury and evaluation (1.6 ± 0.8), level of consciousness (1.5 ± 0.5), symptoms at time of evaluation (1.9 ± 0.5), and plan of care (1.8 ± 0.7). **Conclusions:** These data align with previous findings that concussion documentation is incomplete. There were 2 items with low completeness and no items with high completeness in the physical exam section, contributing to its low section score. It is generally assumed that documentation reflects the clinical encounter; however, it is

unknown whether the notes audited in this study are deficient due to evaluation incompleteness, documentation incompleteness, or both. Additionally, it is also unknown how many ATs contributed to the sample of 60 notes. The CDAT can be used to ensure complete concussion evaluation and documentation. Auditing documentation completeness can inform quality improvement efforts by highlighting areas of concussion documentation, and potentially evaluation, that are being overlooked. Future research should include larger samples, more clinical settings, and seek to identify facilitators of and barriers to high quality documentation.

Fellow sponsored by Tamara C. Valovich McLeod, PhD, ATC, FNATA.

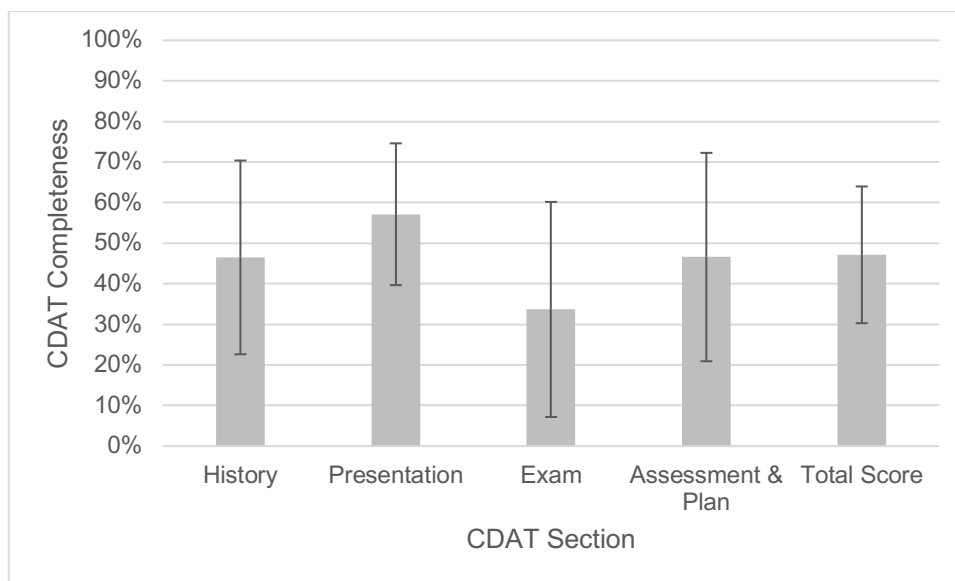


Figure. Mean CDAT completeness \pm standard deviation.

The State of Telehealth Education in Athletic Training

Carr WD, Volberding JL, Christian ME, Winkelmann ZK: Missouri State University, Springfield, MO; Oklahoma State University Center for Health Sciences, Tulsa, OK; University of South Carolina, Columbia, SC

Context: Within the telehealth literature, there are numerous case studies and position statements from various associations of model practices in telehealth delivery. However, there is little known about how healthcare professions are preparing future providers to deliver telehealth. The purpose of this study was to explore how professional athletic training programs are teaching, assessing, and structuring telehealth content for athletic training students. **Methods:** This cross-sectional study used an online survey to athletic training education programs (n=244). We recruited all current program directors listed on the Commission on Accreditation of Athletic Training Education website in January 2022. In total, 82 programs (34% response rate) participated. The programs were mostly state institutions (n=57, 70%), from medium cities (n=24, 29%), and had an average enrollment of 16±11 students in their program. Each program director completed the validated Telehealth Evaluative Content in Higher Education (TECHE; CVI=0.85, p<0.5) instrument on behalf of the program. Each respondent was asked a series of questions on how telehealth content was taught, assessed, and structured. Data were cleaned and basic descriptive statistics were calculated. **Results:** We identified an almost equal representation (yes=39, no=41, missing=2) from

respondents on if telehealth was taught and/or assessed in their athletic training program. Athletic training programs were mostly teaching telehealth content in multiple presentations across the curriculum (n=8, 47%). The most frequently cited techniques for delivering content were class discussion (n=13, 19%), lecture (n=12, 17%), and case/problem-based activities (n=11, 16%). Assessment of learners were conducted primarily by faculty (n=14, 33%) followed by patients (n=10, 23%) and student self-evaluation (n=8, 19%). The most common methods of assessment were simulation (n=11, 29%), class participation (n=10, 26%), and practical exams (n=7, 18%). Respondent indicated that students practiced telehealth skills on simulated patients (n=11, 39%) and classmates (n=9, 32%). Student were given opportunities to practice the telehealth skills primarily in the areas of orthopedics (n=16, 28%), primary care (n=15, 26%) and rehabilitation (n=9, 16%). No respondents indicated that students practiced telehealth in the areas of pediatrics or performance enhancement. **Conclusions:** Overall, about a quarter of professional athletic training programs were teaching telehealth content multiple times throughout the program. While there seems to be more athletic training programs engaging in telehealth teaching, assessment, and structured practice sessions, there is a disconnect between teaching strategies of discussion and lecture with assessment via simulation. Telehealth is a series of specific skills, in addition to ones' training in their healthcare profession, that warrant further development. We suggest that athletic training programs continue exploring how to best prepare athletic training students for virtual healthcare delivery.

**Ensuring the Use of Best-Practices
for Hand Hygiene in an Athletic
Training Healthcare System: A
Quality Improvement Project**
Duncan CT, Snyder Valier AR:
A. T. Still University, Mesa, AZ

Context: While hand hygiene is an expectation in healthcare, adherence to best-practice guidelines by the Centers for Disease Control (CDC) and World Health Organization (WHO) related to the specifics of the handwashing process is a long-standing concern, heightened by the COVID-19 pandemic. Inconsistencies in handwashing practices in a local healthcare system were identified as a quality problem. Improving ATs' adherence to handwashing guidelines would facilitate a safer medical facility for patients by reducing the spread of unwanted pathogens. The purpose of this quality improvement (QI) project was to increase athletic trainers' (ATs) handwashing adherence to 5 key CDC/WHO best-practice recommendations by 15% over a 6-week time period in a local athletic training healthcare system. **Methods:** The QI project took place in a Division-I University with 350 student-athletes cared for by 10 athletic trainers, who work across 2 athletic training clinics. We used the Model for Improvement which included generating a Fishbone diagram and process map to identify areas contributing to handwashing inconsistencies (ie, lack of awareness of best-practices, short-cuts for handwashing duration) and to identify opportunities for improvement. The week prior to the start of interventions, a baseline assessment of self-reported handwashing practices was made by all participating ATs to reflect how well they perceive they adhere to 5 key CDC/WHO recommendations: 20-second washing duration, appropriate soap usage, all surface/crease/nail

coverage, full rinsing, and full drying. AT ratings for these 5 questions were completed on an online form and reported on a scale of 0% (not done) to 100% (done exceptionally well). Three Plan-Do-Study-Act (PDSA) cycles were run, 2 cycles with interventions (2-weeks each) and 1 cycle without intervention (1-week). PDSA cycle 1 targeted improving awareness of handwashing best-practices through posting an informative flier of the CDC/WHO handwashing guidelines near handwashing stations. PDSA cycle 2 targeted improving adherence to the 20-second handwashing recommendation through placement of timers next to handwashing stations. PDSA cycle 3 removed handwashing resources. Athletic trainers self-reported their adherence to the 5 handwashing best-practices 2 times per week using the online form during all PDSA cycles. Data were calculated for percent adherence (mean \pm standard deviation) for each of the 5 best-practice recommendations at each assessment time point. Also, percent relative improvement between the first (baseline) and last (PDSA cycle 3) assessment time points was calculated: $[(\text{end-PDSA3}\% - \text{baseline}\%) / \text{baseline}\%] * 100$. Data are presented as: baseline%, end-PDSA1%, end-PDSA2%, end-PDSA3%; relative improvement%. **Results:** 7 of 10 (70.0%) ATs (age=29.4 \pm 6.7 years; years AT experience=6.9 \pm 6.3) participated in all 6 weeks of the project. Adherence with handwashing best-practices increased across all self-reported variables, including 20 second washing duration (baseline: 59.9 \pm 15.0%, end-PDSA1: 76.7 \pm 8.1%, end-PDSA2: 88.6 \pm 5.6%, end-PDSA3: 89.0 \pm 8.4%; relative improvement=48.6%) using an appropriate amount of soap (baseline: 79.3 \pm 22.8%, end-PDSA1: 89.4 \pm 13.3%, end-PDSA2: 94.9 \pm 5.8%, end-PDSA3: 96.9 \pm 5.4%; relative improvement=22.2%), thoroughness of hand-washing (baseline: 70.9 \pm 29.7%, end-PDSA1: 85.6 \pm 11.9%, end-PDSA2: 92.9 \pm

6.7%, end-PDSA3: 95.9 \pm 5.3%; relative improvement=35.3%), fully rinsing (baseline: 86.7 \pm 26.6%, end-PDSA1: 89.6 \pm 18.0%, end-PDSA2: 93.6 \pm 10.1%, end-PDSA3: 96.3 \pm 6.1%; relative improvement=11.1%), and fully drying (baseline: 66.4 \pm 32.0%, end-PDSA1: 79.7 \pm 24.3%, end-PDSA2: 92.0 \pm 11.0%, end-PDSA3: 93.0 \pm 10.7%; relative improvement=40.1%). Changes from baseline to PDSA cycle 3 and relative improvement exceeded the 15% goal for all handwashing best-practices, except for fully rinsing (9.6% and 11.1%, respectively). **Conclusions:** This 6-week QI initiative successfully increased self-reported adherence to CDC/WHO handwashing best-practice recommendations in a local healthcare system, with over 89% adherence across recommendations at the end of the project. The largest improvement was noticed with adherence to the 20-second washing duration recommendation which is meaningful given that it is often shortened in practice. Signage and support aids, such as a timer, were effective strategies for improving attention to handwashing best-practices and might be useful in other athletic healthcare systems.

Fellow sponsored by Alison R Valier, PhD, ATC, FNATA.

An Epidemiological Assessment of Youth Flag Football Injuries

Barber Foss KD, Khoury J, Eisenmann J, Cappaert T: Emory University Sports Performance And Research Center, Atlanta, GA; Cincinnati Children's Hospital, Cincinnati, OH; Leeds Beckett University, Leeds, England; Rocky Mountain University of Health Professions, Provo, UT

Context: Over the past three years, youth participation in flag football has risen by 39%, more than any other sport. Recent media attention on the potential long-term and deleterious effects of exposure to head impacts, created an impetus to promote flag football as a safer alternative to tackle football. While the participation rates are rising for flag football, there remains a lack of epidemiologic research and thus evidence of sport-specific injuries and relative risk due to participation. Clinicians need data-driven evidence regarding the prevalence of injuries in flag football and the potential risks of injury unique to the sport itself. The purpose of this study aims to explore and describe the epidemiology of injury associated with youth flag football participation. **Methods:** This is a descriptive epidemiology study. Injury and exposure data were collected at one regional and two national flag football tournaments. All injury information was collected by a certified athletic trainer (AT). A total of 1939 (1744 boys; 195 girls) athletes participated in this study. An AT monitored athletes for sports-related injury and exposures during each tournament. Injury counts and rates were examined by body part,

type of injury, mechanism of injury, player position, player activity, and team activity. Athlete risk of injury and injury rates were calculated overall and by gender. Injury characteristics were reported for the total population as well as by gender-specific breakdown. Risk and Rate Ratios with 95% confidence intervals (CI) were estimated using Fisher's exact estimation. The P-value for statistical significance was set at <0.05 a priori. Statistical analyses were conducted using Openepi and IBM SPSS. **Results:** 47 injuries in 1,939 athletes with 9,228 athlete exposures (AEs) were recorded. The overall risk of injury was 2.4% (95%CI 1.82, 3.22), and the overall rate of injury was 5.09 per 1000 AE (95% CI 3.74, 6.77). Of the 47 injuries, 36 occurred in male athletes (8,365 AE) and 11 in female athletes (863 AE). There was a statistically significant lower risk in boys compared with girls ($p<0.001$) for both Injury Risk Ratio 0.366 (95% CI 0.189, 0.707) and Injury Rate Ratio 0.338 (95% CI 0.172, 0.663) using Fisher's exact test. Head/Face/Neck injuries accounted for the largest proportion ($n=15$) 31.9% of all reported injuries (girls $n=6$, 54.5%; boys $n=9$, 25.0%) followed by ankle/foot (19.1%), thigh (10.6%) and wrist/hand (10.6%). The most common types of injury for this overall group were contusion (55.3%), sprain/subluxation (14.9%), and general trauma (10.6%); 74.5% of all injuries resulted from direct impact. **Conclusions:** While the overall risk of injury in flag football appears lower than in tackle counterparts, it is evident that injuries still occur. Interestingly, several injuries were related to the flag belt location, lending to potential equipment modification to prevent further injury.

Free Communications, Rapid Fire Presentations: Vitality of the Athletic Training Profession

Friday, June 23, 2023; 10:20 AM-11:15 AM; Room Entry 233

Moderator: James Onate, PhD, LAT, ATC

Organizational Expectations Regarding Documentation Practices in Athletic Training

Devenney JS, Drescher MJ, Rivera MJ, Neil ER, Eberman LE: Indiana State University, Terre Haute, IN, and Temple University, Philadelphia, PA

Context: Currently, no nationally recognized standard for medical documentation in athletic training exists and individual organizations are responsible for setting expectations and enforcing policies. Previous research has examined mechanisms for documentation and the behaviors of practicing clinicians; however, the supervisor's role in creating policy and procedures, communicating expectations, and ensuring accountability has not been investigated. The purpose of this study was to investigate supervisor practices regarding patient care documentation.

Methods: We used a cross-sectional, mixed-methods design with a web-based survey, chart review of current policies and procedures, and follow-up interviews. The web-based survey explored documentation policy, preparation, and expectations; perception of employee competence and perception of policy clarity and thoroughness on a 6-point Likert scale of strongly disagree to strongly agree. An external panel of five experts content validated the survey (S-CVI=0.93). We used a previously validated chart review to evaluate current requirements in written policies and procedures uploaded by supervisors. The interview script was developed to deepen the context of the survey responses, typical of sequential mixed-methods, by providing supervisor perspectives of expectations and accountability strategies. The interview script was reviewed by an external panel of two experts and piloted with three supervisory athletic trainers (ATs). We criterion sampled supervisory ATs working at an NCAA school (n=1107). Of the individuals identified, 65 participants (age=44±11 y, years of experience as supervisor=12±10 y) completed the entire survey, 6 uploaded their documentation policies and

procedures, and 12 (age 35±6 y, years of experience as supervisor=8±5 y) participated in a follow-up interview. We used measures of central tendency to summarize data from the survey and chart review and the consensual qualitative research approach with a 3-person data analysis team and multi-phase process to create a consensual codebook. We established trustworthiness using multiple-analyst triangulation, member checking, and internal and external auditing.

Results: Less than half of supervisors reported having formal written organizational documentation policies (n=45/93, 48%), procedures (n=32/53, 34%), and time expectations for recording encounters (n=24/84, 29%). The time expected to complete documentation ranged from no expectations to 90 days from the incident. Most supervisors perceived clarity and thoroughness in their documentation policies and procedures (33% slightly agreed, 33% agreed, and 4% strongly agreed) and felt confident in their employees' ability to generate accurate records (29% slightly agreed, 51% agreed, and 7% strongly agreed). The team identified two domains from the interview transcripts: 1) Framework and 2) Limitations. Participants described framework as organizational documentation concepts relative to orienting new and existing employees, communicating policies and procedures, strategies for holding employees accountable, and identifying purpose. Approaches that supported successful documentation practices included annual training and education, individual meetings, frequent documentation review, and emphasis on continuity of care and advocacy for additional resources. The limitations domain included organizational concepts relative to barriers in creating high-quality documentation. The first category included lack of time or prioritization of other roles and responsibilities. The second included supervisor assumptions, including beliefs that staff possess adequate prior training upon hiring and staff produce high-quality documentation, despite supervisors failing to review or audit existing records. **Conclusions:** ATs have reported uncertainty regarding documentation practices

inhibits high-quality record production. These findings demonstrate that despite a lack of clear written policies, procedures, expectations, and prioritization and accountability strategies, supervisors still felt confident in their employees' ability to create complete and accurate records. While supervisors acknowledged the various purposes for medical documentation, these findings indicate a disconnect and highlight the need for clear organizational standards and reinforce the importance of employer accountability and prioritization for improved patient care delivery, system outcomes, and legal compliance.

Negotiating Salary Among Athletic Trainers: Experiences of Negotiators and Non-Negotiators

Detwiler KR, Welch Bacon CE, White I, Jones L, Cavallario JM: A.T. Still University, Mesa, AZ; San Diego State University, San Diego, CA; Old Dominion University, Norfolk, VA

Context: Athletic trainers (ATs) typically work long hours for low wages in high stress environments that often do not allow for work-life balance or result in leaving the profession. Previous research revealed more than half of ATs do not attempt to negotiate salary during the hiring process. Therefore, we aimed to explore the experiences of ATs that did, or did not negotiate during the hiring process.

Methods: We used a consensual qualitative research design to conduct individual videoconference interviews. ATs who 1) responded to a previous survey, 2) self-identified whether they negotiated salary during their most recent hiring process, and 3) indicated willingness to participate in a follow-up interview were recruited. A semi-structured interview guide was developed by the research team and content validation was confirmed following review by 3 content experts. Data saturation guided the number of interviews completed. 28 ATs (10 men, 17 women, 1 prefer not to respond; age=37.8±8.9 years; AT experience=15.1±8.3 years; 18 that did negotiate [negotiators], 10 that did not negotiate [non-negotiators]) employed in 8 practice settings across 18 states participated in recorded interviews that were transcribed. Three researchers with extensive qualitative research experience coded the transcripts in a three-phase analysis process. Researchers met after

each phase to establish consensus on emerging themes and categories. Trustworthiness was achieved via member checking, multi-analyst triangulation, and an external auditor who reviewed the findings to ensure accuracy and representativeness. **Results:** Three themes emerged from analysis. ATs discussed reasons for negotiating / not negotiating. Negotiators cited low initial offers or benefits packages, the cost of living of the location, their known value, and their current financial situation as reasons they pursued negotiation. Those that did not negotiate perceived the offer to be fair or higher than they expected, were concerned with perceptions of others if they did negotiate, or discussed situational factors, such as being a toxic work environment they were desperate to leave, or were unaware negotiating was an option. ATs also discussed negotiation support / deterrents that influenced the negotiation decision. Negotiators capitalized on strong family, peer, or mentor support systems to guide their negotiations, and also relied on past experience, education, or training in negotiation as they navigated the process. Non-negotiators discussed lack of previous experience, lack of education or training, poor advice received, or personal concerns with the individuals involved in the process as deterrents for negotiation. Finally, ATs shared experiences with negotiating / impact of not negotiating. Negotiators perceived past experience with negotiation improved their current experience, noted both positive and negative reactions from the employer when negotiating, and listed both successes and regrets about the negotiation process. Non-negotiators reflected perpetual low salary, long-term financial consequences, and regret were resultant factors of not negotiating.

Conclusions: Non-negotiators did not negotiate because they felt the salary offer was fair or

due to situational factors; however, in hindsight many expressed regret and felt their choice may have resulted in long-term consequences (ie, financial struggles, chronically low salary). Factors that influenced whether an AT chose to negotiate included past experience and training on negotiation strategies, and advice or support received from others. ATs discussed a strong desire for additional resources, training, and education regarding negotiation processes. The presence of support systems among negotiators or the presence of poor advice or mentorship among non-negotiators was also noted and warrants further investigation. These findings provide novel information about ATs' negotiation practices that can be used to guide future educational efforts in hope that ATs will be able to confidently and professionally engage in salary negotiation to improve both individual salaries as well as the expected salaries for the athletic training profession.

Secondary School Athletic Trainers' Experiences Mitigating Organizational-Professional Conflict in the Workplace

Pike Lacy AM, Bowman TG, Singe SM: University of Maine, Orono, ME; University of Lynchburg, Lynchburg, VA; University of Connecticut, Storrs, CT

Context: Athletic trainers face organizational-professional conflict (OPC), often surrounding return to sport decisions. Though conflict most often occurs between athletic trainers and coaches, athletic trainers may experience OPC with other stakeholders including health care professionals, administrators, parents, and patients. To prioritize patient safety and establish a healthy work environment, OPC must be mitigated, yet little research has determined how athletic trainers manage conflicts with stakeholders. The current study explored athletic trainers' experiences managing OPC in the secondary school setting. **Methods:** We used a qualitative research design grounded in phenomenology to understand the lived experiences of secondary school athletic trainers. We developed a semi-structured interview guide based on previous research surrounding OPC. Prior to data collection, the interview protocol was reviewed by a peer expert and piloted with two secondary school athletic trainers. Telephone interviews were digitally recorded and transcribed by a professional transcription company. Data saturation guided recruitment efforts, and was met after interviewing 16 athletic trainers (9 females, 7 males; age = 43 ± 11 years; years certified = 17 ± 9 ; years in their current positions = 9 ± 6). To ensure rigor and trustworthiness of the data, we completed basic member checks along with multiple analyst triangulation. Upon completion of the transcription process, three randomly selected interview participants were

provided with their respective transcripts and asked to confirm the transcript accurately reflects their experiences and content discussed during the interview. We analyzed the qualitative data using an interpretive phenomenological approach. Two research team members read the transcripts independently and assigned codes to the data that addressed the study aim. The two researchers then met to discuss the coding structure and identify the overall themes of the data. **Results:** Analysis of the qualitative data revealed four themes: stakeholder education, effective communication, professional relationships, and professional experience. The stakeholder education theme was further divided into two sub-themes (Figure). Athletic trainers used stakeholder education as a primary strategy for managing OPC. Specifically, athletic trainers discussed engaging in professional advocacy efforts, which often involved conversations with stakeholders about the roles, value, and qualifications of an athletic trainer. Athletic trainers also used effective communication, which was described as frequent, open, and direct, to manage OPC by educating relevant stakeholders (e.g., coach, parent, athlete) about prognosis and return to sport timelines post-injury and providing rationale for decisions made. OPC was reduced when athletic trainers built a professional relationship with stakeholders centered on trust, respect, honesty, and support. Relationship building came more naturally when athletic trainer and stakeholder values and priorities aligned. Furthermore, years of experience served as a mitigating factor of conflict, in that as athletic trainers gained experience, they perceived less OPC. Participants perceived the inverse relationship could be attributed to increased confidence with communication and decision-making, as well as rapport development with stakeholders. **Conclusions:** Though the inherent nature of athletic trainers' roles increases the likelihood for OPC, participants suggested

various interpersonal relationship development strategies that can be implemented to mitigate and manage workplace conflicts, especially when starting a new position or attempting to build rapport with stakeholders (e.g., administrators, parents, coaches, patients, other health care providers). Specifically, educating various stakeholders on reasons for clinical decisions via effective communication and developing strong professional relationships built on mutual respect with stakeholders can assist in avoiding OPC. Since professional experience appears to alleviate conflict, strategies to mitigate OPC should be taught during professional preparation and used early during transition to autonomous clinical practice.

Fellow sponsored by Stephanie Mazerolle Singe, PhD, ATC, FNATA.

Workplace Climate for Sexual and Gender Minorities in Athletic Training
Eberman LE, Nye EA, Edler-Nye JR:
Indiana State University, Terre Haute,
IN, and Grand View University, Des
Moines, IA

Context: Sexual and gender minorities (SGM) are individuals with sexual orientations, gender identities and/or expressions that differ from cultural norms. SGM individuals often face stigma and workplace discrimination and report decreased physical and emotional well-being from overt discrimination and microaggressions. Alternatively, workplace satisfaction increases for SGM individuals in the presence of an affirming workplace climate. Recently, efforts of inclusion have encouraged athletic trainers (ATs) to create safe places to deliver healthcare to SGM individuals, yet little work has focused on the workplace climate for providers who are members of the SGM community. The purpose of this study was to explore the lived experiences of SGM ATs relative to workplace climate and inclusion. **Methods:** We used a phenomenological approach with semi-structured, qualitative interviews. Criterion sampling of SGM ATs yielded a sample of 12 participants (Table 1). Participants were recruited through a broader cross-sectional study and social media posting and upon consent, scheduled a one-on-one interview with the primary investigator. The semi-structured interview script, was developed from the available literature and underwent validation by 4 content experts, 3 of which have substantial experience in qualitative interviewing (scale-level content validity index=0.94). To complete the analysis, consistent with the consensual qualitative research tradition, the research team used a multi-phased process and multi-analyst approach. After the coding and cross-analysis process were completed, the data underwent external review and we assigned a

frequency to each category based on the number of transcripts from which the category emerged: general=11-12 cases, typical=6-10 cases, variant=3-5 cases. Trustworthiness was established through reflexivity (researchers checking bias throughout the research process), member-checking, multi-analyst triangulation, internal and external auditing. **Results:** Two domains emerged from the data: safety and inclusion. The safety domain represents aspects of the workplace climate that make the participants feel safe. Participants found safety in organizational initiatives (general, 12/12) and patient-centered policies (typical, 7/12). They indicated optimism about their organization's willingness to take action, during recent civil unrest and protest, when their organizations caucused around on diversity, equity, and inclusion (DEI) initiatives. When their organizations developed inclusive policies for patients, participants felt those efforts also included them. Some participants found local and federal regulations meant to protect gender identity and sexual orientation had been adopted within the culture of their organization (typical, 7/12); however, for those living in states at risk of losing those protections, there was heightened concern about a loss of safety. Participants felt particularly safe when the organization signaled to them they were included with signage, gender-diverse bathrooms, and email signatures with pronouns (general, 12/12). Participants did express experiencing both inclusive and exclusive signaling, impacting their feelings of safety. The inclusion domain represents how the participants felt a sense of belonging to the organization. They reported aspects of both the patient and employee experience as ways the organization created that sense of belonging for them. When the participants observed SGM patients welcomed culturally, that enhanced their own sense of belonging (typical, 9/12). When they described their own experiences, they discussed the value of community that enhanced their own

inclusion (general, 12/12). Inclusion was more deeply felt when the values of the organization were embedded within the infrastructure by way of inclusive policies, procedures, and training (general, 12/12); however, all but one of the participants indicated knowing very little about inclusive benefits. **Conclusions:** Our findings suggest SGM individuals experience their workplaces as both inclusive and safe, as well as exclusive and unsafe. Organizations must take both structural and cultural actions to address the issues of exclusion and lack of safety. Individuals must be more aware of inclusive benefits because organizational spending priorities should be reflective of organizational values.

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Table 1. Participant Characteristics

Pseudonym	Pronouns	Age	Cultural Ethnicity	Gender Identity	Sexual Orientation	Years of Experience	Setting
Arizona	She/her	53	Caucasian	Woman	Lesbian	31	Physician Practice
Bex	Any	26	Asian/ Indigenous	Gender non- conforming	Pansexual	4	Secondary School
Callie	She/her	33	Mixed Race	Woman	Lesbian	2	Middle School
Carina	She/her	42	Caucasian	Woman	Lesbian	20	Secondary School/ Outreach
Emmit	He/him	42	Caucasian	Man	Gay	20	Secondary School
Erica	She/her	33	Caucasian	Woman	Lesbian	10	Government
Grant	He/him	27	Black	Man	Gay	3	Secondary School
Levi	He/Him	27	Caucasian	Man	Gay	4	College/University
Liv	She/her	40	Caucasian	Woman	Asexual	17	Secondary School
Nico	He/him	33	Asian American	Man	Gay	5	Performing Arts
Rich	He/him	26	Caucasian	Man	Bisexual	3	Secondary School
Teddy	She/her	34	Caucasian	Woman	Bisexual	12	College/University

Exploring Family Interfering With Work Conflict Among Collegiate Athletic Trainers

Singe SM, Cairns A, Eason CM:
University of Connecticut, Storrs, CT

Context: The work family interface has received a lot of interest in athletic training, often examining work interfering with family conflict (WIFC); The concept of work-family conflict is a bidirectional, yet research tends to investigate WIFC only. The purpose was to explore family interfering with work (FIWC) among collegiate athletic trainers, as it is unexplored in athletic training. Specifically, we were focused on the relationships between gender, marital status, employment status of the athletic trainer's spouse, and number of children. **Methods:** Data were collected via a cross-sectional survey (Qualtrics). The scale used provided data specific to WIFC and FIWC and is reliable, valid and used previously in the athletic training literature. The online survey was distributed to 6,148 athletic trainers employed within the collegiate setting. Reminder emails were sent at 1 and 3-weeks post initial recruitment. Descriptive statistics were performed to calculate demographic information, simple compare means to identify the mean scores for each group, and Mann Whitney U analyses were utilized to discover differences among groups. **Results:** 984 (605 women, 370 men, 9 other) collegiate athletic trainers completed this study (response rate 16%). Participants average age was 33 ± 9 , average years of experience 9.79 ± 8.90 , and average years at their current place of employment 5.28 ± 7.05 . We found the scales to be reliable (WIFC=.92, FIWC=.86). Women

collegiate athletic trainers reported statistically significantly ($U=93539.5$, $p<.001$) higher FWC scores $27.49 (\pm 5.62)$ than men collegiate athletic trainers $25.90 (\pm 5.83)$. Married women scored statistically higher ($U=15386.0$, $p=.010$) on the FWC than married men collegiate athletic trainers $26.80 (\pm 6.21)$ and $25.34 (\pm 6.19)$ respectively. Single athletic trainers scored significantly ($U=92164.00$, $p=.003$) higher on the FWC scale $27.30 (\pm 5.41)$ than those who are married $25.99 (\pm 6.23)$. Collegiate athletic trainers whose spouse works full time scored significantly higher ($U=9401.00$, $p=.040$) on the FWC scale $26.85 (\pm 5.88)$ compared to those whose spouse works part-time $24.57 (6.40)$. Collegiate athletic trainers who have no children scored significantly higher ($U=66770.00$, $p<.001$) on the FWC scale $27.56 (\pm 5.39)$ than those who do have children $24.94 (\pm 6.25)$. **Conclusions:** As predicted women athletic trainers reported higher levels of FIWC than males, as they often place more pressures on themselves to balance all life role responsibilities. We also found that both single and married with children athletic trainers report high levels of FWC; suggesting that both groups experience the challenges of family demands. This may indicate that support networks could influence FIWC more than individual demographics and that family can place increased demands on an athletic trainer regardless of marital or family status. Future research is warranted to better understand the athletic trainers' perceptions on why they report more FWC, based upon selected demographics variables.

Fellow sponsored by Stephanie Mazerolle Singe, PhD, ATC, FNATA.

Exploring Well-Being in Athletic Training

Thomassen AN, Young JP, Eberman LE, Rivera MJ, Drescher MJ, Games KE: Indiana State University, Terre Haute, IN

Context: Athletic trainers (AT) experience challenges related to work-life conflict, which may lead to burnout and an intent to leave the profession. Languishing is a state in which an individual lacks positive emotions towards life or is not meeting their individual aspirations, goals, or perceived potential. Languishing is the middle ground between burnout and flourishing and may help describe the experiences of ATs in relation to work-life. The purpose of this study was to explore well-being, including languishing, in ATs. **Methods:** We used a cross-sectional design with a web-based survey. The survey included demographic questions and the Mental Health Continuum Short Form (MHC-SF). The MHC-SF is a validated 14-item tool, which measures languishing using 3 subscales; emotional well-being (EWB), social well-being (SWB), and psychological well-being (PWB). MHC-SF items are rated on a Likert scale ranging from never (0) to every day (5), with total scores ranging from 0 to 70 and higher scores indicating greater mental health. A random sample of 5,667 ATs were recruited using the NATA Research Survey

Service. A total of 15.5% (n=879) individuals accessed the survey and 12.4% (n=706) consented to participate and completed the survey entirely. Participants were 39±11 years old with 7.8±8.6 years of experience in their current position. Participants were mostly women (n=423, 59.9%), working in the collegiate and university setting (n= 655, 92.8%), holding a professional master's degree (n= 284, 40.3%), with greater than 21 years of experience (n= 220, 31.2%), and had worked 41+ hours per week in the past 30 days (n= 426, 62.3%). Descriptive statistics were calculated for the demographic variables and total MHC-SF scores. We used the categorization of well-being, from languishing to flourishing along the mental health continuum to determine the frequency of respondents in each category. Non-parametric tests were used to investigate differences between total scores and demographic groups including gender identity, years of experience, age, and hours worked per week. **Results:** Most participants demonstrated moderate mental health (n=367, 52%), 40.8% were flourishing (n=288), and 7.2% fit the criteria for languishing (n=51). A greater number of women (n=36, 70.5%) were languishing when compared to men (n=15, 29.41%). There were significant differences between demographic variables and total MHC-SF scores including age ($p < .001$), gender identity ($p=.003$), years of experience ($p < .001$), and hours worked per week ($p < .001$). Those who identified as a

woman ($M=42.4\pm13.1$), were 20-29 years old ($M=41.4\pm13.2$), had 6-10 years of experience ($M=39.7\pm13.7$), and worked 41+ hours weekly ($M=41.4\pm13.1$) had the lowest scores across their respective categories, indicating poorer mental health (Table 1). **Conclusions:** Most participants in this study demonstrated moderate to good mental health. Women, early career professionals, and those who worked more hours per week demonstrated poorer mental health compared to their peers.

Table 1. MHC-SF Mean Scores with Standard Deviation

Variable	MHC-SF Score	Variable	MHC-SF Score
Age (Years)	M (SD)	Years of experience (Years)	M (SD)
20-29 ^a	41.3 (13.2)	1-5 ^f	42.7 (12.6)
30-39 ^b	41.9 (12.8)	6-10 ^g	39.7 (13.7)
40-49 ^{a,c}	44.2 (12.7)	11-15 ^h	42.9 (12.8)
50-59 ^{a,b,d}	47.3 (12)	16-20 ^g	44.8 (11.5)
60+ ^{a,b,c,d}	52.1 (10.8)	21+ ^{f,g,h}	47.2 (12.5)
Gender identity		Hours worked per week (Hours)	
Woman ^e	42.4 (13.1)	0-40 ⁱ	47.3 (11.9)
Man ^e	45.6 (12.6)	41+ ⁱ	41.4 (13.1)
Gender Diverse	42 (15.7)		
Prefer not to say	35 (5.6)		

^a represents significant differences between ages 20-29, 40-49, 50-59, and 60+

^b represents significant differences between ages 30-39, 50-59, and 60+

^c represents significant differences between ages 40-49 and 60+

^d represents significant differences between ages 50-59 and 60+

^e represents significant differences between woman and man

^f represents significant differences between 1-5 and 21+ years of experience

^g represents significant differences between 6-10, 16-20, and 21+ years of experience

^h represents significant differences between 11-15 and 21+ years of experience

ⁱ represents significant differences between those who work 0-40 hours and 41+ hours per week

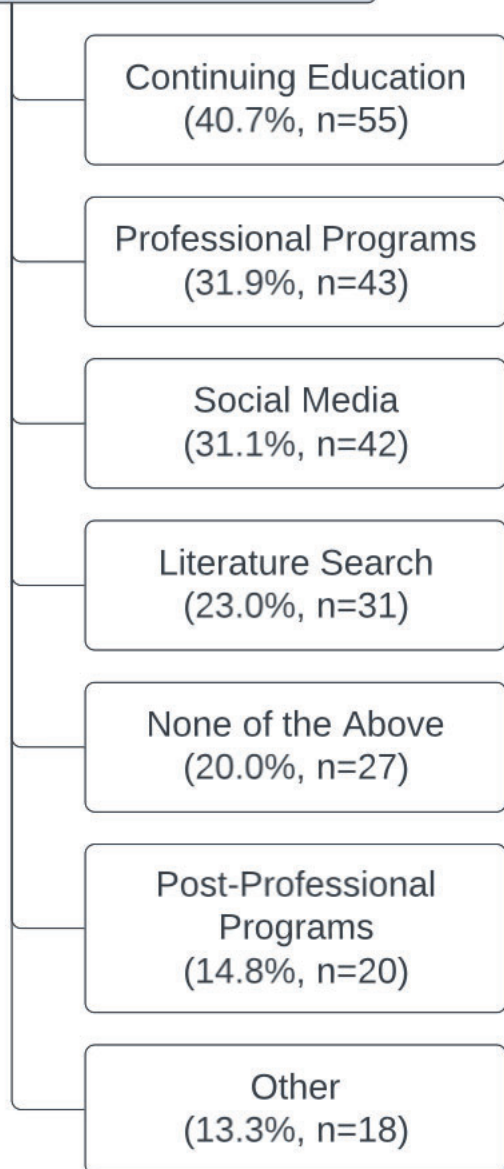
Bridging the Knowledge Gap of Meditation Practices in Athletic Trainers

Martin AK, Drescher MJ, Games KE, Eberman LE: Indiana State University, Terre Haute, IN

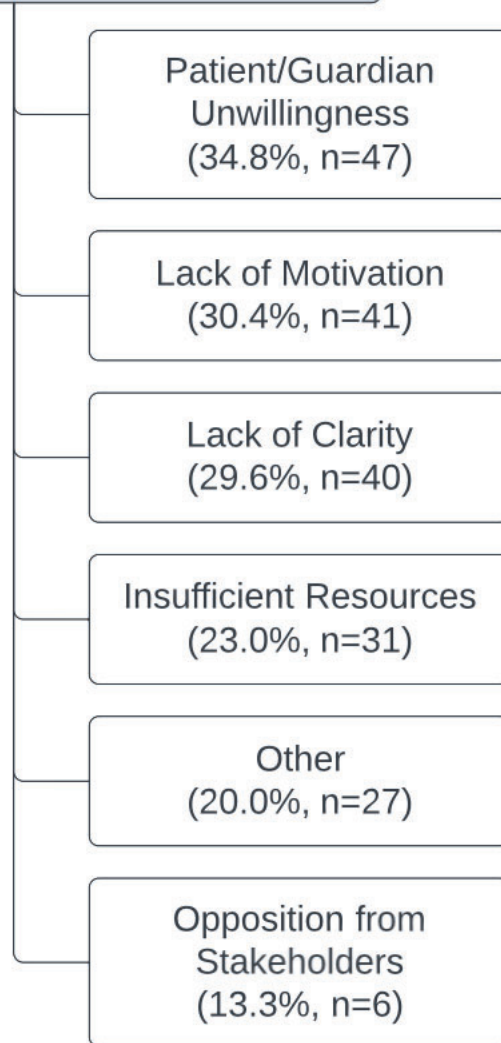
Context: Meditation benefits patients by decreasing pain severity and functional limitations while increasing quality of life when used with therapeutic rehabilitation. However, only 25% of athletic trainers currently use meditation in their clinical practice. In addition, many athletic trainers have identified a lack of education/knowledge as a barrier to implementation. The purpose of this study was to identify athletic trainers' current knowledge of meditation practices and factors that may influence implementation. **Methods:** We used a cross-sectional design and deployed a content-validated web-based survey to explore the relationship between knowledge of meditation effects and factors influencing practitioner implementation. The instrument consisted of demographic variables (4 items), previous exposure to meditation and current clinical application (3 items), and a knowledge quiz (7 items [select all that apply=2, multiple choice=5, maximum score=12]). The survey was distributed to athletic trainers in good standing with the NATA through the NATA research service. Of the 5,666 distributed emails, 261 participants responded (response rate=4.6%), and 135 completed the survey (completion rate=51.7%) (years of experience=10±10 years [range=1-49 years]). Participants indicated their highest earned degree as a professional bachelor's (41.5%, n=56), professional master's (20.7%, n=28), post-professional master's (11.9%, n=16), non-AT post-professional master's (11.1%, n=15), clinical doctorate (10.4%, n=14), doctorate (3.7%, n=5), and other (0.7%,

n=1) degrees. Participants worked in college/university (43.7%, n=59), secondary school (36.3%, n=49), healthcare rehabilitation/administration (8.9%, n=12), an emerging setting (7.4%, n=10), other (3.0%, n=4), and professional sports (0.7%, n=1) settings. A series of one-way ANOVAs with posthoc Bonferroni tests were used to investigate differences in scores on the brief meditation knowledge quiz based on demographic variables. **Results:** Meditation was used by 45.2% (n=61) of participants in patient care plans. Of those who utilize meditation, meditation was implemented with 4±6 (range=0-25) patients per week. The mean score on the meditation quiz was 66.7% (8/12 correct answers). Participants received information on meditation practices from continuing education, professional programs, social media, literature search, none of the above, post-professional programs, and other (Figure 1). Participants identified barriers to implementing meditation, such as patient/guardian unwillingness, lack of practitioner motivation, lack of clarity, insufficient resources, other, and opposition from stakeholders (Figure 1). There was no significant difference between scores on the meditation quiz and participants' highest level of education (p=0.53), clinical setting (p=0.33), or use of meditation (p=0.59). **Conclusions:** While participants identify a range of information sources, knowledge of the benefits of meditation is lacking. Further, participants identified barriers to implementing meditation stemming from an overall lack of knowledge or motivation to include the treatment option in their care, indicating that current methods of information gathering may be ineffective at improving knowledge related to meditation. Future research should investigate the effects of education on knowledge and the clinical application of meditation.

Educational Sources



Barriers to Implementation



Levels of Moral Distress in Secondary School Athletic Trainers

Drescher MJ, Rivera MJ, Eberman LE:
Indiana State University, Terre Haute,
IN

Context: Moral distress (MD) is the negative psychological state created when a person is confronted with an ethically ambiguous situation and unable to take action aligned with their morals. MD frequently occurs in healthcare professionals causing symptoms of burnout, including fatigue and intent to leave the profession. Previous literature has demonstrated athletic trainers in settings with little organizational support, such as the secondary school setting, experience symptoms of burnout, feelings of isolation and intent to leave the profession. One contributing factor to professional retention may be MD, particularly in the secondary school setting. This study aimed to examine levels of MD in secondary school athletic trainers (SSATs). **Methods:** We used a cross-sectional survey design. Participants received an online survey consisting of demographic questions and a modified

Measure of Moral Distress for Athletic Trainers (MMD-AT). The MMD-AT has been previously content validated tool with 21 potentially morally distressing prompts related to athletic training (S-CVI/Ave=0.8). The response scale was slightly modified from a 5-point to a 4-point Likert scale to improve reliability of the frequency (Cronbach's $\alpha=0.86$) and level of distress (Cronbach's $\alpha=0.95$) constructs. Participants were asked to rate the frequency (0=never, 1=sometimes, 2=often, 3=very frequently) and level of distress (0=not distressing, 1=mildly distressing, 2=moderately distressing, 3=very distressing). Frequency and level of distress are multiplied to create a composite score for each item (maximum of 9 per item). The composite scores are then added together to generate an overall MD score (range=0-189), with higher scores indicating higher MD. The survey was distributed through Qualtrics (Provo, UT) to 7212 SSATs registered through the Athletic Training Locations and Services database, and 1035 athletic trainers responded to the survey (response rate=14.4%). In total, 603 complete responses were included for data analysis (completion rate=58.3%). Data

were analyzed with measures of central tendency (mean, standard deviation) for descriptive analysis. **Results:** Participants (Table 1) demonstrated low levels of MD ($M=26.9\pm20.3$). The most morally distressing prompts included "Being required to care for more patients than I can safely care for" ($M=2.74\pm2.63$); "Experience compromised patient care due to lack of resources, equipment, or facility capacity" ($M=2.44\pm2.55$); and "Unable to provide optimal care due to pressures from administrators, parents or stakeholders" ($M=2.03\pm2.27$). The least morally distressing prompt was "Following a physician's, family member's, or support system's request not to discuss the patient's prognosis with the patient" ($M=0.48\pm1.08$). **Conclusions:** SSATs experience MD in clinical practice, with the most common reasons for MD including patient overload, lack of resources, or pressures from administrators, parents, or stakeholders. Because experiences of MD can lead to feelings of burnout even at low levels, employers should focus on implementing policies focused on reducing MD by improving the allocation of resources, improving internal support structures, and developing moral resiliency.

Table 1: Participant Demographics and MMD-AT Scores

Variable	N	%	MMD-AT Score (out of 189)	
			M	SD
<u>Overall Score</u>			26.9	20.3
<u>Gender Identity</u>				
Man	359	59.5	23.3	17.1
Woman	238	39.5	29.6*	22.0
Gender Minority	10	1.7	17.3	14.0
<u>Ethnicity</u>				
Caucasian	554	91.9	27.1	20.7
Hispanic/Latino	22	3.6	26.9	13.5
Black	10	1.7	16.0	12.9
Native American/Indigenous	7	1.2	15.0	N/A
Prefer Not to Answer	7	1.2	32.9	31.3
Prefer to Self-Describe	7	1.2	26.3	18.8
Asian	6	1.0	22.0	10.2
Mixed Ethnicity	3	0.5	26.5	15.4
<u>Age Groups</u>				
20-29	150	24.9	31.2**	20.5
30-39	188	31.2	31.9**	22.5
40-49	127	21.2	20.1	16.1
50-59	108	17.9	21.2	17.0
60+	28	4.6	24.2	19.5
Missing	2	0.3		
<u>Years of Experience</u>				
0-5	117	19.4	32.5**	22.6
6-10	128	21.2	28.6**	17.1
11-15	94	15.6	33.4**	26.3
16-20	61	10.1	22.8*	18.0
21-25	70	11.6	19.8**	13.5
26+**	128	21.2	21.3**	17.5
Missing	5	0.8		
<u>Community Type</u>				
Urban	120	19.9	30.4	24.0
Rural	194	32.2	26.2	21.3
Suburban	286	47.4	26.1	17.8
Missing	3	0.5		
<u>Healthcare Model</u>				
School District	275	45.6	27.8	21.9
Hospital/Clinic	305	50.6	26.4	19.3
Internal Contractor	12	2.0	20.8	9.6
External Contractor	10	1.7	25.9	12.3
Missing	1	0.2		

*significant difference in score between group $p < .05$

**significant difference in score between group $p < .001$

Free Communications, Rapid Fire Presentations: Brain Games: Understanding the Neurocognitive, Neuroplastic and Psychological Factors Associated With Musculoskeletal Injury and Rehabilitation

Friday, June 23, 2023; 7:30 AM-8:25 AM; Room 234-236

Moderator: Ty Hopkins, PhD, ATC

Visual Cortex Gray Matter Volume Correlates With Time From Surgery in Anterior Cruciate Ligament Reconstructed Individuals

Schnittjer AJ, Lepley AS, Onate JA, Simon JE, Grooms DR: Ohio University, Athens, OH; University of Michigan, Ann Arbor, MI; The Ohio State University, Columbus, OH

Context: ACL injury and reconstruction (ACLR) can have lasting effects on physical and neurological function. Recent functional neuroimaging data indicate a compensatory shift toward visual-motor neural activity to maintain simple knee motor control, however structural adaptations in gray matter volume, which may indicate creation of new neuron support cells, are largely unexplored. Therefore, the purpose of this study was to compare structural differences in gray matter volume relative to healthy, matched controls as well as to determine the structural neural correlate for time from surgery for individuals with ACLR. **Methods:** Twenty-five ACLR participants (10 males, 21.76±2.57 years, 170.00±9.70 cm, 69.93±15.04 kg, Tegner activity level 7.40±1.29) and 25 healthy, matched controls (10 males, 23.12±2.70 years, 171.91±10.47 cm, 68.92±14.31 kg, Tegner activity level 8.12±1.59) were enrolled in the study from two separate neuroimaging centers. Participants were matched based on sex, current activity level, and BMI (kg/m²). The average mean difference between groups for activity level was 0.72 (0-4) and for BMI was 0.83 (-2.09-6.17). High-resolution T1-weighted (structural) images were obtained via magnetic resonance imaging by placing each participant headfirst into the scanner. Participants were instructed to lay quietly without moving for the duration of the scan. Images were preprocessed using the CAT12 Toolbox for SPM12. Subject-level analysis included spatial registration,

segmentation, bias correction, and smoothing at 8mm. Absolute masking threshold was set to 0.1. Region of interest (ROI) gray matter volume was extracted from each participant using the Neuromorphometrics atlas in CAT12 and analyzed using paired samples t-tests to identify regions of greater gray matter volume between groups. A ROI based regression model in CAT12 using the Neuromorphometrics atlas was conducted to determine the structural neural correlate for time from surgery in the ACLR group. Both analyses were controlled for total intracranial volume and corrected for multiple comparisons using the false-discovery rate ($p < 0.05$). **Results:** There were no statistical differences in regional gray matter volume between ACLR and control groups for either group-level contrast (ACLR > Control, Control > ACLR) ($p > 0.05$, FDR corrected). The ROI based regression model indicated a positive correlation for gray matter volume in the left calcarine cortex (2.66 ± 0.50 mL) and time from surgery (51.60 ± 32.89 months) ($z = 3.60$, $p = 0.019$, FDR corrected; r value not reported due to circularity). **Conclusions:** There were no regional differences in gray matter volume between groups. Individuals with ACLR displayed a positive correlation of greater gray matter volume in the left calcarine (primary visual) cortex as time from surgery increased. These structural results support current functional neuroimaging findings and may indicate sensory-reweighting toward vision following ACLR. Clinicians may consider incorporating early intervention visual perturbation training such as stroboscopic glasses, eyes-closed exercises, or immersive virtual reality to upregulate somatosensory processing during rehabilitation following ACLR. Future longitudinal studies are needed to confirm these results.

Fellow sponsored by James A. Onate, PhD, ATC.

Do Cognitive and Motor Brain Function Associate With the Biomechanical Dual-Task Cost During Double-Limb Landing?

Nicholson EP, Rush JL, Murray AM, Grooms DR, Bazett-Jones DM, Norte GE: University of Toledo, Toledo, OH, and Ohio University, Athens, OH

Context: Physically active individuals with lower neurocognitive and corticomotor function demonstrate poor landing biomechanics and a reduced ability to rapidly generate quadriceps torque, which may contribute to risk for knee injury. However, it is unclear whether poor landing biomechanics resulting from the addition of a cognitive challenge (dual-task), similar to what would be experienced in an athletic environment, may be exacerbated by having worse neurocognitive or corticomotor function. Our objective was to investigate the relationships between neurocognitive performance and corticomotor function and biomechanical dual-task cost during a landing assessment in uninjured, physically active females. We hypothesized that worse neurocognition and corticomotor function would associate with a greater dual-task cost in ACL-loading mechanisms. **Methods:** This descriptive laboratory study was performed in a university laboratory. Eighteen right leg dominant, physically active, uninjured females (age: 21.8 ± 2.6 years, height: 1.7 ± 0.1 m, mass: 66.9 ± 14.5 kg, Tegner Activity Scale: 5.8 ± 1.0) were assessed on two separate days. Quadriceps corticospinal excitability was measured in the vastus medialis during a single-leg squat on day 1 using transcranial magnetic stimulation, and quantified by the active motor threshold (AMT). Neurocognitive and three-dimensional biomechanical assessment of the landing error scoring system (LESS) were collected on day 2. Following a traditional LESS (single task), two dual-task paradigms (number-based and

visually-mediated) were performed in random order. For the number-based paradigm, the LESS was performed while concurrently completing serial 7's subtraction beginning from a random number. For the visually-mediated paradigm, the LESS was performed with participants' vision focused on a screen, and required them to recall a string of five numbers shown for 250 ms during the flight-phase of the task. Five successful trials of each condition were completed. Peak hip and knee angles and moments in the sagittal and frontal planes, and vertical ground reaction forces, were examined during the first 100 ms of landing. Percent change scores in outcomes from single to dual-task were used to quantify the dual-task cost for each paradigm. Correlation coefficients were used to assess the relationships between dominant limb dual-task cost and neurocognition (Immediate Post-Concussion Assessment and Cognitive Testing composite scores) and corticospinal excitability (AMT). **Results:** During the number-based paradigm, worse visual motor composite scores moderately associated with a greater increase in knee flexion angles ($r = -.597$, $p = .011$). During the visually-mediated paradigm, higher AMT (lower corticospinal excitability) moderately associated with a greater decrease in hip adduction angles ($r = -0.542$, $p = .037$). **Conclusions:** Worse neurocognitive and corticomotor function associated with changes in landing biomechanics consistent with greater knee flexion angles and more neutral hip positions during a dual-task landing assessment. Our findings may suggest that uninjured females with lower visual processing ability or corticospinal excitability default to knee-protective movement patterns in the presence of added cognitive loads or environmental constraints.

This study was funded by the Great Lakes Athletic Trainers' Association Gordy Graham Research Assistance Award.

Eyes on the Prize: Neurocognitive Contributions of a Choice Reaction Drop-Cutting Maneuver

Rush JL, Murray AM, Grooms DR, Nicholson E, Norte GE: University of Toledo, Toledo, OH, and Ohio University, Athens, OH

Context: Neurocognitive and visual processing are essential for sports performance, yet the effects of perturbation to either on landing biomechanics is unknown. Our purpose was to compare knee biomechanics of a single-leg drop-cut (single-task) to a visually-mediated choice reaction drop-cut (dual-task), and to determine the association between baseline neurocognition and cognitive-motor interference induced by the choice reaction task. We hypothesized that the choice reaction drop-cut would induce injury risk biomechanics and that slower reaction time and worse baseline neurocognition would associate with greater cognitive-motor interference. **Methods:** Twenty physically active females (22.05±2.54 years, 67.01±13.77 kg, 1.68±0.07 m) participated in this descriptive laboratory study. Composite scores of visual-memory, visual-motor processing, and reaction time were derived from the Immediate Post-Concussion Assessment and Cognitive Testing software. Participants were

outfitted with 45 retroreflective markers on the trunk and bilateral lower extremities, then instructed to jump off a 30 cm box, land onto a force plate, and perform a 45° cut in the opposite direction of their landing foot. Participants repeated this task with their vision focused on a monitor in front of them. A foot pedal was used to change the color of the screen; blue directed participants to perform the same drop-cut; yellow directed participants to perform a single-leg landing without cutting, while maintaining their balancing. Participants completed five successful cutting trials for each condition and limb using a counterbalanced sequence. Peak sagittal and frontal knee angles and internal moments, and vertical ground reaction forces (vGRF) were recorded from initial force plate contact to toe-off. Paired-samples t-tests, or the non-parametric equivalent, were used to determine differences in biomechanical outcomes between task conditions. Cohen's d effect sizes with 95% confidence intervals were calculated to determine the magnitude of significant differences. Relationships between neurocognitive function and the cognitive-motor interference (change from single- to dual-task) were assessed using correlation coefficients. **Results:** All data are reported in Table 1. The added cognitive challenge of the choice reaction task increased knee flexion angles, knee extension moments, and vGRFs in both limbs, and increased knee abduction

angles in the non-dominant limb only. Better visual memory associated with greater increases in knee extension moments ($p=0.467$, $p=0.038$) in the non-dominant limb. Faster reaction times associated with greater increases in knee flexion angles ($p=-0.635$, $p=0.003$) and knee abduction angles ($p=-0.510$, $p=0.022$) in the non-dominant limb. **Conclusions:** Uninjured females demonstrated bilateral changes in drop-cut landing mechanics indicative of greater knee loading when presented with a visually-mediated choice reaction constraint. Greater neurocognitive capacity associated with both favorable and unfavorable adaptations to the choice reaction task. Increased peak knee abduction angles in those with faster reaction times may suggest a speed-accuracy trade-off, where biomechanical errors become present due to the prioritization of visual processing more than task execution.

This study was partially funded by the Gordy Graham Research Assistance Award through the Great Lakes Athletic Trainers' Association.

Table 1: Peak Kinematic and Kinetic Differences Between Drop-Cut Tasks

Outcome Measure	Single Cut Mean ± SD	Choice Reaction Cut Mean ± SD	P Value	Effect Size (95% CI)
Knee Flexion Angle (°)				
Dominant	55.28 ± 10.25	63.77 ± 7.49	0.002	0.78 (0.27, 1.28)
Non-Dominant	54.65 ± 11.43	63.21 ± 8.00	0.004	0.87 (0.22, 1.52)
Knee Abduction Angle (°)				
Dominant	8.17 ± 7.22	8.83 ± 7.27	0.332	0.09 (0.71, 1.38)
Non-Dominant	10.62 ± 4.94	12.91 ± 5.35	0.009	0.66 (0.16, 1.13)
Knee Extension Moment (Nm/kg*m)				
Dominant	1.74 ± 0.33	2.01 ± 0.28	<0.001	1.11 (0.54, 1.66)
Non-Dominant	1.68 ± 0.40	1.94 ± 0.30	<0.001	0.74 (0.09, 1.38)
Knee Adduction Moment (Nm/kg*m)				
Dominant	0.24 ± 0.10	0.21 ± 0.11	0.065	-0.30 (-0.93, -0.32)
Non-Dominant	0.44 ± .20	0.44 ± 0.19	0.970	0.00 (-0.62, 0.62)
Ground Reaction Force (Nm/kg*m)				
Dominant	3.44 ± 0.80	4.04 ± 0.59	<0.001	0.85 (0.21, 1.50)
Non-Dominant	3.51 ± 0.75	3.90 ± 0.72	0.007	0.67 (0.18, 1.15)

BOLD – P Value < 0.05

Italics – Large magnitude differences between tasks indicated by effect sizes, positive effect sizes indicate increases in magnitude of the outcome measures from the single task to the choice reaction task

Inhibition of Motor Planning and Response Selection Following Anterior Cruciate Ligament Reconstruction

Sherman DA, Stock MS, Baumeister Murray AM, Bazett-Jones D, Norte GE: Live4 Physical Therapy and Wellness, Acton, MA; Boston University, Boston, MA; Harvard University, Cambridge, MA; University of Central Florida, Orlando, FL; Paderborn University, Paderborn, Germany; University of Toledo, Toledo, OH

Context: Despite the large body of evidence detailing neuroplastic differences in individuals with ACL reconstruction (ACLR), whether they translate to impairments in motor performance is unclear. The study of the neural processes and time-course underlying motor response decisions may provide evidence of neurobehavioral impairments with insight into the adaptability (i.e., responsiveness to environmental perturbation) of individuals with ACLR. Therefore, we compared cortical motor planning activity and response selection performance between individuals with ACLR and uninjured controls during a reaction time and response selection task. We hypothesized that individuals with ACLR would exhibit smaller lateralized brain activation compared to controls, indicating higher inhibition and thus lesser ability to generate proper motor responses. **Methods:** Individuals with primary, unilateral ACLR (N=20, 12 females, age=21.2±2.2 years, time from surgery=15.1±9.6 months) and uninjured controls (N=20, 12 females, age=21.5±2.2 years) were cross-sectionally investigated during a single session in a research laboratory. Participants performed a lateralized choice reaction time task (e.g., Go or NoGo). Electrocranial activity and reaction time were recorded concurrently using electroencephalography and inertial measurement units. Separate stimulus-locked and response-locked event related potential waveforms were computed for each limb.

The lateralized readiness potential (LRP) was computed as the interhemispheric difference between waveforms, and the mean LRP area ($\mu V2$) and onset latency (ms) were recorded. Quadriceps active motor thresholds (%) were determined using transcranial magnetic stimulation. Differences between groups (ACLR v. control) and limbs (involved v. uninvolved), and the associations between LRP characteristics and response performance (% of errant responses), were assessed using separate two-way analyses of variance and correlation coefficients, respectively. Cohen's d effect sizes were calculated for statistically significant findings. **Results:** Participants with ACLR demonstrated smaller LRP areas than controls during periods of response selection (ACLR=0.159±0.015 $\mu V2$, Control=0.211±0.015 $\mu V2$; $p=0.043$, $d=0.4$) and motor execution (ACLR=0.127±0.013 $\mu V2$, Control=0.164±0.012 $\mu V2$; $p=0.015$, $d=0.5$), and committed more errors in both Go (ACLR=4.2±2.0%, Control=1.9±1.9%; $p < 0.001$, $d=0.8$) and NoGo (ACLR=14.7±7.2%, Control=9.9±6.7%; $p=0.032$, $d=0.5$) response conditions. There were no differences in onset latency of response selection or motor execution. Participants with ACLR had higher active motor thresholds (ACLR=30.8±6.3%; Control=23.0±5.6%; $p=0.001$, $d=1.3$) than controls, which were weakly associated with smaller LRP areas ($r=-0.32$ to -0.42 , $p < 0.05$). All results are shown in Figure 1. **Conclusions:** Participants with ACLR demonstrated greater motor planning and response inhibition during a choice reaction time task than uninjured controls. More errant performance also suggests poorer decision making in the presence of a "speed-accuracy" trade-off. Key features of the sample, including lower corticospinal excitability, lend support to an interpretation of widespread cortical inhibition contributing to impairments in response selection and motor execution.

This work was funded by the American College of Sports Medicine Doctoral Grant.

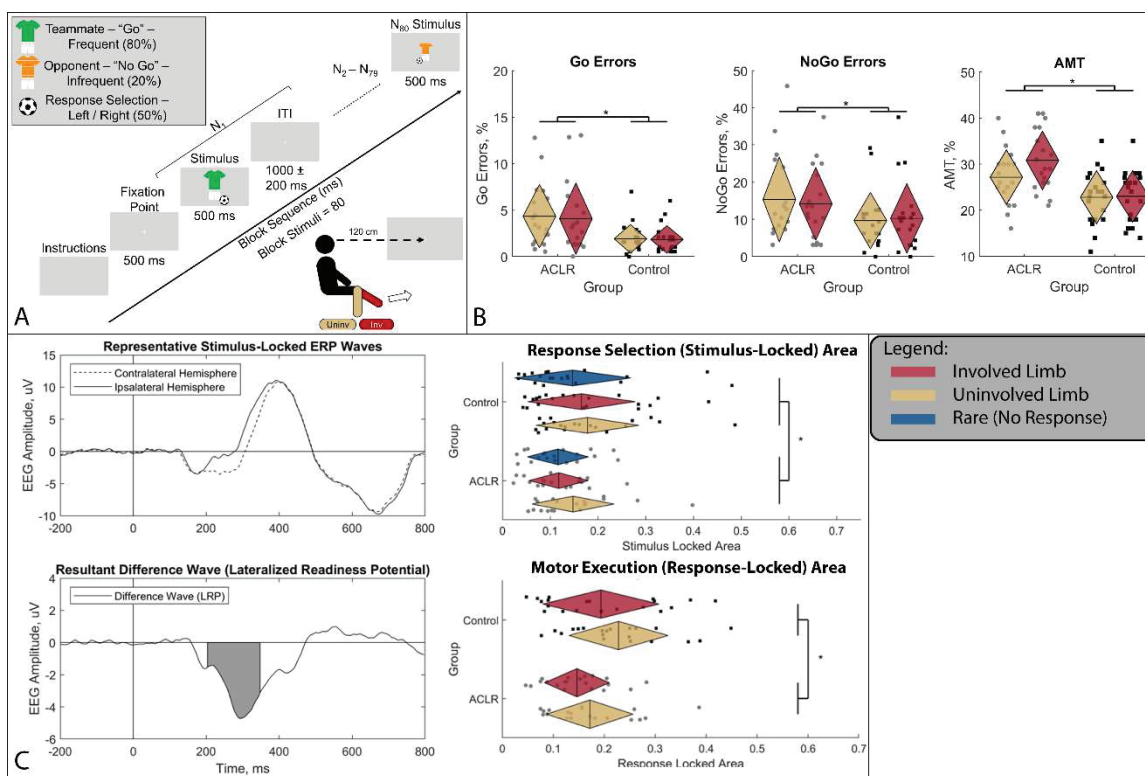


Figure 1. A) Task and stimulus paradigm. Stimuli depicting images of a soccer player and ball were presented. Each stimulus was presented for 500ms, followed by an intertrial interval (ITI) of 1000±200ms. Participants responded as quickly as possible by kicking with the left or right foot as determined by the position of the ball. Participants were told to pass the ball to their teammates, which appeared (80%) of the time. Left and right limb use was equally probable (50%) and randomized. Participants completed 12 blocks of testing (80 stimuli each, ~ 120 seconds). **B)** Reaction time performance. Go errors, NoGo errors, and Active Motor Threshold (Mean±SD) with post hoc testing results. **C)** Representative stimulus locked wave (upper left panel) with lateralized readiness potential (lower left panel) along with stimulus locked and response locked area results (right panels). The isolation of the LRP from other components by means of the subtraction technique are shown in the first and second panel for one participant. In response to the stimulus, large components are generated in both the ipsilateral and contralateral hemisphere. Peaks latency and amplitude are 400ms and 10uV, respectively. The contralateral component remains negative for longer (from approximately 200ms to 300ms). The result of subtraction of the waveforms (i.e., difference wave) at C1 and C2 electrodes are shown in panel 2. The area for the a priori temporal window of 200–350ms is shaded in gray. Latency and area were determined using 50% fractional area latency and rectified area, respectively. Right panels present results (Mean±SD) with post hoc testing results for each response type. Gold is contralateral/matched limb. Red is involved/matched limb. Blue is NoGo responses. Individual participants are shown as dark grey circles (ACLR) and black squares (Control) for each condition. Brackets with asterisk depict statistically significant differences. Group effects are present when brackets have bases (ACLR: dashed, dark grey; Control: solid, black). Abbreviations: ITI, Intertrial interval; ms, milliseconds; AMT, active motor threshold

The Relationship Between Neurocognitive Hop Performance and Self-Reported Ankle Function Among Chronic Ankle Instability Participants, Ankle Sprain Copers and Healthy Controls

Choi JY, Vogel CM, Remski LE, Knarr BA, Rosen AB: University of Nebraska at Omaha, Omaha, NE

Context: Individuals with CAI have demonstrated difficulty performing unexpected dynamic movements potentially due to altered sensorimotor function. The Choice-Reaction Hop Test (CRHT) is a functional performance test that challenges neurocognitive function during side-hopping to resemble unexpected dynamic movements during unconstrained situations, however, the CRHT has not been leveraged in CAI populations. Therefore, the purpose of this study was to compare the relationship between self-reported ankle disability and neurocognitive hop performance among three groups of healthy controls, ankle sprain copers, and those with CAI. We hypothesized that there would be 1) differences in CRHT among the three groups and 2) a negative correlation between self-reported ankle disability and CRHT in those with CAI. **Methods:** Fifty physically active participants (>90 minutes of physical activity/week) completed the Cumberland Ankle Instability Tool (CAIT) before the study and were assigned to three different groups based on their CAIT score and history of ankle sprain and giving-way episodes: healthy control (no history of ankle sprain, no ankle giving-way episodes, and a CAIT score ≥ 28), ankle sprain coper (a history of ankle sprain, CAIT score of ≥ 28 and no episodes of giving-way), and CAI (a history of ankle sprain,

a CAIT score of ≤ 25 and the presence of giving-way episodes or “feelings of instability”). Participants included 15 healthy controls (Male/Female=9/6, age=23.9 \pm 4.3years; height=170.3 \pm 9.7cm; mass=69.2 \pm 14.8kg), 12 copers (Male/Female=10/2, age=23.2 \pm 3.0 years; height=177.4 \pm 6.8cm; body mass, 77.7 \pm 11.6 kg), and 23 CAI (Male/Female=15/8, age=21.87 \pm 2.6years; height=175.8 \pm 8.6cm; mass=75.2 \pm 13.5kg). During the CRHT, participants were asked to hop on the mat indicated by a flashing light in front of the screen as fast as they can. Participants completed three CRHT trials with 10 repetitions on each limb. To determine differences in neurocognitive hop performance among groups, a one-way ANOVA and Tukey post-hoc comparisons were performed. Non-parametric Spearman’s Rho correlation coefficients were calculated in the CAI group to investigate the relationship between self-reported disability and neurocognitive hop performance. **Results:** There was no significant difference in the CRHT among the three groups (control=21.9 \pm 3.6s, coper=20.3 \pm 3.0s, CAI=21.8 \pm 3.7s, $p=0.405$). However, there was a large correlation between the CAIT and the average CRHT trial ($r=-0.55$, $p=0.003$) and a large correlation with the fastest time trial of the CRHT ($r=-0.51$, $p=0.006$) in the CAI group. **Conclusions:** There was no difference in CRHT performance among control, coper, and CAI participants. However, there was a large correlation between self-reported disability and neurocognitive performance in CAI, indicating those with greater disability also performed worse on the CRHT. The CRHT may be a useful functional performance test to assess neurocognitive hop performance in those with CAI and may assist clinicians in clinical decision making for these patients.

Psychological Readiness Among Patients Following ACLR and ACLR Revision Surgery

Thompson XD, Bruce Leicht AS, Kuenze C, Hart JM: University of Virginia, Charlottesville, VA, and University of North Carolina Chapel Hill, Chapel Hill, NC

Context: Patients with primary ACL reconstructions have an elevated risk for secondary injury to the reconstructed and contralateral knees. Outcomes following additional surgical reconstruction may differ due to prior experiences as patients are returning to desired levels of physical activity. Notably, patient psychological well-being and readiness may be affected by repeat injury, surgery, and post-operative management. The purpose of this study was to examine the psychological readiness of patients following first-time (primary) ACLR and revision ACLR. We hypothesized that the primary ACLR group would report greater psychological readiness as characterized by the ACL Return to Sport Index (ACL-RSI) and lesser injury-related fear as characterized by Tampa Scale of Kinesiophobia (TSK-17) when compared to the revision ACLR group. **Methods:** A total of 128 participants (55 males, 73 females) were included in this sample as part of a return-to-sport testing program within a point-of-care longitudinal research study at a sports medicine lab. The distribution of the surgical groups was 74 primary (41 males, 33 females, 21.9±8.6yrs, 171.2±9.8cm, 76.3±17.9kg, 7.2±0.9 months post-surgery) and 54 revision (22 males, 32 females, 23.1±7.9yrs, 172.2±9.0cm, 75.2±16.1kg, 7.3±0.8 months post-surgery) ACLRs. Inclusion criteria were primary or revision ACLR within the previous

6-9 months without current clearance to return-to-sport. Participants were excluded if they had lower extremity joint surgery prior to ACLR, multiple ligament reconstruction, contralateral knee surgery, or another lower-extremity injury within 6-months. Participants all completed the ACL-RSI and TSK-17 prior to clearance to return-to-sport. One-way ANCOVAs, with time post-surgery as a covariate, were used to analyze ACL-RSI and TSK-17 scores. Tests were considered significant if $p \leq 0.05$. **Results:** When accounting for time post-surgery, there was no difference in ACL-RSI score (Primary: 68.5±23.4, Revision 64.9±25.0, $p = 0.24$) between the primary ACLR and revision ACLR groups. There was also no difference in TSK-17 score between the primary ACLR and revision ACLR groups after accounting for time post-surgery (Primary: 32.7±6.0, Revision 33.1±5.4, $p = 0.62$). **Conclusions:** Following a revision ACLR, patients reported similar levels of readiness to return-to-sport and kinesiophobia when compared to the primary ACLR group. It appears that additional ACL surgery may not modify levels of patient perception of readiness to return-to-sport or kinesiophobia at similar post-surgical time points, however, both groups reported low levels of readiness to return-to-sport. These findings indicate that a single ACL revision may not modify psychological factors compared to initial ACLR when approaching return-to-sport. The reported levels of readiness from both groups indicate that additional consideration to psychological readiness may be necessary for patients following initial and revision ACLR.

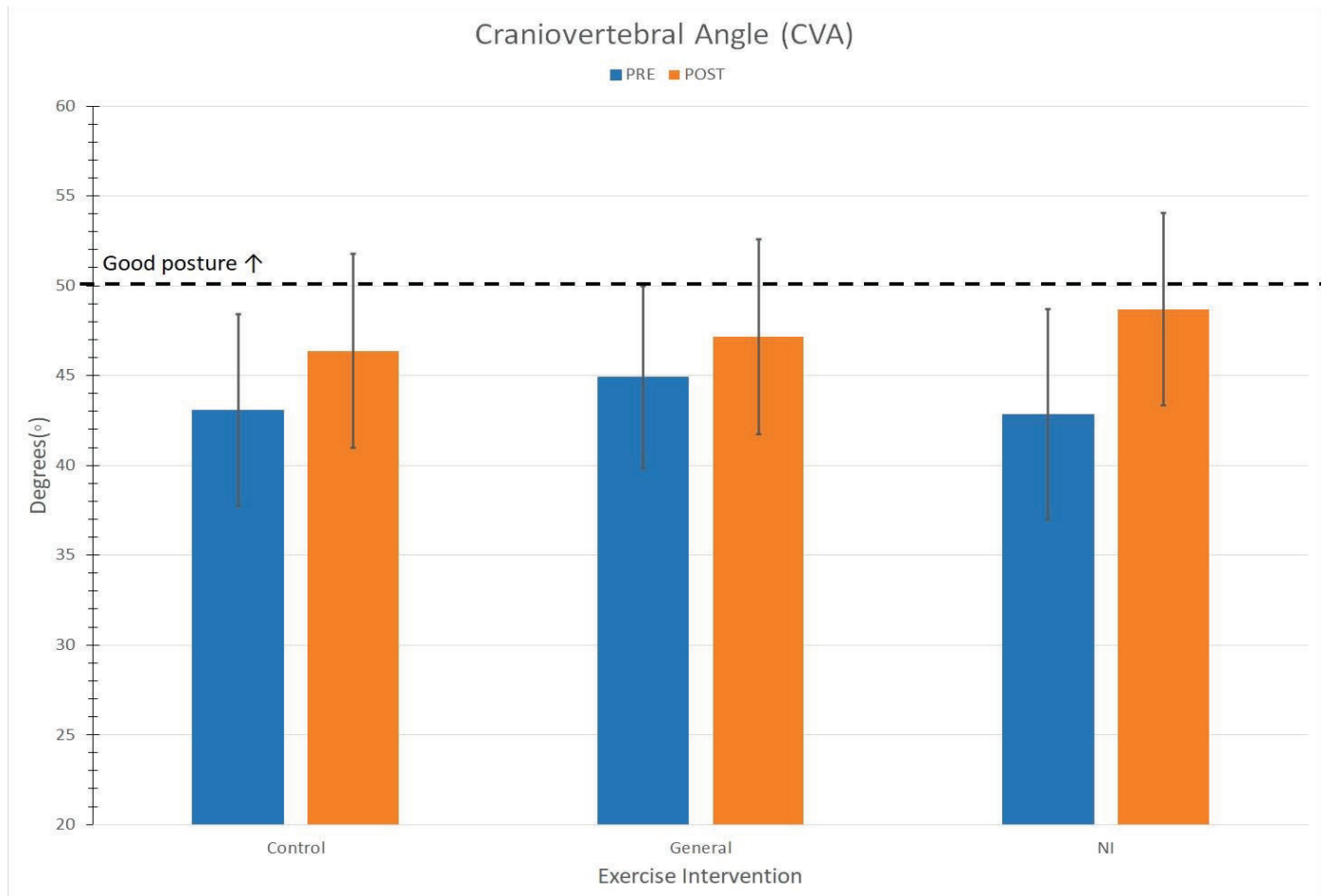
Fellow sponsored by Joe M. Hart, III, PhD, ATC.

Investigation into the Physical and Psychological Adaptations to a Neuromuscular Integration Approach to Rehabilitating Forward Head Posture in College-Aged Students

Lauman ST, Trowbridge C, Decker-Hamm M, Ricard M, Anderson DI, Iba D: University of Texas at Arlington, Arlington, TX, and Children's Health Andrews Institute, Plano, TX

Context: Forward head posture (FHP) is a common postural fault in college-aged individuals due to hunching over phones and computers. Nonverbal communication literature has demonstrated a link between posture and psychological disposition where negative psychological states such as anxiety and submissiveness are linked to FHP. Therefore, the objective of this study was to compare the effectiveness of two 8-week interventions (general and neuromuscular integration (NI) exercises) on changes in FHP and anxiety levels in college-aged students classified with FHP. Anxiety levels were measured by the General Anxiety Disorder – 7 (GAD-7) and FHP was measured using craniovertebral angle (CVA). We hypothesized that the NI intervention would improve CVA and GAD-7 scores more than general exercise. **Methods:** Improvements in GAD-7 scores and CVA were investigated in this 8-week single blind pre- and post- intervention study. One hundred twenty-one college-aged students volunteered through face-to-face and email communications and were assessed for FHP. Participants qualified for the study if they had no acute or chronic injuries and a CVA $\leq 50^\circ$. Previous literature indicates that a smaller CVA indicates a greater

FHP. Forty college-aged students qualified for study and were assigned to one of three intervention groups: control (no exercise), general exercise, and NI. The NI intervention specifically targeted muscles identified as weak and tight in the upper cross paradigm whereas general exercise was based on whole body calisthenics. Pre- and post- measures were taken for CVA and GAD-7 and statistical analysis was performed using separate 3x2 mixed-effects models with repeated measures. Alpha was set apriori at 0.05 and post-hoc Tukey tests were used. **Results:** There was a significant interaction for CVA ($F(2,37)=3.7$, $p=0.0001$) but not for GAD-7 scores ($F(2,38)=0.35$, $p=0.70$). The NI group significantly increased CVA angle (Figure 1) from pre ($42.8 \pm 1.5^\circ$; 95%CI:39.8-45.9) to post ($48.7 \pm 1.6^\circ$; 95%CI:45.7-51.7) ($p<0.0001$; Cohen's $d = 0.94$), whereas the other groups did not significantly improve. Although the changes were not significant, the NI group reduced their GAD-7 score by over 1 point from 5.6 ± 4.6 (pre) to 4.2 ± 4.3 (post); however, the general and control groups had minimal or no change in GAD-7 score (-0.07 and 0 points, respectively). **Conclusions:** The NI intervention was successful at increasing CVA and improving FHP after 8-weeks, so focused flexibility and strength exercises can improve a common postural deviation. Although statistically non-significant, the NI group tended to improve their levels of anxiety. This improvement in anxiety contrasts with the little to no improvement seen in the general exercise and control groups. These data begin to demonstrate a biopsychosocial connection where focused exercises can improve posture and thereby affect feelings of anxiety. Future studies with a larger sample size are likely to further validate the trends we observed.



Perceptual-Motor Training Program Improves Neural Processing Efficiency in College Football Athletes

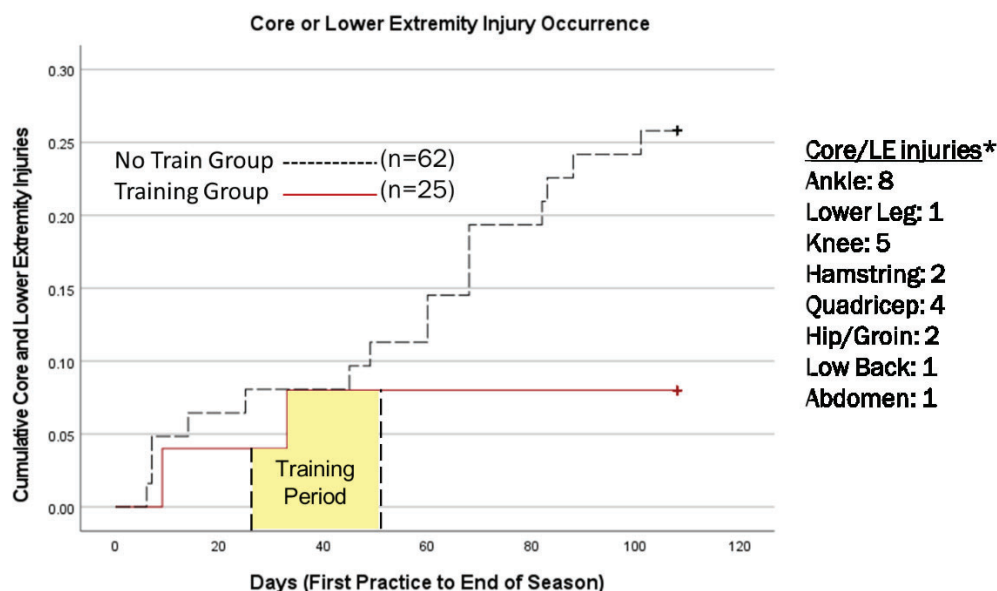
Carlson LM, Wilkerson GB, Linderman RN, Rogers EA, Wilhite DR: University of Tennessee at Chattanooga, Chattanooga, TN

Context: Previous studies have demonstrated elevated risk for core and lower extremity injury among college football players exhibiting suboptimal visual-cognitive performance. The purposes of this study were to assess the potential for improvement of visual-cognitive reaction time (RT) metrics through a motion detection training program, and to document associations between change in performance and injury occurrences across a college football season. **Methods:** A smartphone app was used to administer a flanker task to a cohort of 87 football players (age: 20.7 ± 1.7 years; height: 185.2 ± 10.1 cm; mass: 102.5 ± 19.5 kg) prior to initiation of pre-season practice and again at the end of the season. Responses to the center arrow direction of 20 5-arrow flanker displays (congruent: <<<<< or >>>>> ; incongruent: <<<<< or >>>>>) involved manual tilting of the phone in the corresponding direction. Derived metrics included Flanker Conflict Effect (FCE = incongruent RT minus congruent RT), intra-individual

RT variability (RTV), and Rate Correct Score (RCS = number of correct responses divided by sum of RTs). Prior research documented the reliability of reaction time values derived from the app (ICC=.797), and the prospective predictive validity of FCE for core and lower extremity injury occurrence among high school and college football players (OR=2.1). Players with FCE ≥ 66 ms were assigned to a training program administered during the first 4 weeks of the regular season that involved whole-body lunging responses to animated PowerPoint stimuli (filled or open circles) that moved horizontally in right or left directions from the center of a computer screen. Each training session consisted of 2 sets of 20 repetitions of responses corresponding to stimulus-response instructions to lunge in the same direction as the motion of filled circles and in the opposite direction to the motion of open circles. The addition of distracting circles that moved in various directions progressively increased task complexity whenever $\geq 90\%$ response accuracy was achieved at each of 6 difficulty levels. **Results:** Cox regression analysis adjusted for starter status demonstrated a substantial difference in core and lower extremity injury occurrence (Figure) between no-training (n=62) and training (n=25) groups (Model $\chi^2(2)=6.18$; $p=.046$; HR=3.5, 90% CI: 1.0, 12.1). Post-season data were collected from 55 players who did not

participate in training and 15 players who completed a total of 5-12 training sessions (1-3 per week). Mann-Whitney test comparison of pre- to post-season change demonstrated significant differences between the no-training and training groups for FCE ($p < .001$), RCS ($p=.039$), and RTV ($p=.047$). **Conclusions:** Observed pre- to post-season changes in FCE and RCS with RTV suggest a positive training effect that may represent improved efficiency in neural processing, which may have contributed to decreased core and lower extremity injury occurrence among players participating in the perceptual-motor training program.

Fellow sponsored by Gary B. Wilkerson, EdD, ATC, FNATA.



Cox regression analysis adjusted for starter status: Model $\chi^2(2)=6.18$; $p=.046$; HR=3.52 (90% CI: 1.02, 12.09)

Completed sessions for 25 Training Group players: median=8 (range 3-12)

Free Communications, Rapid Fire Presentations: Identification and Care of Core and Upper Extremity Pathologies

Friday, June 23, 2023; 10:20 AM-11:15 AM; Room Entry 236

Moderator: Kellie Huxel Bliven, PhD, ATC

Bilateral, Multi-Level Lumbar Facet Arthropathy in a 20-Year-Old as a Consequence of Early Sport Specialization: Type 1 CASE Study

Sheerin JP, Martin BM, Evans TA: The Steadman Clinic, Vail, CO, and Steadman Philippon Research Institute, Vail, CO

Background: Low back pain (LBP) is a leading cause of disability worldwide and often associated with concurrent pathology including facet joint disease (FJD). FJD is suggested to be present in 30.6% of LBP cases and primarily seen in adult populations affecting 44% of individuals 51-60 years old. However, some populations, like competitive gymnasts, show variance from averages. Gymnastics often requires early specialization and repetitive hyper-extension skills causing changes in spinal alignment and mechanics leading to pathological FJD pain. A 2020 clinical case-control series examined how early sports specialization (ESS) affected injury rates. The researchers found in females younger than 12yo ESS significantly increased their risk of developing acute and chronic injuries. The subject of this type 1 CASE study supports these claims **Patient:** Patient is a 20-year-old female complaining of worsening LBP with atraumatic and insidious onset of intermittent pain when she was 8yo. The patient reports specializing in gymnastics as a 5yo and retiring at 18yo. The patient has a history of Celiac's disease and ADHD but is otherwise healthy. The pain first began and worsened with gymnastics skills emphasizing lumbar hyperextension. The patient reported her pain is limiting her participation in athletic activities and ADLs. Active thoracolumbar extension reproduced

pain complaints, and a positive lumbar facet loading test was appreciated. Differential diagnosis included spondylosis, spondylolisthesis, and lumbar FJD. Radiographs and MRI images showed 70° of lumbar lordosis, lumbar FJD, sacralization and lumbarization with pseudo-articulation (Bertolotti's Syndrome). She was diagnosed with bilateral FJD at the L4-L5 and L5-S1 levels. **Intervention & Treatment:** The patient's treatment plan included physical therapy and medial branch radiofrequency ablations (MBRFAs). The patient's physical therapy focused on core stabilization and postural correction to manage lumbar hyper-lordosis. Diagnostic medial branch blocks (MBBs) were done at the levels of the prospective ablation. Significant temporary relief after MBBs provides evidence to support the MBRFA's efficacy. MBRFAs were recommended to limit sensory innervation at the affected joints preventing the perception of pain but are limited by not treating the cause of the patient's pain. **Outcomes or Other Comparisons:** The outcome examined in this case presents a unique circumstance surrounding the onset and etiology of her pain. In specific populations, like competitive gymnasts, a comparative study found 82.5% of 13-24yo gymnasts reported a history of LBP. Of those participants 15% had FJD, or related pathologies including spondylosis (40%), and spondylolisthesis (15%). This can be attributed to the common practice of ESS amongst gymnasts before adolescence. The patient presented was at high risk for LBP after ESS. The 2020 comparative study reported that year-round participation in a single sport by skeletally immature athletes significantly increases risk of acute and chronic injury. In the general population the rate of FJD is 28%, much lower than in specialized athletes. **Conclusions:** Its important healthcare providers

recognize specific risks associated with specialized athletic populations. The presence of translational anatomy increases the likelihood of LBP but can also remain benign. Therefore, it cannot be confirmed that its presence is the exclusive reason for her LBP. The patient's ESS should be considered as a factor causing her LBP. The patient met criteria for ESS which coincided with onset of her chronic pain. This case provides support for the negative outcomes associated with ESS. **Clinical Bottom Line:** For those working with specialized populations, understanding the risk factors for conditions like LBP is critical. Those managing the health and wellness of young athletes should be able to identify, and manage ESS, allowing young athletes' mental and physical health to be maintained and improved. For sports that require ESS, an interdisciplinary approach is important to continually assess and ensure at-risk athletes are not experiencing negative outcomes.

Paget-Schroetter Syndrome in a Collegiate Baseball Player: A Type 4 Clinical CASE Study

Rizopoulos J, Odai ML, Birchell J: Florida International University, Miami, FL

Background: A 24-year-old right-handed baseball pitcher complained of right arm heaviness during normal pre-game routine. The extremity appeared normal upon inspection and gentle effleurage and stick massages were done by the Athletic Trainer (AT). The AT did note some tightness in the bicep. The athlete continued to the dynamic warmup and after 2 pitches, stated he could no longer continue. Upon evaluation, the AT noted point tenderness, swelling, and a change in skin color in the right upper arm. Radial pulse was slightly weaker when compared bilaterally and there was noted effusion when flexing the elbow. There was no noted change in skin temperature or compartment firmness and the athlete was not experiencing numbness or tingling. After 1 hour of rest, there were no changes in symptoms and the athlete was referred to an urgent care center. After returning to campus, there still was no change in the athlete's condition and the AT referred him to an emergency department (ED). **Differential Diagnosis:** Differential diagnosis included infection and thoracic outlet syndrome. **Intervention & Treatment:** The urgent care physician diagnosed the athlete with tight shoulder muscles and injected Toradol and a muscle relaxer. There was no improvement in the patient's condition after approximately 2 hours and he was referred to the ED. A blood panel and diagnostic ultrasound were conducted. The ED physician diagnosed a right subclavian clot. There were no other remarkable findings. The athlete was given a heparin IV via drip to thin the blood. The athlete was admitted to the ED for further testing and monitoring. A vascular surgeon reviewed the case and diagnosed the athlete with Paget-Schroetter Syndrome (PSS) due to obstruction of the vein

causing the blood to clot in the subclavian. A venogram was administered to see what was obstructing the vein, either the first rib or the scalene muscle. This would determine the course of action. Three days following initial onset, a thrombolysis procedure was used to dissolve the clot. Swelling in the athlete's arm was intermittent and eventually subsided the following day. The surgeon determined that the first rib was causing the obstruction and would need to be surgically modified if the athlete wanted to play baseball again. The athlete was discharged from the hospital 2 days after lysis procedure, was instructed to have complete bed rest for 7 days and will continue blood thinning medication for 2-6 months. At the follow-up visit 1 week after discharge, the athlete made the decision to have the surgery, which has a return to play timeframe of 1.5 - 3 months. Athlete continued modified bed rest for 3 weeks until the surgery was performed. A portion of the athlete's first rib was removed, and no surgical complications were reported. Post-surgical instructions included rest and limited activity to allow for proper wound healing. Rehabilitation began once wound was healed and focused on range of motion and strengthening. The athlete first threw a baseball approximately 3 months after the surgery. He was pitching at full speed 8 months post-surgery. **Uniqueness:** PSS is a rare case of spontaneous upper extremity deep vein thrombosis combined with vigorous activity of the upper extremity. The incidence ranges from 1 to 2 per 100,000 individuals per year in various studies. A key pathogenic factor is costoclavicular crowding due to anatomical abnormalities which was confirmed in this athlete via imaging. **Conclusions:** After a misdiagnosis at an urgent care center, the AT made the decision to refer the athlete to the ER. This decision allowed the correct diagnosis and plan of care. It is important for the AT to understand this condition and its presentation, as it can be life threatening if left untreated.

Pre-Professional/Professional Student Winner

Identifying and Treating Hip Dysplasia in Young Athletes With a Special Consideration for Ehlers-Danlos Syndrome: Level 3 CASE Study
Porter MP, Martin BM, Matta JM:
The Steadman Clinic, Vail, CO

Background: Hip dysplasia is characterized by a shallow hip socket providing inadequate coverage of the femoral head, causing predisposition to osteoarthritis of the hip. It can be congenital or developmental. Ehlers-Danlos Syndrome (EDS) is a hereditary disorder of the connective tissue, resulting from various abnormalities in collagen and primarily affects the skin, musculoskeletal tissues, and vessels. There are 13 subtypes, which are generally characterized by hyperextensible skin, hypermobile joints, and tissue fragility; common complications are joint dislocations and early-onset osteoarthritis. Extremely loose joints, fragile skin, and a family history of EDS are clinical indications, and it is confirmed with genetic tests. Hypermobile EDS (hEDS) is a common subtype seen in orthopedics for treatment of chronic pain and joint instability. This is a Level 3 CASE report of a 27-year-old female swimmer and dancer with hEDS and insidious onset of hip pain. **Patient:** Patient is a 27-year-old female swimmer and dancer presenting with bilateral, insidious onset of hip pain, right > left, persistent and worsening. She self-reported a right hip dislocation in June 2020. Symptoms included deep pain in the groin and buttocks, catching, giving away, instability, and weakness. Forearm crutches were utilized for ambulation. Medical history includes hEDS, postural orthostatic tachycardia syndrome, asthma, and chronic pain. Beighton score of 6/9 confirmed hypermobility. Physical findings included hypermobility, decreased hip internal rotation, decreased strength in hip flexion and positive anterior impingement test.

Radiographs demonstrated a center edge angle of 25°, normal Tönnis angle, and a positive crossover sign. MRI demonstrated a labral tear, cam deformity and acetabular retroversion. **Intervention & Treatment:** Patient consented to a right periacetabular osteotomy (PAO) with arthroscopic labral repair. Precaution with patient handling during the case was noted to minimize complications from EDS. Postoperative protocol included partial weight bearing on crutches for 6 weeks, hip bracing, no external rotation or flexion above 90° for 4 weeks, PT for 6 weeks, and return to normal activities at 12 weeks. The patient will undergo a PAO, and possible labral repair pending MRI results, on the left hip, after her right hip is fully recovered. **Outcomes or Other Comparisons:** A PAO and arthroscopic labrum repair corrects the acetabular orientation and prevents continued shearing on the labrum. Ten-year and 20-year survivorship of the native hip after PAO is approximately 86% and 60% respectively. The combination labral repair with a PAO is ideal for younger patients to prevent a total hip arthroplasty (THA). Surgical management of joint instability in patients with EDS can be challenging due to likely inferior biomechanical properties of the collagen-containing structures. Clinicians must take care with EDS patients in surgery to reduce the risk of joint luxation and skin fragility, bleeding, and hematomas. More research is necessary to determine potential differences in tissue quality and joint mechanics between patients with joint instability and EDS. This case study reveals positive outcomes after undergoing a labral repair and PAO for acetabular retroversion. **Conclusions:** Labrum injuries increase with high impact activities requiring hip hypermobility, such as dancing. Patients with hip dysplasia may show hypermobility fitting to their sport participation, but few have true EDS. Early recognition of hip dysplasia shows better

outcomes for patients. Understanding indications for surgery and providing proper intervention preserves the native hip joint and prevents early THA. A preoperative diagnosis of EDS allows for optimal perioperative care. **Clinical Bottom Line:** Surgical treatment of hip dysplasia in EDS patients is under-reported in the literature. Understanding the associated risks of EDS in an active population is important to reduce early onset of osteoarthritis and improve quality of life. Athletic trainers play a key role in decreasing the prevalence of early onset osteoarthritis in their patients by identifying risk factors and providing proper referrals.

Management of an Iliopsoas Hemorrhage Causing Neurological Impairment in a Hemophilic Teenager: Type 4 Rare Events CASE Study
Garg S, Meyer CM, Hand AF: University of South Carolina, Columbia, SC

Background: The patient is a 16-year-old high school male athlete who plays various sports throughout the year. He has a known congenital factor IX deficiency called hemophilia B without a history of inhibitor. His medical history includes posterior epidural hemorrhage of the lumbar spine 2 years prior, along with other minor joint bleeds in the bilateral tibiofemoral and talocrural joints. He began to complain of left hip and groin pain during standing, walking, and sleeping after slipping on ice while walking to school 1 week prior. The patient received immediate coagulation medication and Tylenol for management of pain at home. **Differential Diagnosis:** He was initially evaluated at emergency department, where he was complaining of severe left hip and groin pain and loss of sensation down his left leg. At this time, differentials included an adductor or hip flexor strain accompanied with hematoma, sports hernia, and re-injury of the lumbar spine. The patient was scheduled for a radiograph and magnetic resonance imaging (MRI). **Intervention & Treatment:** The MRI confirmed a large hematoma in the left iliopsoas with no abnormality in the lumbar spine, and the patient was referred to his hematologist for further treatment plan. Upon evaluation by the hematologist, the patient had distress with left hip active range of motion, and manual muscle tests for the hip flexor group presented with decreased strength and pain distal to the anterior superior iliac spine. He additionally complained of pain during Ely, Thomas,

and Straight Leg Raise special tests. A sensory deficit in the left L2-L4 dermatomes was noted with no corresponding motor or reflex deficits. The patient was hospitalized and received 5000 units of prophylactic medicine for 48 hours and was placed in a complete leg immobilizer, on crutches, and given non-weightbearing exercises prior to discharge. His dose was decreased to 3000 units every 24 hours when he no longer complained of pain with standing and lying supine. Two weeks after the injury, he was able to advance to outpatient physical therapy focusing on regaining range of motion and re-learning proper gait. The patient was cleared for light resistance exercise 4 months after injury and was not cleared for sport activities until 6 months after injury. The patient transitioned to prophylaxis from prophylactic medication when he returned to full weightbearing and exercising without deficits. **Uniqueness:** Due to the location and severity of the injury, the patient's physicians chose a conservative treatment approach. Hemophilia can cause complications in any common wounds due to lack of either clotting factor VIII or IX. The treatment for hemophilia includes coagulation factor replacement therapy administered as an intravenous infusion. Patients with hemophilia will either utilize a short-acting medication lasting 24 hours (prophylactic) or a long-acting medication lasting 7-14 days (prophylaxis). Evidence has shown prophylaxis medication has a significant impact on decreasing school or workdays missed, improved quality of life, and overall physical health status. It is important to know a patient's medical history to treat injuries and conditions not commonly encountered in the athletic population appropriately. **Conclusions:** Although the patient made a full recovery, he was discouraged and unsatisfied with the disease-oriented intervention approach and the extent of the timeline

for return-to-activity. Research has shown introducing prophylaxis medication earlier could have prevented the hematoma or accelerated the rehabilitation process. Athletic trainers may not see many hemophilic athletes in practice, making it difficult to diagnose the severity of one's injury or determine the appropriate intervention approach. In cases with a deficit of literature, clinicians should consider including patients in the intervention plan, as they may know more about the potential complications of their condition. In addition, patient engagement may improve intervention adherence and ultimately improve outcomes.

Avulsion Fracture of the Anterior Superior Iliac Spine in a High School Baseball Player

Yuan X, Kulpa TA, Marchetti DP:
King's College, Wilkes-Barre, PA

Background: Apophyseal avulsion fractures are commonly seen in the adolescent population, anterior superior iliac spine (ASIS) avulsion fractures account for about 30% of all apophyseal avulsion fractures to the pelvis but only 1.4% of all the hip and pelvis injuries. Most ASIS avulsion fractures are sustained by a sprinting, jumping, or kicking motion in sports such as soccer, track and field, and gymnastics. Only 3 cases in the literature have reported this injury caused by baseball batting with a multiplanar twisting and hyperextension mechanism of the trunk and hip. **Patient:** 16-year-old right-handed baseball catcher who complained of severe pain in his right anterior hip after swinging at a pitch. An acute pain was felt in the middle of the swing phase when the athlete hyperextended and rotated his right hip. Physical examination revealed point tenderness and mild edema at the right ASIS and iliac crest. No deformity, discoloration, or crepitus. The patient reported pain 9/10 and felt that his right hip was 'stuck' in flexion, thus he could not bear weight on his right leg. X-ray examination revealed an avulsion fracture was sustained at the right ASIS. **Intervention & Treatment:** A conservative treatment plan was implemented. The athlete was instructed to avoid weight-bearing initially for 2 weeks until he could tolerate the pain while walking without crutches. 2 weeks post injury, the athlete was able to perform simple therapeutic exercises (TEs) as tolerated, such as aquatic range of motion exercises and isometric quadriceps activation. 3 weeks post injury,

the athlete was able to walk normally without crutches although he reported occasional muscle weakness when going up the stairs and pain 2/10 when doing straight leg raises and hyperextending his right hip. The rehabilitation program consisted of TEs to improve core stability, flexibility, muscular strength, and proprioception of the lower extremities while monitoring the patient for pain using visual analog scale (VAS). The athlete was able to return to normal athletic activities without any symptoms or complications 9 weeks post injury. **Outcomes or Other Comparisons:** The majority of the ASIS avulsion fractures are treated conservatively if the size of the avulsed fragment is smaller than 15 millimeters. The time period for return-to-play varies, although most athletes under conservative treatment returned to sports between 3 to 6 months. In this case, the athlete returned to normal sports activities in 9 weeks without complications, which was likely due to the early recognition and immediate referral by the athletic trainer on site, an easy access to the athletic training services, and the effective implementation of TEs. **Conclusions:** The challenge associated with this case is that a lack of relevant literature made it difficult to effectively recognize the potential of ASIS avulsion fractures caused by baseball batting. Furthermore, a lack of delineated and time-specific rehabilitation and return-to-play guidelines also challenged the clinicians in this case. **Clinical Bottom Line:** Clinicians should be aware of the possibility that a multiplanar twisting and hyperextending mechanism of the trunk and the hip in baseball batting can cause avulsion fracture of the ASIS. Therefore, ASIS avulsion fracture should be included as a differential diagnosis in adolescent athletes experiencing severe pain and inability to bear weight after swinging a baseball bat.

Novel Surgical Repair of Adductor Longus in Division 1 Men's Ice Hockey Player: A Level 4 Case Study
DeVeglio J, Bartels A, Pollard-McGrandy AM, Walaszek M, Hosler A, Covassin T: Michigan State University, East Lansing, MI

Background: A 23-year-old male Division 1 collegiate fifth-year hockey player with a previous history of left adductor longus strain. The athlete suffered an acute adductor injury during the 2020-2021 season, rehabilitated the injury, however was not removed from participation. The athlete sustained a subsequent strain of the left adductor on October 22, 2021, requiring a 72-hour rest period immediately followed by structured rehabilitation with the team athletic trainer, return to non-contact practice 2 weeks post-injury, and return to game play 3 weeks post-injury. On December 30, 2021, the athlete sustained a contact injury to the left groin during game play. The athlete was battling an opposing player for puck possession when his left leg slipped out further into abduction. At the time of injury, the athlete complained of a pop sensation of the left groin with pain at the proximal adductor longus attachment point. **Differential Diagnosis:** Rectus abdominus strain at the pubic attachment site, adductor strain. **Intervention & Treatment:** During orthopedic evaluation, imaging revealed full thickness, near complete tear of the left adductor longus tendon at the pubic attachment. Based on imaging results, a conservative pre-operative plan was discussed with a 10-12 week return to game play timeline. Upon further evaluation by the team physician, it was decided to complete a novel surgical procedure using Dacron mesh graft to repair the left adductor longus, which would allow the athlete to return to play in 4-6 weeks including post-operative rehabilitation. The novel procedure was performed on January 7, 2022 with post-operative rehabilitation completed by the team athletic trainer. On February

7, 2022, the team physician allowed the athlete to participate in warm up and conditioning drills. Following this, on February 10, 2022, the athlete was cleared to participate in non-contact position-specific drills and special teams drills. On February 16, 2022, the team physician fully cleared the athlete to return to practice with no restrictions. On February 18, 2022, 6 weeks after the novel surgical intervention, the athlete returned to game play. **Uniqueness:** Although adductor tears are a common injury in ice hockey, only 3.1% require surgical intervention. The surgical procedure commonly performed with this type of injury includes suturing of adductor longus. However, in this case the surgeon used a Dacron mesh graft to secure the adductor longus to its attachment point and currently there is no evidence-based literature for this type of procedure to repair the adductor longus tendon rupture. According to the surgeon, the Dacron mesh graft would provide more security and stability of the tendon attachment site compared to the FiberWire sutures allowing the athlete to progress more quickly through rehabilitation and return to game play. **Conclusions:** In general, injuries to the tendon attachment, versus musculotendinous junction, can result in a longer return to game play timeline, which can greatly affect an athlete's season and even career. Often, there is widespread debate regarding surgical versus non-surgical interventions for treatment of this injury. Athletes return following non-surgical interventions in an average of 10-12 weeks, compared to 8-10 weeks with typical surgical interventions (use of sutures). The use of the Dacron mesh graft technique and initiation of functional movements sooner after surgery afforded this athlete the opportunity to return to high-level play at an expedited rate compared to traditional surgical treatment. The Dacron mesh graft is a superior method to repair complete adductor longus tears due to the accelerated return to game play that has occurred in this case, although more research is needed to support this finding.

A Supraspinatus Tear at the Musculotendinous Junction in a 13-Year Old Female Snowboarder With Anterior Instability: Type 3 CASE STUDY

Hannigan-Luther SP, Riordan SM, Martin BM, Hackett TR: The Steadman Clinic, Vail, CO, and The Steadman Philippon Research Institute, Vail, CO

Background: Rotator cuff tears (RCT) are a common shoulder pathology in adults, but are uncommon in adolescents. Adolescent RCT represent under 1% of total RCT and 1.4% of adolescent shoulder injuries. In young athletes, they are usually associated with trauma or previous overuse injuries. In the general population, RCTs commonly occur at the greater tuberosity insertion, while in adolescent athletes the tears often involve a greater tuberosity avulsion. Musculotendinous junction tears of the rotator cuff (RC) are extremely rare, particularly in an adolescent. Glenohumeral instability is associated with RCT in older adults, but this association is uncommon in adolescents. RCT also have a higher false negative rate of diagnosis on MR-Arthrogram in adolescents compared to adults. This is a Type 3 clinical CASE study of an atypical presentation of RCT in an adolescent. **Patient:** A 13-year-old female competitive snowboard athlete presented with a chief complaint of right shoulder instability. She reported 5 glenohumeral dislocations over the previous year, despite physical therapy and utilizing a sully brace. Upon physical examination, she demonstrated full AROM and strength, positive anterior apprehension/relocation and posterior drawer tests and a 4/9 score on Beighton's criteria. MRI demonstrated mild RC tendinosis, irregularity of the anterior inferior labrum, and a small Hill-Sachs lesion. After one-year of conservative treatment she reported worsening instability and multiple dislocation events that

had required emergency department reductions. While she presented with limited ROM due to apprehension, she demonstrated full RC strength, negative speed's and O'Brien's tests, and positive sulcus sign and posterior load and shift tests. A second MRI was obtained, which demonstrated a Bankart lesion, small Hill-Sachs lesion, mild RC tendinosis, subacromial bursitis, and mild glenohumeral effusion. **Intervention & Treatment:** The patient was consented for an arthroscopic Bankart repair, subacromial debridement, and anterior and posterior capsulorrhaphy. During the diagnostic arthroscopy, a nearly full thickness tear of the supraspinatus at the musculotendinous junction was identified and addressed with a successful rotator cuff repair (RCR). She successfully underwent the rest of her consented procedure. Post-operatively, referral to PT included ROM limitations and an extended return to strengthening due to the RCR. **Outcomes or Other Comparisons:** The patient returned to limited snowboarding activities at 5.5 months and was cleared for full activity at 6.5 months. Risk factors for recurrent instability following an adolescent Bankart repair include surgery >6 months from the initial dislocation and more than 2 pre-operative dislocations. This patient experienced her first dislocation event 2 years prior to surgery and suffered 7 dislocations, placing her at higher risk of recurrent instability. She has not reported any recurrent instability events post-operatively and has returned to full activity. RCT outcomes in adolescents are not well established in the literature. Eisner et al. found that 70% of patients under 19-years-old that underwent a RCR for a partial thickness tear returned to their previous level of athletic competition. This patient's successful return to competitive snowboarding with no reported complications supports these findings. **Conclusions:** This case demonstrates an uncommon presentation of a supraspinatus tear in a 13-year-old female with repeated anterior glenohumeral instability. RCT are very

uncommon in an adolescent population but can be associated with glenohumeral instability. The tear in this patient occurred at the musculotendinous junction, presenting added difficulty for the treating surgeon due to the lack of viable tissue for suturing. **Clinical Bottom Line:** Awareness of possible RC pathologies associated with anterior glenohumeral instability is needed when working with adolescents. A thorough history and physical examination are especially critical given the increased likelihood of this pathology being missed on imaging. MR-Arthrogram have high false negative rates in diagnosing RCT in adolescents and care should be taken during the initial arthroscopy to rule out a RCT.

Highly Comminuted Three-Part Fracture-Dislocation of the Proximal Humerus: Level 3 CASE Study

Avila KL, Martin BM, Vidal LB: The Steadman Clinic, Vail, CO, and Steadman Philippon Research Institute, Vail, CO

Background: Posterior dislocations are rare, most occur via electrical shock and epileptic fit. Less frequently, high-energy trauma may lead to a posterior dislocation. Sixty percent of cases are misdiagnosed and overlooked. Locked shoulder dislocations account for approximately 2-4% of all shoulder dislocations, a diagnostic delay can lead to a locked dislocation. Three-part and 4-part displaced fractures can be associated with dislocations and are treated surgically. Recommended treatment in older populations is a total shoulder arthroplasty (TSA) and for younger patients, an open reduction internal fixation (ORIF). In 3-and 4-part fractures, revision surgery resulting in arthroplasty can take place in over 50% of patients. In this type 3 CASE study, initial misdiagnosis and severity of injury predisposes the patient to post-surgical complications. **Patient:** A 47-year-old male presented for a second opinion regarding a proximal left humerus fracture. Patient sustained acute injury while mountain biking, describing landing on the posterior aspect of his shoulder. Pertinent medical history included a failed ORIF of the proximal humerus performed by another surgeon 6-days post-injury. Patient presented with an anterior deltopectoral incision with no signs of infection and neurovascularly intact. Shoulder examination was limited due to pain. Elbow ROM is within normal limits. Outside facility radiographs taken acutely consisted of views that would make it difficult to assess the complexity of his fracture pattern and did not demonstrate the humeral head posteriorly dislocated and rotated. Updated and additional

radiographs included an anteroposterior (AP), grashey, axillary and scapular Y views, showing humeral head dislocated posteriorly with a highly comminuted proximal humerus fracture. AP view demonstrates the humeral head in a varus, medially displaced position in relation to the proximal shaft. **Intervention & Treatment:** The patient was informed of surgical risk, including delayed union, nonunion, malunion, and avascular necrosis of the humeral head, which may lead to total joint considerations. Patient consented and underwent an ORIF of the proximal humerus fracture-dislocation. The surgical procedure consisted of 90-90 plating with bone grafting. Surgical intervention 48 hours after incident is considered late surgery for fracture reduction and increases the chances for revision surgery in elderly patients. Recent case studies have identified that successful ORIF surgery is superior when compared to joint replacement surgery in a young patient population. **Outcomes or Other Comparisons:** Follow-up 9-days status post-surgery and radiographs demonstrate a stable reduction and placement of the plates. Patient was immobilization for 6-weeks. At the follow-up, it was too early to determine if there was failure of fixation or avascular necrosis of the humerus. The literature points out that it typically takes up to 3-months to demonstrate avascular necrosis, delayed union, nonunion or malunion of a proximal humerus fracture. If poor outcome of ORIF is determined at a 3-month follow-up, consideration of reverse TSA may be recommended.

Conclusions: Misdiagnosis is a major concern, compromising the glenohumeral joint and vascularity of the humeral head. The recommended views for shoulder radiographs are AP, axillary, and scapular Y views, which are necessary for the proper diagnosis. Joint preservation in younger populations should be considered, educating the patient on the associated risks. Consideration of TSA in traumatic injuries of the glenohumeral joint has shown good

outcomes. The athletic training profession has highlighted injury prevention and treatment for osteoarthritis (OA), this case highlights that not only should athletic trainers be knowledgeable of TSA as a treatment for OA but that it can also be considered with traumatic injuries. **Clinical Bottom Line:** Proper radiographic views are necessary for accurate diagnosis of posterior shoulder dislocations. A traumatic humeral fracture can lead to a TSA, though not commonly seen in athletic populations, there is good evidence to support this treatment outside of OA.

Acute Triquetrum Fracture in a Softball Player

Casmus R, Volpicelli K: Novant Sports Medicine, Winston-Salem, NC

Background: A 17-year-old female high school softball player reported that as she was reaching for a pitched ball the batter swung and struck the ulnar side of her left wrist. There was immediate pain and the onset of swelling. The athlete was unable to put her glove back on and she could not grip the ball. Upon examination there was point tenderness to palpation over the ulnar styloid process and along the carpal bones. Range of motion was sore and limited for active and passive for wrist flexion and wrist extension. Range of motion for wrist ulnar and radial deviation was extremely painful and minimal. **Differential Diagnosis:** Contusion, Distal Ulnar Fracture, Pisiform Fracture, Lunate Fracture, Triquetrum Fracture. **Intervention & Treatment:** The athlete was removed from play and treated with ice for twenty minutes and then placed in a forearm splint. She was referred to an orthopedic specialist for follow-up care. A/P lateral and oblique x-rays of the left wrist revealed a non-displaced longitudinal fracture to the body of the triquetrum. The athlete was placed in a short arm cast for three weeks. After three weeks the cast was removed, and follow-up x-rays revealed fracture site healing. She was placed in a removable wrist splint and permitted to begin range of motion and strengthening exercises for the wrist and forearm muscles. As her sports season had ended during her immobilization period there was no return to play program initiated and the academic year ended. **Uniqueness:** Wrist injuries in sports comprises 3-9% of all sports injuries. In

general, compressive injuries such as fall on the outstretched hand or direct blows can result in fractures. Triquetral fractures comprise 3-5% of all carpal fractures. The three primary triquetral fractures that occur are the dorsal chip or cortical fracture, palmar cortical fractures, and triquetral body fractures. Triquetral body fractures involving high energy injuries to the hand and can result in perilunate fractures or dislocations and as such physicians should seek to rule out associated ligamentous injuries to the wrist and carpal bones. Triquetral fractures can also be seen concurrently with fractures to the hamate, distal ulna, and distal radius. Triquetral fractures can be missed in up to 20% of x-rays and thus magnetic resonance and computerized tomography are useful in diagnosing occult triquetral fractures. Fractures to the triquetrum have been shown to be more common in individuals with a long ulnar styloid process which impacts on the triquetrum. **Conclusions:** Fractures to the triquetrum are second to the scaphoid bone for fractures occurring to the carpal bone yet they have a low occurrence. Management of isolated triquetrum fractures varies pending on the fracture pattern. Triquetral fractures to the body normally heal without consequence and rarely have a non-union. Most triquetral body fractures are immobilized for at least 3-6 weeks. Likewise, the dorsal cortical and palmar cortical fractures also heal with 3-6 weeks of immobilization. Should the rare case of a displaced triquetral body fracture occur than open reduction and internal fixation would be advised. This case illustrates the appropriate evaluation, treatment, and care of an athlete with a non-displaced fracture to the triquetrum. The athlete is currently asymptomatic and has resumed all activities of daily living.

Free Communications, Rapid Fire Presentations: Chronic Ankle Instability: Mechanisms and Interventions to Improve Outcomes

Friday, June 23, 2023; 7:30 AM-8:25 AM; Room 237-239

Moderator: Patrick McKeon, PhD, ATC, CSCS

Protective Factors and Risk Factors for Persistent Pain 6-Months After Lateral Ankle Sprain

Kosik KB, McCann RS, Slone S, Orhnberger E, Gribble PA: University of Kentucky, Lexington, KY, and Old Dominion University, Norfolk, VA

Context: Nearly half of all individuals experience persistent pain 6-months after a lateral ankle sprain (LAS). Individuals who experience persistent ankle pain report moderate intensity levels that interfere with walking, running, and vigorous activities. The purpose of this project is to prospectively examine factors at the time of injury or return to activity that may be protective or increase the risk of persistent pain. Prospectively evaluating such outcomes may provide valuable insight for identifying individuals who are susceptible to pain chronification. **Methods:** A prospective cohort study design was used to enroll twenty-nine participants (F:19, M:10; 21.2 ± 7.8 years; 171.7 ± 10.7 cm; 75.9 ± 17.9 kg) who had sustained an acute LAS within the previous 7 days. Participants completed a standardized survey that was distributed electronically at the time of enrollment, return to activity, and 6-months post-injury. Items in the survey outlined as protective factors included having attended supervised physical rehabilitation with a healthcare provider, weight-bearing status at the time of enrollment, and the use of an external support during physical activity. Items representing risk factors included demographic information (e.g., age, body mass index, sex), and ankle pain intensity levels at return to activity. Scores on the Pain subscale of the Foot and Ankle Disability Index were used to dichotomize participants as

having persistent pain ($n=11$) or no pain ($n=18$). Separate logistic regression models calculated odds ratios (OR) and 95% confidence intervals to identify predictors of pain at 6-month follow-ups from the protective factors and risk factors. Because of missing data, only 25 participants were available for the analysis examining potential risk factors. However, data from all enrolled participants were available for potential protective factors. **Results:** The logistic regression model for risk factors demonstrated that reporting pain at the time of return to activity was associated with an increased likelihood of persistent pain at 6-months post-injury ($p=0.05$; $OR=7.35[0.98, 55.04]$). The logistic regression model for protective factors demonstrated that full weight-bearing status at the time of enrollment was associated with an increased likelihood of persistent pain at 6-months post-injury ($p=0.05$; $OR= 5.63[0.93-33.76]$). **Conclusions:** The clinical practice guidelines for an ankle sprain recommend progressive weight-bearing with support during the early phase of recovery and supervised rehabilitation. Interestingly, supervised rehabilitation was not identified as a preventative factor against developing persistent pain despite almost 62% of our participants seeking care. Instead, our results suggested full weight-bearing status at the time of enrollment and ongoing pain at the time of return to activity were associated with persistent pain 6-months after an ankle sprain. These results provide preliminary support for the need to re-examine recommendations for the early phases of recovery post-injury and potential reasons why individuals are returning to activity with ongoing symptoms (e.g., pain).

Fellow sponsored by Phillip Gribble, PhD, ATC, FNATA.

Effects of A Single Balance Training Session on Neural Excitability in Individuals With Chronic Ankle Instability

Chung SH, Rodriguez A, Alijanpour E, McCann RS: Old Dominion University, Norfolk, VA, and Cape Henry Collegiate, Virginia Beach, VA

Context: Chronic ankle instability (CAI) is a neurophysiologic dysfunction, but the ability of common rehabilitation techniques to restore patients' neurosignature remains largely unknown. Individuals with CAI have consistently shown balance deficits caused by the inability to modulate spinal reflexive excitability during progressive balance tasks, indicating that the CNS cannot shift motor control to supraspinal levels. Previously, a single session of balance training demonstrated improved spinal reflexive excitability in elderly populations. However, it was unknown if a single session of balance training could begin modulating spinal reflexive excitability while increasing reliance on supraspinal motor control. Therefore, the purpose of this study was to determine the effects of a single session of balance training on spinal reflex modulation, corticospinal excitability, and balance function in individuals with CAI. **Methods:** 29 participants with CAI (F:17, M:12, 22.5±2.8yrs, 171.1±9.0cm, 77.3±19.6kg) were randomly assigned to the balance training group (BAL) or control group (CON). Subjects underwent Hoffmann-reflex (H-reflex) testing of the soleus while prone and in single-limb stance so to assess spinal reflexive excitability modulation. Also, transcranial magnetic stimulation (TMS) was utilized to measure corticospinal excitability represented via motor evoked potential (MEP), active motor threshold (AMT), and cortical silent period (CSP) during single-leg

balance. To measure balance function, participants were instructed to perform single-leg balance on a force plate to extract the center of pressure (COP) variables such as Maximum velocity of COP in anterior to posterior and medial to lateral directions. BAL performed a single balance training session, which included single-leg stance on a foam pad and wobble board as well as hop and stabilization exercises. Separate 2x2 mixed-model analysis of variances (ANOVA) was conducted to determine the effect of group (BAL and CON) and time (baseline and post-training) on each dependent variable. Cohen's d effect sizes examined the magnitude of significant pairwise differences. Significance was set at $P<0.05$. **Results:** A significant group x time interaction was present for H-reflex modulation ($F=4.763$, $P=0.04$). Post-test H-reflex modulation was significantly greater in BAL (43.79 ± 19.96) than CON (20.97 ± 34.86) ($d=0.81[0.03,1.54]$). Also, there was a significant group x time interaction effect for CSP ($F=4.727$, $P=0.04$). BAL (40.58 ± 20.08) had significantly lower CSP at post-test compared to CON (78.41 ± 52.68) ($d=0.95[0.17, 1.70]$). There were no significant interaction effects on the remaining outcomes for the corticospinal excitability and balance function. **Conclusions:** A single session of balance training exhibited positive benefits to corticospinal excitability and spinal reflex excitability modulation in individuals with CAI. Thus, it is possible that the balance-related neurosignature of individuals with CAI might be restored with a sufficient dose of balance training. This study signifies the importance of further investigation to determine the optimal dose of balance training to restore the neurosignature in the CAI population.

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Patient-Reported Outcomes and Walking Boot Use Following an Acute Lateral Ankle Sprain Predict Chronic Ankle Instability

McCann RS, Kosik KB, Ohnberger E, Gribble PA: Old Dominion University, Norfolk, VA, and University of Kentucky, Lexington, KY

Context: Acute lateral ankle sprains (LAS) are commonly sustained by physically active individuals, and chronic ankle instability (CAI) develops in 40-70% of cases. While a limited body of previous research has identified several potential contributing factors, continued work is needed to identify the most effective clinical determinants of CAI development after an acute LAS. The purpose of this study was to determine the ability of applied care strategies and various patient-reported outcome (PRO) scores to predict the presence of CAI 12 months after an acute LAS. **Methods:** We enrolled 51 individuals (F:32, M:19; 21.5±1.3yrs; 172.4±1.7cm; 75.0±2.5kg) from the local community, each of which sustained an acute LAS one week prior to beginning the study. This analysis was part of a larger study in which participants completed web-based surveys at return-to-activity (RTA), 6-month follow-up, and 12-month follow-up periods. Surveys asked participants about their use of assistive weight-bearing devices (crutches, walking boot) following injury and also included several PRO questionnaires: Identification of Functional Ankle Instability (IdFAI), Foot and Ankle Disability Index (FADI), Godin Leisure-Time Exercise questionnaire, and Short Form-8 (SF8). We used the 12-month follow-up IdFAI scores to dichotomize our cohort into CAI (>11) and ankle sprain copers groups (COP: 0-11). Chi-square analyses compared frequencies of assistive weight-bearing device use between groups. Independent

t-tests and Cohen's d effect sizes compared PRO scores between groups. Backward logistic regression and receiver operating characteristic (ROC) curve analyses assessed the ability of RTA and 6-month survey responses to predict CAI and COP status at the 12-month follow-up.

Results: Based on 12-month follow-up IdFAI scores, 42 (82.5%) participants were classified as having CAI and 9 (17.5%) were classified as COP. Chi-square analysis revealed a higher frequency of walking boot use in COP (55%) versus CAI (21%) ($\chi^2=4.33$, $P=0.04$). At the 6-month interval, the CAI group displayed lower SF8 physical component (CAI: 55.7±5.6 vs COP: 59.7±2.5, $P<0.01$, $d=0.88[0.09,1.66]$) and higher IdFAI (CAI: 21.7±6.3 vs COP: 15.9±8.2, $P=0.03$, $d=0.76[-0.02,1.54]$) scores compared to COP. Logistic regression analysis revealed the combination of walking boot use and 6-month IdFAI and SF8 physical component scores were significant predictors of CAI classification at 12-months ($\chi^2=13.13$, $P<0.01$, $R^2=0.41$). ROC curve analysis further indicates the combination of these variables had strong predictive value for CAI classification at 12-months (AUROC=0.87[0.76,0.99], $P<0.01$).

Conclusions: Use of a walking boot immediately following an acute LAS along with more favorable IdFAI and SF8 scores at a 6-month follow-up were associated with reduced odds of presenting with CAI at a 12-month follow-up. Thus, a temporary immobilization period following an acute LAS might be protective against the onset of CAI. Furthermore, clinicians should monitor patient perceptions beyond RTA, as PRO scores at a 6-month follow-up might be valuable determinants of CAI development.

Early Career Winner

Fellow sponsored by Phillip Gribble, PhD, ATC, FNATA.

The Effect of Different Cognitive Processing Tasks on Single-Leg Postural Control in Those With Chronic Ankle Instability
Custer LE: Towson University,
Towson, MD

Context: A recent systematic review concluded that cognitive demand impairs motor control behavior in individuals with musculoskeletal injuries, including chronic ankle instability (CAI). However, there is vast heterogeneity of cognitive tasks incorporated into the dual-task research. Minimal research has evaluated the effects of various types of cognitive processes (cognitive manipulation, information processing speed and flexibility, and selective attention) on motor control. The purpose of this study was to assess the effects of three different cognitive processing tasks on single-leg postural control. **Methods:** This cross-sectional, controlled laboratory study, included 20 individuals with no history of ankle sprain (16 females; age = 22.19 ± 4.14 years; height = 168.51 ± 9.22 cm; weight = 70.58 ± 13.83 kg; Cumberland Ankle Instability Tool (CAIT) = 28.20 ± 3.73 ; Foot and Ankle Ability Measure-Activities of Daily Living (FAAM-ADL) = $99.40 \pm 4.20\%$; FAAM-Sport = $98.28 \pm 4.32\%$) and 19 participants with CAI (10 females; age = 22.06 ± 2.23 years; height = 167.03 ± 9.47 cm; weight = 74.83 ± 15.89 kg; CAIT = 18.05 ± 4.34 ; FAAM-ADL = 90.87 ± 6.30 ; FAAM-Sport = 80.26 ± 7.46). Participants performed three successful trials of single-leg static balance on a force plate for 30-seconds with their eyes open while simultaneously performing four cognitive conditions [no cognitive task (No task), visual reverse digit recall (Digits), visual modified Stroop test (Stroop), Paced Auditory Serial Addition Test (PASAT)].

The following center of pressure (COP) force plate outcomes were analyzed: COP velocity in the mediolateral (ML velocity) and anteroposterior (AP velocity) directions; COP standard deviation in the mediolateral (ML SD) and anteroposterior (AP SD) directions; COP range in the mediolateral (ML range) and anteroposterior (AP range) directions, and 95% ellipse. For each outcome, a 2x4 repeated measures ANOVAs was conducted to compare group means during each cognitive task. In the case of significant interaction or main effects, Fisher's least significant difference was used for post hoc comparisons. A significance level was set a priori at $P < .05$. **Results:** There were no significant group by condition interactions. Significant condition main effects were found for ML range ($F(3,37) = 8.44$, $P < .000$), AP range ($F(3,37) = 3.84$, $P = .013$), ML SD ($F(3,37) = 11.36$, $P < .000$), and 95% ellipse ($F(3,37) = 7.71$, $P < .000$). For all four significant condition main effects, the combined groups performed significantly better single-leg postural control while performing both the Digits and the Stroop tasks compared to both the No task and PASAT conditions. **Conclusions:** Regardless of group, participants had better balance while performing the two cognitive processing tasks (Digits and Stroop) that incorporated included a visual aspect. The proposed sensory re-weighting theory and potential increased activation of the visual cortex may produce beneficial results during static balance. Whereas the PASAT, which emphasizes information processing speed and flexibility, resulted in reduced balance, possibly indicating the need for incorporate various types of cognitive processing tasks when utilizing the dual-task paradigm.

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The Effect of Joint Mobilization on Dynamic Postural Control in Patients with Chronic Ankle Instability: Evolution of a Critically Appraised Topic to a Systematic Review

Zuk EF, Berardo AJ, Kim S, Sheldon LN, DiStefano LJ, Glaviano NR: Department of Kinesiology, University of Connecticut, Storrs, CT, and Department of Athletics, United States Naval Academy, Annapolis, MD

Context: Lateral ankle sprains are the most common lower extremity musculoskeletal injury among physically active populations and often lead to chronic ankle instability (CAI). The Star Excursion Balance Test (SEBT) is a clinical movement assessment to evaluate dynamic postural control and frequently used in individuals with CAI. A previously published Critically Appraised Topic (CAT) reported inconclusive results regarding the ability of ankle joint mobilizations to improve functional movement and postural control in patients with CAI. Due to new literature published related to this clinical question, the purpose of this systematic review was to reappraise the effect of ankle joint mobilization on functional movement during the SEBT in individuals with CAI. **Methods:** PRISMA guidelines were followed. PubMed and CINAHL were used to mimic the search by Kosik et al in 2018 that initially investigated ankle joint mobilization on SEBT performance in patients with CAI. “Chronic Ankle Instability,” “Joint Mobilizations OR Manual Therapy,” and “Star Excursion Balance Test OR Dynamic Postural Control OR Postural Control” were used as search terms. Studies were included if they met the following inclusion criteria: 1) any methodological design that investigated

CAI in individuals 2) articles were published in English 3) an intervention that included > 1 ankle joint mobilization, and 4) dynamic postural control needed to be measured using the SEBT. Articles were assessed for methodological quality using the PEDro scale. We extracted study design, patient demographics, intervention details, and SEBT performance. Means and standard deviations of the joint mobilization and control group SEBT data were used to calculate Cohen’s d effect size (ES) and 95% confidence intervals. ES were calculated independently for each direction (i.e., anterior, posteromedial and posterolateral). **Results:** There were 3 articles included in the initial CAT with an additional 3 studies meeting the inclusion and exclusion criteria since the original publication. Of 6 included articles, 1 was a single blind randomized control trial, 1 was a controlled laboratory study, 2 utilized a randomized controlled clinical trial design, and 2 were prospective individual cohort studies. The average PEDro score increased from 4.67 / 10 to a 5.67 / 10 with the addition of the 3 new studies. The new, higher quality articles provide the largest support that joint mobilizations improve SEBT scores in the posteromedial (Cohen’s d: -1.65 ± 0.65) and posterolateral (Cohen’s d: -2.10 ± 0.69) directions. The new evidence continues to support the use of joint mobilizations to improve anterior reach (Cohen’s d: -1.64 ± 0.59). **Conclusions:** The evolution of a CAT to systematic review shifted the clinical bottom line and improved the strength of recommendation from level C to level B evidence to support the use of ankle joint mobilizations to improve performance on the SEBT in patients with CAI.

Fellow sponsored by Lindsay DiStefano, PhD, ATC.

Muscle Contributions and Ankle Joint Contact Forces Are Altered During Drop Vertical Jumps Landings in Patients With Chronic Ankle Instability

Jang J, Pietrosimone BG, Lin FC, Franz JR, Wikstrom EA: University of North Carolina at Chapel Hill, Chapel Hill, NC

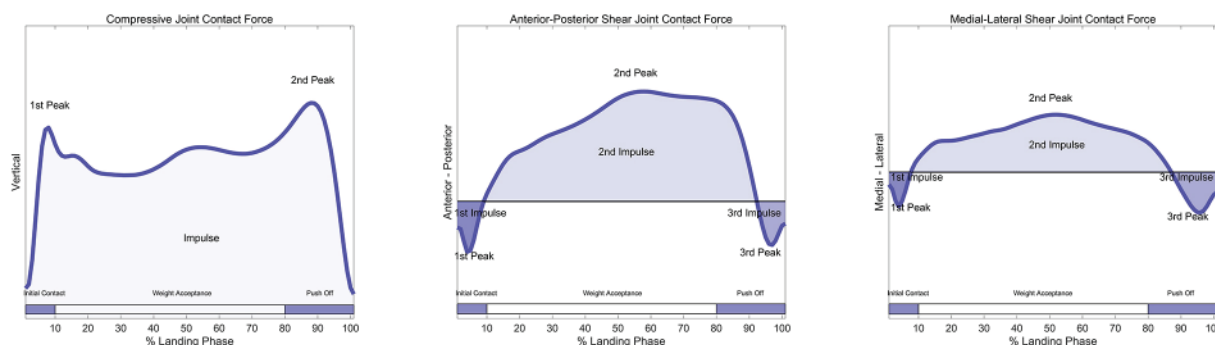
Context: Chronic ankle instability (CAI) is a known factor for early onset ankle joint degeneration. Patients with CAI exhibit altered landing biomechanics and aberrant ankle joint loading which are believed to contribute to ankle joint degeneration. More specifically, those with CAI display lower compressive and higher anterior and lateral shearing joint loads at the ankle during walking driven by altered muscle forces. However, knowledge gaps exist with regards to ankle joint loading during more dynamic tasks such as landing. Therefore, the purpose of this study was to compare tri-axial joint load (i.e. compressive, anteroposterior shear, mediolateral shear) in those with and without CAI (CON) while landing. We hypothesized that patients with CAI exhibit different muscle forces and subsequently lower ankle joint loads in all directions. **Methods:** Fifteen individuals with CAI (age: 22.7±4.3 years, mass: 69.6±11.7 kg, height: 170.3±5.5 cm, jump height: 21.5±7.0 cm) and fifteen without CAI (age: 21.3±3.1 years, mass: 62.5±8.2 kg, height: 169.0±8.3 cm, jump height: 21.1±8.8 cm) participated. CAI inclusion criteria were in accordance with the

International Ankle Consortium guidelines. All participants completed 5 trials of drop vertical jump maneuvers within a 3-D motion capture volume. The dominant (CON) and involved (CAI) limb during the ground contact phase was analyzed. We deployed musculoskeletal modeling to quantify muscle force contributions and tri-axial joint contact force variables scaled in body weight (i.e. peak and impulse). How JCF variables were defined and how the variables aligned temporally with ground contact phases of drop vertical jump can be found in the Figure. An independent t-test or a Wilcoxon signed-rank test, based on data normality, was used to compare JCF variables and muscle force contributions during peaks. An a priori alpha level of 0.05 was used to determine statistical significance for all analyses. **Results:** Compared to CON, those with CAI exhibited lower 1st peak (CAI: 4.35±0.91 BW, CON: 5.16±0.65 BW, p=.009) and impulse (CAI: 2.35±0.51 BW·s, CON: 2.72±0.34 BW·s, p=.027) in the compressive JCF. Lower 2nd peak (CAI: 1.81±0.34 BW, CON: 2.33±0.63 BW, p=.009) and 2nd impulse (CAI: 0.59±0.23 BW·s, CON: 0.87±0.31 BW·s, p=.009) were noted in the posterior JCF. Lower 2nd peak (CAI: 0.17±0.07 BW, CON: 0.23±0.07 BW, p=.028) and 2nd impulse (CAI: 0.57±0.24 BW·s, CON: 0.85±0.29 BW·s, p=.01) were noted in the lateral JCF. Lower medial gastrocnemius and soleus muscle forces were noted in those with CAI during the 1st peak in the compressive JCF (p<.05). Similarly, lower soleus force was noted during the 2nd peak in the posterior and lateral JCF (p<.05). **Conclusions:**

Our finding suggests that those with CAI exhibit smaller compressive, posterior, and lateral ankle joint loads than uninjured controls while landing. These altered loading patterns are driven by reduced soleus muscle force contributions to the ankle.

Fellow sponsored by Erik A. Wikstrom, PhD, ATC, LAT.

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The Effects of Pain Level on Static Postural Control in Patients With Chronic Ankle Instability

Oh M, Han S, Lee H, Hopkins JT:
Brigham Young University, Provo, UT

Context: A slight majority of CAI patients report ankle pain, while others report no pain. Previous studies have not classified pain levels for CAI cohorts. The purpose of this study was to identify the effects of pain level on static postural control in CAI patients. **Methods:** A randomized controlled clinical trial. Guidelines from the International Ankle Consortium's position statement and Foot Ankle Outcome Scores (FAOS) pain questionnaire were used to recruit qualified CAI patients. 14 CAI with moderate/severe pain (M=7, F=7; 22±2yrs, 174±10cm, 79.6±14.6kg, 67.4±7.7 FAOS), 14 CAI with less pain (M=7, F=7; 21±3yrs, 173±8cm, 74.1±12.7kg, 91.7±3.9 FAOS), and 14 healthy controls (M=7, F=7; 22±1yrs, 174±9cm, 67.7±10.1kg, 100±0 FAOS). Subjects performed three trials and each trial for 10 seconds in static postural control (a single-leg stance) with eyes open (EO) and eyes closed (EC) conditions. X and y represent data points of medial/lateral and anterior/posterior, respectively. A one-way ANOVA will be used to compare static postural control among the three groups. **Results:** Results: In the EO condition, relative to the control group, the moderate/severe pain group showed a significant difference in total center of pressure (COP) velocity (3.85±1.08 vs. 2.71±0.62, $p=.01$) and COP velocity X (2.72±0.75 vs. 1.91±0.44, $p=.01$). Relative to the control group, the slight pain group showed a significant difference in total COP velocity (3.64±1.18 vs. 2.71±0.62, $p=.04$) and COP velocity X (2.57±0.84 vs. 1.91±0.44,

$p=.01$). In the EC condition, there is a significant difference in total COP velocity (8.8±2.67 vs. 6.99±1.66 vs. 1.84±0.53, $p<.0001$) and COP velocity X (6.23±1.89 vs. 4.95±1.17 vs. 2.55±0.71, $p<.0001$) among three groups. Specifically, the moderate/severe pain group showed a significant difference in total COP velocity compared to the slight pain group (8.8±2.67 vs. 6.99±1.66, $p=.03$) and COP velocity X (6.23±1.89 vs. 4.95±1.17, $p=.04$). In the Romberg ratio, relative to the control group, the moderate/severe pain and slight pain group showed a significant difference in total COP velocity (2.31±0.50 vs. 0.69±0.15, $p<.0001$) and COP velocity X (2.31±0.12 vs. 1.35±0.12, $p<.0001$). Relative to the control group, the slight pain group showed a significant difference in total COP velocity (2.04±0.48 vs. 0.69±0.15, $p<.0001$) and COP velocity X (2.04±0.12 vs. 1.35±0.12, $p=.0004$). **Conclusions:** In the Romberg ratio, CAI patients have more reliance on visual information regardless of pain compared to healthy controls. In the EC condition, CAI patients with moderate/severe pain have decreased static postural control compared to CAI patients with less pain, which indicated altered static postural control during a single-leg stance. In conclusion, CAI patients with moderate/severe pain may demonstrate deficient static postural control and sensorimotor function without visual information. Therefore, the current results may suggest the need for pain control and clinical classification of CAI patients according to pain level.

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Table 1. Static Postural Control

Group	CAI with moderate/severe pain	CAI with slight pain	Control
N	14	14	14
Age (year)	22 ± 2	21 ± 3	22 ± 1
Sex (M/F)	7/7	7/7	7/7
Weight (kg)	79.4 ± 14.6	74.2 ± 12.7	68.2 ± 10.2
Height(m)	1.74 ± 0.10	1.73 ± 0.08	1.74 ± 0.09
FAAM ADL (%) *,**,†	73.4 ± 10.9	86.2 ± 5.4	100 ± 0
FAAM Sports (%) *,**,†	54.5 ± 12.4	71.8 ± 9.3	100 ± 0
AII *,**	6.7 ± 1.6	6.1 ± 0.8	0 ± 0
MAII *,**,†	4.4 ± 1.2	3 ± 1	0 ± 0
FAOS pain *,**,†	67.4 ± 7.7	91.7 ± 3.9	100 ± 0

Abbreviations: FAAM = foot and ankle ability measure ADL = active daily living, AII = ankle instability instrument, MAII = modified ankle instability instrument, FAOS = foot and ankle outcome scores, and CAI = chronic ankle instability.

* Moderate/Severe pain group showed a significant difference in demographics compared to the healthy control group.

** Slight pain group showed a significant difference in demographics compared to the healthy control group.

† Moderate/Severe pain group showed a significant difference in demographics compared to the slight pain group.

Table 2. Static Postural Control

Variables	Group	Condition (mean ± SD)		Romberg ratio
		EO	EC	EC/EO
Total COP velocity (cm/s)	CAI with moderate/severe pain	3.85 ± 1.08 *,**	8.8 ± 2.67 *,**,†	2.31 ± 0.50 *,**
	CAI with slight pain	3.64 ± 1.18	6.99 ± 1.66	2.04 ± 0.48
	Control	2.71 ± 0.62	1.84 ± 0.53	0.69 ± 0.15
COP velocity X (cm/s)	CAI with moderate/severe pain	2.72 ± 0.75 *,**	6.23 ± 1.89 *,**,†	2.31 ± 0.12 *,**
	CAI with slight pain	2.57 ± 0.83	4.95 ± 1.17	2.04 ± 0.12
	Control	1.91 ± 0.44	2.55 ± 0.71	1.35 ± 0.12
COP velocity Y (cm/s)	CAI with moderate/severe pain	3.00 ± 0.20*	5.76 ± 1.23 *,**	2.06 ± 0.61 *,**
	CAI with slight pain	2.68 ± 0.20	5.48 ± 1.60	2.10 ± 0.42
	Control	2.23 ± 0.20	2.81 ± 0.42	1.31 ± 0.26

Abbreviations: COP = center of pressure, SD = standard deviation, and CAI = chronic ankle instability.

* Moderate/Severe pain group showed a significant difference in lower static postural control/greater Romberg ratio compared to the healthy control group.

** Slight pain group showed a significant difference in lower static postural/greater Romberg ratio control compared to the healthy control group.

† Moderate/Severe pain group showed a significant difference in lower static postural control compared to the slight pain group.

Progressive Balance Training and Hip Strengthening Improve Psychosocial Outcomes in Individuals With Chronic Ankle Instability

Suttmiller AMB, Johnson K, Chung S, Ramirez V, McCann RS: Atlantic Orthopaedic Specialists, Virginia Beach, VA; Norfolk Christian Academy, Norfolk, VA; Old Dominion University, Norfolk, VA

Context: CAI is associated with both physical and psychosocial consequences. Reduced balance performance is one of the most identified physical deficits noted in these individuals, whereas injury-related fear has emerged as an important psychosocial factor. Self-efficacy is a protective psychosocial factor that has shown to mediate the relationship between fear and balance. Thus, rehabilitation protocols that can enhance self-efficacy through progressive and successful practice may improve balance as well as reduce the burden of injury-related fear, which is a direct contributor to decreased function and increased disablement within those with CAI. Progressive balance training (BAL) and hip strengthening (HIP) protocols have both demonstrated success in improving balance, but their effects on psychosocial factors is less known. Therefore, our objective was to compare the effects of progressive BAL and HIP protocols on injury-related fear and self-efficacy in those with CAI. **Methods:** Forty-five individuals with CAI volunteered for this randomized

laboratory-controlled study. Participants were randomly assigned into BAL (n=15; F=11; M=4; 22.7+/-3.1yrs; 166.9+/-6.7cm; 74.1+/-13.1kg), HIP (n=15; F=11; M=4; 22.0+/-4.0yrs; 167.5+/-11.2cm; 75.8+/-11.9kg), or CON group (n=15; F=7; M=8; 22.3+/-3.1yrs; 170.0+/-7.9cm; 79.9+/-15.3kg). Intervention groups participated in their respective 8-week progressive training programs (3, 25-minute supervised sessions/week) while the CON group received no intervention. Participants completed dimension-specific patient-reported outcome assessments before and after the intervention. Injury-related fear was assessed with the Tampa Scale of Kinesiophobia-11 (TSK-11) and the Fear-Avoidance Beliefs Questionnaire (FABQ) and self-efficacy was assessed with the Self-Efficacy of Balance Scale (SEBS). Multiple imputation was used for missing data. A multivariate repeated-measures analysis of variance was conducted to determine the effects of the interventions. If statistically significant interactions were found, a post hoc univariate analysis with pairwise comparison was performed. A significance level of P<0.05 was set a priori. **Results:** Multivariate analysis reveals a significant time-by-group interaction (P=.008, $\chi^2=18$). Univariate analyses showed a significant time-by-group interaction for the FABQ (P=.028, $\chi^2=16$) and the SEBS (P=.011, $\chi^2=19$). We also observed a main effect for time (P=.006, $\chi^2=26$). Univariate analyses reveal differences between pretest and posttest for each instrument: TSK-11 (P=.007), FABQ (P=.006), and SEBS (P=.005). BAL demonstrated significant

improvements between baseline and posttest on the TSK-11 (P=.040), FABQ (P=.017), and SEBS (P<.001) and HIP demonstrated significant improvements on the FABQ (P=.003) and SEBS (P=.029), but not TSK-11 (P=.295). There was a significant difference between the baseline TSK-11 scores between BAL and HIP groups (P=.048) but not between posttest scores (P=.141). The CON group did not demonstrate any significant improvements in any measure between baseline and posttest (P>.05; Table 1). **Conclusions:** Eight-week progressive balance training and hip strengthening protocols can both enhance balance self-efficacy and reduce injury-related fear in individuals with CAI. These interventions can be used to reduce the psychosocial burden associated with CAI.

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Table 1. Pre- and Posttest Data for Psychosocial Factors

Questionnaire	Group	Mean \pm Standard Deviation (95% Confidence Intervals)		P-Value
		Pretest	Posttest	
Tampa Scale of Kinesiophobia-11	BAL	21.5 \pm 4.5 (19.3 to 23.8) ^a	19.5 \pm 3.5 (17.4 to 21.6)	.040 ^b
	HIP	17.5 \pm 3.2 (15.3 to 19.8) ^a	16.5 \pm 4.5 (14.4 to 18.6)	.295
	CON	21.0 \pm 5.2 (18.7 to 23.3)	19.3 \pm 3.9 (17.2 to 21.4)	.084
Fear-Avoidance Beliefs Questionnaire	BAL	25.5 \pm 15.1 (19.0 to 32.1)	20.0 \pm 13.3 (14.4 to 25.6)	.017 ^b
	HIP	19.8 \pm 13.4 (13.2 to 26.4)	12.9 \pm 7.9 (7.3 to 18.5)	.003 ^b
	CON	16.2 \pm 8.1 (9.6 to 22.8)	17.5 \pm 10.3 (11.9 to 23.1)	.572
Self-Efficacy of Balance Scale	BAL	68.6 \pm 16.8 (59.9 to 77.2)	81.6 \pm 12.2 (73.2 to 90.3)	<.001 ^b
	HIP	75.9 \pm 15.1 (67.3 to 84.5)	84.1 \pm 12.1 (75.7 to 92.5)	.029 ^b
	CON	75.1 \pm 16.8 (66.5 to 83.7)	72.3 \pm 22.0 (63.9 to 80.7)	.448

Abbreviations: BAL, balance training group; HIP, hip strengthening group; CON, control group.

^a Statistically significant difference between pretest scores between groups

^b Statistically significant difference in pre- and posttest scores

Free Communications, Rapid Fire Presentations: Biologic and Perceptual-Motor Considerations for ACL Injured and Reconstructed Individuals

Friday, June 23, 2023; 10:20 AM-11:15 AM; Room Entry 239

Moderator: Adam Lepley, PhD, ATC

Ultrasound-Detected Knee Effusion-Synovitis is Highly Prevalent and Associated With Asymmetrical Lower Limb Loading During Treadmill Walking in People 1 to 5 Years After ACL Reconstruction

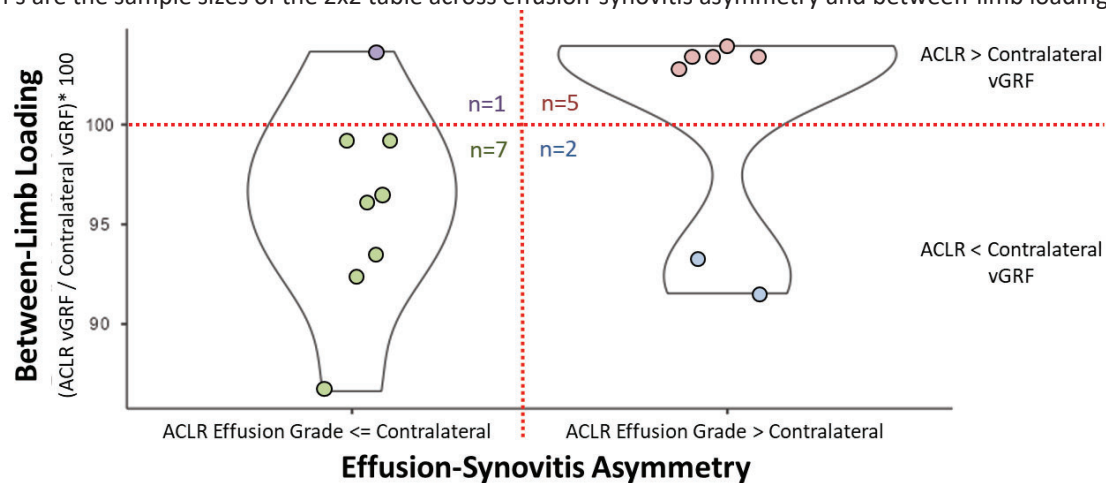
Harkey MS, Grozier C, Tolzman J, Fagan M, Collins K, Kuenze C, Fajardo R: Michigan State University, East Lansing, MI; Grand Valley State University, Allendale, MI; University of Virginia, Charlottesville, VA; Lansing Radiology Associates, Lansing, MI

Context: Chronic inflammation and altered walking biomechanics are common following ACL reconstruction (ACLR) and play a role in the development of osteoarthritis. Clinically accessible techniques to monitor inflammation (i.e., ultrasound-assessed effusion-synovitis) and walking biomechanics are needed to identify patients that are at risk for the development of early osteoarthritis post-ACLR. The purposes of this study were to determine the prevalence of ultrasound-based knee effusion-synovitis and the association between knee effusion-synovitis and between-limb lower limb loading during treadmill walking in people 1 to 5 years after ACLR. We hypothesize that a large prevalence of participants will have knee effusion-synovitis and that greater ACLR limb loading will be associated with worse effusion-synovitis. **Methods:** Fifteen individuals who were 1-5 years post-ACLR (9 females; age: 26 ± 6 years; mass: 71.1 ± 15.1 kg; height: 173.1 ± 9.3 cm, months post-ACLR: 29 ± 13) participated in a cross-sectional laboratory study. Ultrasound-based knee effusion-synovitis was assessed bilaterally using a longitudinal suprapatellar scan with the participant supine and the knee resting on a bolster in 30° flexion. A single rater graded each ultrasound image on an ordinal scale from no effusion (i.e., 0) to grades of increasingly larger

effusions (i.e., 1, 2, 3) using the OMERACT knee ultrasound scoring atlas. Effusion-synovitis asymmetry was operationally defined as: 1) ACLR grade worse than the contralateral limb, or 2) Contralateral grade equal to or less than the ACLR limb. Lower limb loading was assessed using force-measuring insoles (loadsol, Novel Electronics) while walking on a treadmill for a 1-minute trial at their self-selected speed. We used a MATLAB program to extract and average the body weight normalized peak vertical ground reaction force (vGRF) during the loading phase of every step during the treadmill walking trial. Between-limb loading was operationally defined as: greater ACLR limb loading ($ACLR_vGRF > contralateral_vGRF$) or lesser ACLR limb loading ($ACLR_vGRF \leq contralateral_vGRF$). We used a binary logistic regression to determine the association between effusion-synovitis asymmetry and between-limb loading. **Results:** Effusion-synovitis was absent in both limbs of 2 (13%), present unilaterally in the ACLR limb of 7 (47%), and present bilaterally in both the ACLR and contralateral limbs in 6 (40%) participants. Participants with a worse effusion-synovitis grade in their ACLR limb were more likely to present with greater ACLR limb loading compared to participants with lesser or equal grade effusion-synovitis in their ACLR limb (Figure, odds ratio=17.5, 95%CI=1.2, 250.3). **Conclusions:** It is concerning that individuals between 1-5 years post-ACLR have such a high prevalence of effusion-synovitis in both their surgical and contralateral limbs. The individuals with worse effusion-synovitis in their ACLR compared to their contralateral limb were more likely to present with greater ACLR limb loading during treadmill walking. This highlights the need for novel interventions to minimize inflammation and effusion-synovitis post-ACLR.

Dr. Harkey was funded by the following NIH Grant (K01AR081389).

Figure. Individuals with Worse Effusion-Synovitis in their ACL Reconstructed Limb Compared to their Contralateral Limb are More Likely to Present with Greater ACL Reconstructed Limb Loading During Treadmill Walking. The x-axis represents ultrasound-assessed effusion-synovitis asymmetry: 1) ACL reconstructed (ACLR) limb effusion grade less than or equal to the effusion-synovitis grade of the contralateral limb, 2) ACLR limb effusion grade worse than the effusion-synovitis grade of the contralateral limb. The y-axis represents the between-limb loading defined as the limb symmetry index between the ACLR and contralateral limb vertical ground reaction forces (vGRF) during treadmill walking. The horizontal dashed red line is at 100. Values above 100 indicate that the ACLR vGRF is greater than the contralateral vGRF. Values below 100 indicate that the ACLR is less than the contralateral vGRF. The n's are the sample sizes of the 2x2 table across effusion-synovitis asymmetry and between-limb loading asymmetry.



No Association Between Injury-Related Fear and Isokinetic Quadriceps Strength in Individuals With a History of Anterior Cruciate Ligament Reconstruction

Brinkman CB, Reiche EL, Genoese FM, Hoch JM, Baez SE: University of North Carolina, Chapel Hill, Chapel Hill, NC; Michigan State University, East Lansing, MI; University of Kentucky, Lexington, KY

Context: Despite improvements in physical function and knee stability after ACL reconstruction (ACLR), 1 out of 3 individuals do not return to their previous level of sports participation. Injury-related fear is strongly associated with failure to return to sport (RTS) and secondary ACL injury risk. Quadriceps strength has also been associated with failure to RTS after ACLR and secondary injury risk. However, we do not know whether injury-related fear and quadriceps strength are associated, despite their individual predictive capabilities for RTS and secondary ACL injury. Therefore, the purpose of this study is to examine the association between injury-related fear and quadriceps strength in individuals at least 1-year after ACLR. We hypothesized that a negative association between injury-related fear and isokinetic quadriceps strength would be observed. **Methods:** This is a secondary analysis from a previously published cohort study. Forty participants with a history of unilateral primary ACLR were included (25 females, age=24.3±0.7years, height=170.8±8.6cm, weight=75.3±17.2kg, time since surgery=5.92±4.1 years). Participants were included if they sustained an ACL injury during sport activity with or without meniscal pathology. Participants completed the Tampa Scale

of Kinesiophobia-11 (TSK-11) and a standard isokinetic quadriceps strength assessment. The TSK-11 is a reliable and valid questionnaire used to assess kinesiophobia (i.e., fear of movement and/or reinjury). Higher TSK-11 scores reflect elevated injury-related fear. The Biodex Isokinetic Dynamometer was used to assess concentric isokinetic quadriceps peak torque at 60°/sec (Nm/kg). This was measured on the ACLR and contralateral limbs. Descriptive statistics were calculated for TSK-11 scores, ACLR limb quadriceps peak torque, and contralateral limb quadriceps peak torque. Pearson Product Moment correlations were used to examine the association between TSK-11 scores, ACLR limb peak torque, and contralateral limb peak torque (Nm/kg). Pearson Product Moment correlation coefficients (r) were interpreted as very high (.90 to 1.00), high (.70 to .90), moderate (.50 to .70), low (.30 to .50) and no correlation (.00 to .30). Alpha was set a priori to $p<0.05$. **Results:** The average TSK-11 score was 18.2±5.3, average ACLR peak quadriceps torque was 1.9±0.50 kg/Nm, and average contralateral peak quadriceps torque was 2.3±0.48 kg/Nm. There were no statistically significant correlations between the TSK-11 and peak quadriceps torque for the ACLR limb ($r=0.12$, $p=0.46$) or the contralateral limb ($r=0.29$, $p=0.07$) (Figure 1a and 1b).

Conclusions: There was no association between injury-related fear and peak isokinetic quadriceps strength in individuals at least 1-year post-ACLR. Both factors, independently, have been shown to influence RTS rates and risk of secondary injury in patients after ACLR. Clinicians should address both psychological responses and biological outcomes throughout the rehabilitation process. Future research should examine this relationship in an acute ACLR population prior to clearance for RTS.

Sex Differences in Self-Reported Symptoms of Anxiety, But Not Depression, Among Individuals With ACL Reconstruction

Genoese FM, Reiche ET, Collins KA, Walaszek MC, Harkey MS, Kuenze C, Baez SE: Michigan State University, East Lansing, MI; University of North Carolina, Chapel Hill, Chapel Hill, NC; University of Virginia, Charlottesville, VA

Context: Females with history of primary ACL reconstruction (ACLR) have an increased risk of secondary ACL injury when compared to males after ACLR. Symptoms of anxiety and depression are psychological responses frequently experienced after ACLR. Furthermore, anxiety and depression are associated with increased risk of injury during sport and may negatively influence secondary injury risk for females with ACLR. However, it is unknown whether there are sex differences in mental health symptoms exhibited by individuals with ACLR. Therefore, the purpose of this study was to examine differences in self-reported symptoms of anxiety and depression between males and females with ACLR. Given that anxiety and depression are more prevalent among uninjured females compared to males, we hypothesized that females with ACLR would exhibit greater symptoms of anxiety and depression when compared to males with ACLR. **Methods:** A

cross-sectional analysis of an ongoing, prospective study examined differences in self-reported symptoms of anxiety and depression between males and females with ACLR. 62 participants (26 females, 36 males; age=22.8±5.3 years, time since surgery=6.2±3.0 months) with history of unilateral ACLR at least 3-months post-surgery were included. Biologic sex was self-reported via a demographics questionnaire. Participants completed the Patient Reported Outcomes Measurement Information System (PROMIS) Anxiety and Depression short form (4a) assessments. The PROMIS-Anxiety (4a) includes 4-items that measure emotional distress caused by hyperarousal, fear, stress, and related somatic symptoms in the past 7 days. The PROMIS-Depression (4a) includes 4-items that measure negative affect, mood, self-image, and social interaction in the past 7 days. Items on each questionnaire are scored on a Likert scale from 1-5 with total raw scores for each questionnaire ranging from 4-20. Higher scores on the PROMIS-Anxiety indicate greater symptoms of anxiety and higher scores on the PROMIS-Depression indicate greater symptoms of depression. As the data were not normally distributed, medians and interquartile ranges were calculated for PROMIS-Anxiety and PROMIS-Depression scores (median[IQR]). Mann-Whitney U tests and Hedge's g effect sizes were used to compare differences in PROMIS-Anxiety and PROMIS-Depression scores between sexes. Effect sizes were interpreted as small (0-0.39), medium (0.40-0.69), and large (> 0.70). Alpha was set

a priori $p < 0.05$. **Results:** Descriptive statistics for PROMIS-Anxiety and PROMIS-Depression scores are presented in Table 1. Females reported greater symptoms of anxiety when compared to males but there were no between sex differences in symptoms of depression (Table 1). **Conclusions:** Females with ACLR reported more anxiety symptoms compared to males indicating a difference in psychological response to ACL injury. Through interprofessional collaboration with appropriate mental health providers, anxiety may be assessed and addressed throughout the rehabilitation process and reduce secondary ACL injury risk among females with ACLR. Future research should explore intervention strategies to address anxiety in females throughout ACLR rehabilitation.

Table 1. PROMIS-Anxiety and PROMIS-Depression Scores for Males and Females with History of ACLR

	Males (n=36) Median [IQR]	Females (n=26) Median [IQR]	TOTAL (n=62) Median [IQR]	P-Value	Hedge's G (95% CI)
PROMIS-Anxiety	5.0 [2.25]	7.0 [4.75]	5.0 [4.0]	0.03*	0.52^ (0.15-1.03)
PROMIS-Depression	4.0 [1.0]	4.5 [2.0]	4.0 [2.0]	0.14	0.15 (-0.35-0.65)

*denotes statistical significance ($p < .05$), ^medium effect size; PROMIS = Patient Reported Outcomes Measurement Information System, ACLR = Anterior Cruciate Ligament Reconstruction, 95% CI = 95% Confidence Interval

Skeletal Age at the Time of Pediatric ACL Injury: A Retrospective Chart Review

Fegley JA, Shultz SJ, Boeyer ME:
University of North Carolina – Greensboro, Greensboro, NC, and University of Missouri, Columbia, MO

Context: Injury surveillance studies of pediatric ACL injuries are largely based on chronological age (CA). There is a critical gap in our understanding of the timing of injury relative to physical maturation, which ultimately drives physical risk development. The purpose of this study was to assess maturity status via skeletal age (SA) in girls and boys based on knee radiographs taken at the time of ACL injury. **Methods:** This was a retrospective chart review of 100 consecutive pediatric patients (8-18 years of age) seen at a local orthopedic group with a confirmed ACL tear (2016-2021). Eighty-seven of these patients (51G, 15.7+1.2yrs, 166.2+8.3cm, 67.9+14.3kg; 36B, 15.4+1.5yrs, 174.2+10.7cm, 78.2+24.3kg) had a standing knee radiograph obtained at the time of their assessment. SA was estimated using the Roche-Wainer-Thissen (RWT) method. The abbreviated RWT method was utilized to estimate maturity offset (MO; estimated number of years from age at peak height velocity (APHVEST)). A single examiner (JAF) performed all SA assessments (ICC±SEM = 0.99±0.06yrs). Measures of central tendency

and frequencies were used to describe SA and MO at the time of injury. Independent sample t-tests examined sex differences in SA and MO at the time of ACL injury. SPSS version 28 was used for all analyses. **Results:** The average SA at time of injury was 15.9+2.1 and 16.2+1.3 years in boys and girls, respectively ($P = 0.533$) while average MO was +1.7+1.3 and +3.0 + 0.8 years, respectively ($P < .001$). In girls, 4% of injuries occurred within 1 year of APHVEST, 8% occurred 1-2 years after APHVEST, 29% occurred 2-3 years after APHVEST, and 59% occurred 3-4 years after APHVEST. In boys, 6% of occurred before APHVEST, 19% occurred within 1 year of APHVEST, 25% occurred 1-2 years after APHVEST, 44% occurred 2-3 years after APHVEST, and 6% occurred 3-4 years after APHVEST. There was no difference in chronological age ($P = 0.265$) between girls and boys at the time of injury. **Conclusions:** APHVEST is a clinically meaningful milestone and typically occurs during mid-puberty (~1 yr before menarche) in females and mid-late puberty in males. These data suggest ACL injuries more often occur 2-4 years post APHVEST in females and increasingly occur from 0-3 years post APHVEST in males; both of which suggest ACL injuries peak late adolescence. These data provide insight into the timing of pediatric ACL injuries relative to biological maturation, which may help clinicians identify timing to risk development, and the best time for screening and intervention.

The Relationship Between Physical Literacy Outcomes and Physical Activity in Individuals With a History of ACL Reconstruction

Kleis RR, Dlugonski D, Hoch MC, Hoch JM: University of Kentucky, Lexington, KY, and University of Wisconsin Eau Claire, Eau Claire, WI

Context: Individuals with a history of ACL reconstruction (ACLR) are 2.36 times less likely to meet physical activity guidelines compared to their healthy counterparts. Physical literacy has been proposed as a determinant of health and has been linked to greater physical activity participation across a lifespan. However, this holistic concept has been largely unexplored post-ACLR, despite evidence to suggest that elements of physical literacy (e.g., motivation, confidence, knowledge, physical competence) are key factors that influence an individual's willingness and ability to return to activity after ACLR. Therefore, the purpose of this study was to determine if components of physical literacy were predictive of moderate-to-vigorous physical activity (MVPA) in individuals with a history of unilateral or bilateral ACLR. **Methods:** A modified cross-sectional design was employed. Participants reported to the laboratory for two testing sessions separated by one-week of objective physical activity observation. At the first session, participants completed four surveys to assess the motivation (Behavioral Regulation in Exercise Questionnaire-3 [BREQ-3]), confidence (Knee Self-Efficacy Scale and Self-Efficacy for Exercise Scale), and knowledge (Physical Activity Knowledge Questionnaire) components of physical literacy, which served as predictor variables. At the second session, participants completed a series of functional tasks to assess physical competence including the LESS-Real Time (LESS-RT), single leg hop, triple hop, cross over hop, and PLAYbasic,

which also served as predictor variables. Between sessions, participants wore an accelerometer to quantify time spent (minutes) in MVPA. Bivariate analyses were performed to determine which predictors moved forward ($r > .20$). A stepwise linear regression was utilized to examine the relationship between the predictor variables and MVPA. Univariate analyses of covariance (ANCOVA) were utilized to examine the effect of predictor variables that remained in the final model while controlling for confounding demographic variables (age and time since surgery). **Results:** Forty-five participants (age: 22.8 ± 4.2 years, height: 169.3 ± 10.1 cm, weight: 71.7 ± 13.5 kg) who were an average 5.3 years (± 2.0) post-ACLR completed all study tasks and were included in the analysis. Bivariate analyses determined that the BREQ-3 Integrated and Intrinsic regulations, LESS-RT, PLAYbasic run, and PLAYbasic hop were associated with MVPA (Table 1). The final stepwise linear regression model demonstrated that the PLAYbasic run task accounted for 13.5% of the variance of objectively measured MVPA in individuals with a history of ACLR. After adjusting for age and time since surgery, the PLAYbasic run remained a significant predictor variable ($p = .032$) and the observed variance increased to 27.2%. **Conclusions:** Aspects of motivation and physical competence were associated with MVPA in young adults with a history of ACLR, but the PLAYbasic run was the only variable to predict MVPA participation while controlling for age and time since surgery. This suggests that physical competence may be especially salient in this population and could be utilized to promote physical activity after ACLR.

This research was financially supported by the Endowed University Professor in Health Sciences Fund and the University of Kentucky Graduate Student Congress Research Award.

Table 1: Predictor Variable Summary Scores and Spearman Correlations

Variable	Median	Interquartile Range	Correlation to Daily MVPA
BREQ-3 Amotivation	0.0	0.00	.005
BREQ-3 External	0.75	1.00	.147
BREQ-3 Introjected	2.25	1.25	-.091
BREQ-3 Identified	3.50	1.00	.055
BREQ-3 Integrated	2.50	1.63	.206
BREQ-3 Intrinsic	3.25	0.88	.245
KSES	8.7	1.18	-.046
SEE	67.0	23.0	.149
Knowledge	12.00	6.00	-.070
LESS-RT	4.00	3.00	-.361*
SLH	96.15	9.82	-.160
TH	98.65	7.54	-.083
COH	102.50	8.77	-.073
PLAYbasic run	60.00	16	.437**
PLAYbasic hop	56.00	13	.269
PLAYbasic throw	52.00	8.50	.038
PLAYbasic kick	58.0	22	-.079
PLAYbasic balance	59.0	13	-.015

Abbreviations: BREQ-3: Behavioral Regulation in Exercise Questionnaire-3; COH: Cross-over hop; KSES: Knee Self-Efficacy Scale; LESS-RT: Landing Error Scoring System-Real Time; SEE: Self-Efficacy for Exercise Scale; SLH: Single-leg hop; TH: Triple hop

*Statistically significant at $P < 0.05$

**Statistically significant at $P < 0.01$

Kinesiophobia is Associated with Lower Extremity Perceptual-Motor Function After ACL Reconstruction

Reiche ET, Genoese FM, Collins KA, Walaszek MC, Harkey MS, Kuenze CM, Baez SE: University of North Carolina, Chapel Hill, NC; Michigan State University, East Lansing, MI; University of Virginia, Charlottesville, VA

Context: Individuals experience deficits in perceptual-motor function (e.g., slower visuomotor reaction time [VMRT]) and elevated kinesiophobia after ACL reconstruction (ACLR). Deficits in VMRT increase risk of lower extremity injury and kinesiophobia is associated with risk of secondary ACL injury after ACLR. Kinesiophobia is a psychological response that describes the fear of movement and/or reinjury. Kinesiophobia is commonly assessed with the Tampa Scale of Kinesiophobia (TSK-11) which evaluates two constructs via the following subscales: 1) activity avoidance (TSK-AA) and 2) somatic focus (TSK-S). Characterizing the association between kinesiophobia and VMRT after ACLR may help reduce secondary injury risk by understanding how specific constructs of kinesiophobia are related to functional outcomes. The purpose of this study was to examine the association between the constructs of kinesiophobia (i.e., somatization

and activity avoidance) and lower extremity VMRT (LEVMRT) in individuals 4-48 months after ACLR. We hypothesized that the TSK-S and TSK-AA would be associated with slower LEVMRT. **Methods:** Thirty-three participants with history of ACLR (24 Female, 20.7±4.8 years, 13.6±12.2 months since surgery) were included in this study. Participants were included if they were 14-35 years old and sustained a primary, unilateral ACL injury while participating in sport or physical activity. Outcome measures were the TSK-AA, TSK-S and LEVMRT. LEVMRT was assessed using 5 wireless light-emitting discs positioned in a semicircle 45 degrees apart that illuminated in a random order (Fitlight Trainer™, Fitlight Sports Corp). Distance of lights were standardized for all participants based on shank length. Participants stood on one limb and deactivated the lights by stepping on a disc as quickly as possible after it illuminated. LEVMRT was presented as the average time (ms) it took for to extinguish the lights. LEVMRT was assessed while the surgical limb deactivated the lights (ACLR-Active) and while the non-surgical limb deactivated the lights (ACLR-Stable). Separate multiple regression analyses were used to evaluate the association between TSK-AA and LEVMRT, and TSK-S and LEVMRT while controlling for time since surgery. Alpha was set a priori to $p < 0.05$. **Results:** TSK-S significantly predicted ACLR-Stable LEVMRT (Table 1) with every point increase in the TSK-S resulting in a 10 second

improvement in LEVMRT. There were no significant associations between the TSK subscales and ACLR-Stable LEVMRT or ACLR-Active LEVMRT (Table 1). **Conclusions:** Somatization was associated with improved LEVMRT when the ACLR limb stabilized. This may suggest that patients experiencing increased focus on physical symptoms (e.g., pain, weakness) may perceive single-leg tasks as harmful which resulted in a sympathetic stress response. Failing to characterize the constructs associated with the fear response may not be sufficient to improve psychological and functional outcomes. Utilizing specific constructs, like somatization and activity avoidance, can inform appropriate and relevant therapeutic and psychological interventions during return to activity.

Table 1. Regression Models

	Predictors	Adjusted R ²	β (95%CI)	F	p-value
ACLR-Active LEVMRT	TSK-S and TSS	0.095	-7.877 (-15.991 – 0.236)	2.687	0.057
	TSK-AA and TSS	0.016	6.171 (-5.390 – 17.732)	1.257	0.284
ACLR-Stable LEVMRT	TSK-S and TSS	0.125	-10.061 (-18.193 – 1.929)	3.292	0.017*
	TSK-AA and TSS	-0.050	3.263 (-8.911 – 15.437)	0.233	0.588

*denotes statistical significance. Abbreviations: Tampa Scale of Kinesiophobia (TSK), TSK-Somatic Subscale (TSK-S), TSK-Activity Avoidance Subscale (TSK-AA), lower extremity visuomotor reaction time (LEVMRT)

The Relationship Between Knee Joint Effusion and Quadriceps Strength and Activation After ACL Injury and Reconstruction

Palmieri-Smith RM, Johnson AK, McCollin T, Garcia SA, Krishnan C: University of Michigan, Ann Arbor, MI

Context: Knee joint effusion and quadriceps strength/activation deficits are common consequences of ACL injury and reconstruction. The presence of an effusion may initiate or worsen the quadriceps dysfunction present after ACL trauma. In simulated effusion studies, evidence indicates an inverse relationship between effusion size and quadriceps dysfunction, with larger effusions being related to greater strength loss/activation failure. A single study in persons with ACL injury did not show a relationship between effusion and quadriceps strength, but was limited by a clinical assessment of effusion grade, and was only assessed after injury. The purpose of this study was to determine if the size of the suprapatellar knee joint effusion, measured via ultrasound, after ACL injury and reconstruction influences quadriceps strength and activation. **Methods:** Forty-one individuals (23 females, age=21.8+/-7.5years, height=171.7+/-7.9cm, mass=72.3+/-14.2kg), who reported with a primary ACL injury to a single sports medicine clinic were prospectively followed for 2 sessions [one prior to reconstruction (average=45+/-24 days post-injury) and one ~16 weeks after ACL reconstruction (average=130+/-15days post-surgery)] in a research laboratory. After resting for 15 minutes,

three B-mode ultrasound images (GE LogiqE) of the suprapatellar pouch were obtained from the ACL-affected knee while it was bent at 30 degrees. Three trials of isometric quadriceps strength (knee at 60 degrees), extension isokinetic strength (concentric at 60 degrees/sec), and quadriceps activation using the interpolated twitch technique were gathered using an isokinetic dynamometer (HUMAC NORM). Effusion cross-sectional area was measured using ImageJ, averaged and inputted into linear regression models as the independent variable to determine if effusion size influenced the dependent variables of quadriceps isometric and isokinetic strength and interpolated twitch activation ratio. Analyses were considered significant at $P < 0.05$. **Results:** Descriptive data are presented in Table 1. No relationship was found between effusion size and isometric strength ($R^2=0.041$), isokinetic strength ($R^2=0.0001$), or activation ($R^2=0.056$) prior to ACL reconstruction ($p > 0.05$). After reconstruction, however, there was a small relationship between effusion size and activation ($R^2=0.122$; Standardized $B=-0.349$; $p=0.025$), while no relationship was found for strength (isometric $R^2=.009$; isokinetic $R^2=0.006$; $p > 0.05$). **Conclusions:** The size of the joint effusion after ACL injury does not influence strength or activation. However, after ACL reconstruction effusion size does influence quadriceps activation, with a larger effusion being related to lower quadriceps activation. Prior research using simulated joint effusions appears to overestimate the effects of effusion on strength and activation. Clinically speaking, interventions to decrease effusion size may be

beneficial to improve quadriceps activation after ACL reconstruction only.

Fellow sponsored by Riann Palmieri-Smith, PhD, ATC.

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Table 1. Descriptive data for all study variables.

Variable	Mean (SD)
Effusion @ baseline (mm ²)	131.99 (92.71)
Effusion @ 16 wks (mm ²)	96.48 (53.48)
MVIC @ baseline (Nm)	161.53 (58.05)
MVIC @16 wks (Nm)	147.81 (48.22)
Isokinetic knee extension strength @ baseline (Nm)	138.96 (64.74)
Isokinetic knee extension strength @ 16 wks (Nm)	110.88 (39.78)
Quadriceps activation @ baseline (%)	71.94 (15.71)
Quadriceps activation @16 wks (%)	68.65 (16.73)

MVIC = Maximum voluntary isometric contraction

Nm = Newton Meters

Wks = Weeks

Anterior Cruciate Ligament Injury Alters Cortical Motor Output

Beethe AZ, Harper SA, Lu B, Horsley H, Harrison K, Bolton DAE: Colby College, Waterville, ME, and Utah State University, Logan, UT

Context: ACL injury leaves the body vulnerable to subsequent re-injury, as apparent by recurrence rates between 30% and 75%. With recent evidence of neurocognitive decline and increased performance variability after injury, chronic neurological adaptations are considered the predominant mechanism for such risk. These adaptations include greater dependence upon sight, preparation time, and increased involvement of both hemispheres to initiate action, further reducing the capacity to inhibit unnecessary action. The purpose of this study was to challenge these adaptations, in rapid and goal-specific movements, to investigate inhibitory control after an ACL injury. **Methods:** Corticospinal adaptations were measured at the vastus lateralis in 12 ACL (6 male, 6 female) and 17 healthy control (CON; 10 male, 7 female) participants using Transcranial Magnetic Stimulation (TMS) immediately prior to action. Participants wore a safety harness to support a forward lean, connected to a magnet on a supporting wall. Upon magnet release, the participants were released to take either a right or left step, based upon an open pathway set by blocks, to establish a base of support. Cues were given by vision, controlled by occlusion goggles which allowed participants to see the blocks as they moved (i.e., proactive), or were only given 400ms of vision (i.e., reactive) prior to release. The ability to inhibit and initiate a new action was tested through a 70/30% of common/

uncommon stepping limb, which was counter-balanced. Prior to magnet release, but after vision, TMS was delivered to the more common stepping limb to assess corticospinal activity using the long intracortical inhibition (LICI) protocol. Motor evoked potentials (MEPs) were evaluated using surface electromyography sensors. Two-way ANOVAs, with Sidak post-hoc analyses, assessed differences in groups (ACL, CON) by visual cue (proactive, reactive), step (common, uncommon), limb (dominant/uninjured, nondominant/injured), and gender (male, female) by evaluating changes in MEP and LICI. **Results:** In observation of LICI, there were no significant differences in visual cue, step, or limb, but ACL was significantly higher than CON ($F = 15.34$, $p < 0.001$). Similar results were found in MEP, where the ACL group shows greater activity compared with CON ($F = 7.46$, $p < 0.001$). When grouped by gender, females with ACL injury had significantly less LICI (i.e. facilitation) than males with ACL injury and CON ($F = 9.02$, $p < 0.001$), and males with ACL injury had higher MEP than females with ACL injury and CON ($F = 26.55$, $p < 0.001$). **Conclusions:** Results demonstrate overall change in corticospinal excitability in persons with ACL injury through increased MEP excitability and decreased LICI. Gender differences are likely influenced by subject selection, impacting gender and ACL injury inference. These results suggest altered neural recruitment strategies may reduce inhibition control, but further assessment of movement strategies is necessary to finalize conclusions.

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Hamstrings Corticomotor Function in Individuals With Anterior Cruciate Ligament Reconstruction

Koohestani M, Sherman DA, Rush JL, Norte GE: University of Toledo, Toledo, OH; Live4 Physical Therapy and Wellness, Acton, MA; Boston University, Boston, MA; Harvard University, Cambridge, MA

Context: Alterations in hamstrings neuromuscular function have been identified after ACL reconstruction (ACLR). To appropriately assess and treat such impairments, it is essential to accurately understand their neural origins. The corticospinal pathway has been extensively studied relative to quadriceps function, with deficiencies in corticospinal excitability consistently reported after ACLR. However, these findings are difficult to contextualize without similar data in the reciprocal hamstrings. Therefore, our purpose was to assess hamstrings corticomotor and neuromuscular function in individuals with ACLR, and to determine the relationships between each. We hypothesized that individuals with ACLR would demonstrate lesser hamstrings strength, ability to rapidly generate torque, and corticospinal excitability in the involved limb. Secondly, we expected that lesser corticospinal excitability would associate with poor neuromuscular function. **Methods:** Twenty-three individuals with primary, unilateral ACLR via hamstrings tendon autograft (14F/9M, age: 22.6 ± 3.0 years, height: 172.4 ± 10.7 cm, mass: 76.9 ± 17.2 kg, time from surgery: 46.9 ± 26.3 months) were assessed during a single session in a research

laboratory. In this study, single- and paired-pulse transcranial magnetic stimulation (TMS) paradigms were used to examine semitendinosus corticomotor function at 60° of knee flexion. Corticomotor function was quantified via active motor threshold (AMT), motor evoked potential (MEP), short-interval intracortical inhibition (SICI), intracortical facilitation (ICF), and cortical silent period (CSP). Neuromuscular function was measured via knee flexion maximal voluntary isometric contraction (MVIC) torque, and early and late-phase rate of torque development (RTD100, RTD200). Paired t-tests, or Wilcoxin signed-rank tests, were used to compare outcomes between involved and uninvolved limbs—mean differences with 95% confidence intervals and Cohen's d effects sizes are reported below. Relationships between corticomotor and neuromechanical outcomes were assessed for the involved limb using correlation coefficients. **Results:** The involved limb demonstrated lower MVIC torque (-0.68 Nm/kg [$-1.22, -0.15$], $p=.015$, $d=-0.43$), lower RTD200 (-0.12 Nm/kg/s [$-0.22, -0.03$], $p=.012$, $d=-0.32$), and shorter CSP (-33.11 ms [$-49.4, -16.8$], $p<.001$, $d=-1.08$) than the uninvolved limb. We did not observe significant differences in AMT, MEP, SICI, ICF, or RTD100 between limbs (Table 1). Lower AMT associated with lower MVIC torque ($r=0.522$, $p=.011$). Additionally, lower RTD100 ($r=0.714$, $p<.001$) and RTD200 ($r=0.475$, $p=.022$) associated with lower MVIC torque. **Conclusions:** Our findings highlight hamstrings weakness (lower MVIC torque) and a lesser ability to rapidly generate late-phase torque (lower RTD200), which may implicate contributions from known muscular impairments (e.g. smaller muscle volume). A shorter

CSP indicated less hamstrings corticospinal inhibition in the involved limb, which was partially supported by higher SICI amplitudes on average (less intracortical inhibition). Even though MVIC torque was lower, early RTD (which is governed by neural factors) appeared to be preserved. Interestingly, greater corticospinal excitability (lower AMT) associated with lesser strength (MVIC torque). Collectively, these findings may suggest a compensatory pattern of cortical facilitation in attempt to preserve hamstrings force output.

Data from this abstract were partially supported by funding from the American College of Sports Medicine.

Table 1. Between-limb comparison of corticomotor and neuromuscular outcomes

	Involved limb	Uninvolved limb	<i>P</i> value ^a	Effect size (95% CI) ^b
Corticomotor				
AMT (%)	41.35 ± 6.64	42.65 ± 9.49	.404	-0.16 (-0.74, 0.42)
Raw MEP (mV)	0.21 (0.11) ^c	0.22 (0.26) ^c	.212 ^d	-0.16 (-0.75, 0.41)
Normalized MEP ^e	7.16 (6.44) ^c	8.20 (7.86) ^c	.808 ^d	-0.17 (-0.75, 0.41)
Normalized SICI ^f	0.74 (0.22) ^c	0.65 ± 0.29	.078 ^d	0.39 (-0.19, 0.98)
Normalized ICF ^f	0.86 ± 0.34	0.91 ± 0.55	.540	-0.11 (-0.69, 0.47)
CSP (ms)	59.40 ± 19.57	92.51 ± 38.80	<.001*	-1.08 (-1.71, -0.45)
Neuromuscular				
MVIC torque (Nm/kg)	2.10 ± 1.19	2.79 ± 1.94	.015*	-0.43 (-1.01, 0.16)
RTD ₁₀₀ (Nm/kg/s)	2.10 (1.86) ^c	2.96 ± 1.53	.052 ^d	-0.17 (-0.75, 0.41)
RTD ₂₀₀ (Nm/kg/s)	1.27 ± 0.38	1.39 ± 0.36	.012*	-0.32 (-0.91, 0.26)

Abbreviations: AMT, active motor threshold; MEP, motor evoked potential; SICI, short-interval intracortical inhibition; ICF, intracortical facilitation; CSP, cortical silent period; MVIC, maximum voluntary isometric contraction; RTD, rate of torque development

^a Comparison between involved and uninvolved limbs

^b Effect sizes were calculated for each variable using the pooled standard deviation of the involved and uninvolved limbs. Negative effect sizes indicate a lower value for the involved limb

^c Median values presented with interquartile range

^d Wilcoxon signed-rank test

^e MEP amplitudes were normalized by the processed background EMG from the 20 milliseconds immediately preceding the TMS stimulus artifact

^f SICI and ICF amplitudes were normalized by the raw MEP amplitudes

* Statistically significant at $P \leq .05$

Free Communications, Rapid Fire Presentations: Rehab, Recovery and Return-to-Duty In the Tactical Athlete

Saturday, June 24, 2023; 8:55 AM-9:50 AM; Room Entry 231-233

Moderator: Nicholas Heebner, PhD, LAT, ATC

Patient-Reported Outcomes Differ Between Civilians and Service Members with Chronic Ankle Instability

Walsh BM, Torp DM, Hoch MC, Heimark NE, Song K, Green BS, Gribble PA, Hoch JM, Sessoms PH, Fraser JJ: University of Kentucky, Lexington, KY; Leidos, Inc., San Diego, CA; Warfighter Performance Department, Naval Health Research Center, San Diego, CA

Context: Ankle sprains occur at high rates among physically active civilians and service members and up to 70% of these patients may develop chronic ankle instability (CAI). Individuals with CAI often experience decreased health-related quality of life (HRQL) and heightened levels of injury-related fear compared to their healthy counterparts. It is unclear if HRQL and injury-related fear differ between civilian and active-duty military patients with CAI. Therefore, the objective of this study was to compare HRQL and injury-related fear between civilians and service members with CAI. **Methods:** Sixteen active-duty service members from the U.S. Marine Corps (2 Female, Age: 22.9±2.7yrs, Height: 175.9±9.5cm, Weight: 82.0±12.7kg, Previous Number of Ankle Sprains: 4.6±4.0, Episodes of Giving Way: 7.9±3.4) and twenty physically active civilians (10 Female, Age: 31.6±8.9yrs, Height: 172.5±10.0cm, Weight: 82.6±21.4kg, Previous Number of Ankle Sprains: 6.1±3.9, Episodes of Giving Way: 6.7±3.8) with CAI volunteered to participate. Inclusion criteria for all participants was based on previously established recommendations from the International Ankle Consortium. All participants completed a series of patient-reported outcomes (PRO) including the Fear-Avoidance

Beliefs Questionnaire (FABQ), Foot and Ankle Disability Index Activities of Daily Living (FADI-ADL) and Sport (FADI-Sport), and the modified Disablement in the Physically Active scale (mDPA). The FABQ is a dimension-specific PRO with two subscales: FABQ-Physical Activity (FABQ-PA) and FABQ-Work (FABQ-W). FABQ-PA scores range from 0-24 and FABQ-W scores range from 0-42, with higher scores indicating increased injury-related fear. The FADI-ADL and FADI-Sport are region-specific PROs with scores that range from 0-100% with lower scores indicating lower foot and ankle function. The mDPA is a generic PRO with two summary components: the mDPA-physical summary component (mDPA-PSC) and the mental summary component (mDPA-MSC). mDPA-PSC scores range from 0-48 and mDPA-MSC scores range from 0-16, with higher scores indicating increased disablement. Separate univariate analyses compared PROs between groups while controlling for sex and age. The alpha level was set a-priori at $p \leq 0.05$.

Results: Means, standard deviations and effect sizes for all variables are reported in Table 1. Despite Marines reporting lower scores on the FADI-ADL and FADI-Sport and higher scores on all other patient-reported outcomes, when controlling for sex and age only the group difference in the mDPA-PSC reached statistical significance ($p=0.004$). **Conclusions:** Marines with CAI reported increased levels of physical disablement compared to physically active civilians with CAI. These results indicate that CAI may create greater perceptions of physical disablement in Marines compared to physically active civilians. However, no differences were identified in injury-related fear or ankle-specific function. Further understanding the HRQL and injury-related fear differences in service members and civilians with CAI could aid in understanding the impact of this condition on

individuals with physically demanding occupations and enhance the intervention strategies for treating these populations.

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Successful Return to Full Duty of a Student Marine Following Posterolateral Knee Reconstruction and Fibular Neurolysis: A Rare Events Case Study

Heimark NE, Garner ST, DeShane NS, Van Haute TD: Leidos, Inc, San Diego, CA; Warfighter Performance Department, Naval Health Research Center, San Diego, CA; IGSF, Orlando, FL; 52 Area SMART Clinic, Naval Hospital Camp Pendleton, Camp Pendleton, CA; Decypher, San Antonio, TX

Background: An 18-year-old male United States Marine Corps School of Infantry student Marine (SM) reported to the Sports Medicine and Reconditioning Team (SMART) Clinic for right knee pain following a fall while on leave. Radiographs were performed and the SM was issued an immobilizer at a civilian emergency room. An athletic trainer (AT) at the SMART Clinic noted significant edema and ecchymosis surrounding the tibiofemoral and proximal tibiofibular joints. Knee range of motion was limited in all planes. Strength was 5/5 for knee flexion and extension with pain and 1/5 for ankle dorsiflexion. Varus stress testing was positive for pain and laxity at 0° and 30°. Sensory deficits along the dorsal foot and shin were also present. **Differential Diagnosis:** A positive varus stress test indicated a grade 3 LCL tear. ACL, hamstring, iliotibial band (ITB), meniscus, and peripheral nerve pathology were also suspected but determining the extent of the injury was difficult due to effusion and deformity of the lateral thigh. **Intervention & Treatment:** Further evaluation was performed by a sports medicine physician who ordered a non-contrast MRI exam. Results indicated a partially torn ACL, ruptured LCL and PCL, probable popliteal fibular ligament tear, medial collateral ligament sprain, and tears of the distal attachments of the biceps femoris and ITB with retraction.

Reconstructive knee surgery was scheduled in two parts. The first surgery consisted of posterolateral corner reconstruction with a semitendinosus allograft, fibular neurolysis, and LCL, biceps femoris, ITB, and joint capsule repair. Following the initial procedure, the SM was issued a brace locked in full extension and completed four inpatient physical therapy sessions. A second surgery was unnecessary as the surgeon noted the ACL and PCL remained partially intact. The SM still presented with sensory and motor dysfunction indicative of fibular nerve palsy. Electromyography testing at four months post-surgery revealed absent superficial fibular nerve sensory and motor responses for tibialis anterior and fibular longus muscles. An ankle-foot orthosis was prescribed to assist with proper ambulation. The SM was reassigned to the Medical Rehab Platoon because the SM was unable to meet the demands of Marine Combat Training (MCT). This allowed the SM to be treated at the SMART Clinic to help maintain physical fitness while rehabilitating the injury; this included two scheduled physical therapy appointments and four additional rehab appointments per week with ATs. The SM started tactical strength and conditioning sessions, weekly hikes with load progression, and a running program 6 months post-surgery. Weekly meetings allowed the clinical team to discuss specifics about the SM's case throughout his eight month rehabilitation process. The SM was returned to training once cleared by an orthopedic surgeon, after demonstrating the ability to hike six miles with a 60-pound pack and run three miles within 25 minutes. Although the SM never regained full function of the affected fibular nerve, use of the ankle-foot orthosis allowed the SM to return to full duty (RTFD). **Uniqueness:** While there are numerous accounts of civilians returning to activity following posterolateral corner reconstruction, this is unique in the military. According to a study on military service members, only 41% of patients

with multiligamentous knee injuries (MLKIs) were able to RTFD. Additionally, civilians with nerve injury and MLKI were found to have significantly lower return to work rates than those without nerve injury. While medical separation was warranted, the SM was able to RTFD with the use of an ankle orthosis. **Conclusions:** Following knee reconstruction and fibular nerve palsy, the SM was able to RTFD following 8 months of rehabilitation. The SM's determination and the interprofessional clinical collaboration allowed for a successful return to duty and completion of MCT.

None of the authors have any financial disclosures. NSD is military service member or employee of the U.S. Government and this work was prepared as part of his official duties. Title 17, U.S.C. §105 provides that copyright protection under this title is not available for any work of the U.S. Government. Title 17, U.S.C. §101 defines a U.S. Government work as work prepared by a military service member or employee of the U.S. Government as part of that person's official duties. The views expressed in this work are those of the authors and do not necessarily reflect the official policy or position of the Department of the Navy, Department of Defense, nor the U.S. Government.

Structural Network Impairments Associated With Greater mTBI Incidence in Special Operations Forces Soldiers

Powell JR, Dums EJ, DeLellis SM, Depenbrock PJ, Kane SF, Means GE, Mihalik JP: Matthew Gfeller Center, The University of North Carolina at Chapel Hill, Chapel Hill, NC; Fort Bragg Research Institute, The Geneva Foundation, Tacoma, WA; United States Army Special Operations Command, Fort Bragg, NC

Context: Special Operations Forces (SOF) Soldiers are at high risk for traumatic brain injury (TBI) in combat and training. Over 82% of all service-related neurotrauma is classified as mild TBI (mTBI). Multiple mTBI exposures have been linked to poor long-term cognitive, behavioral, and neurological outcomes. Advancements in diffusion imaging and mathematics, particularly graph theory, offer methods for analyzing complex brain networks. To examine how network differences may increase long-term risk, this study's purpose was to innovatively identify persistent neurophysiological changes through structural brain network differences associated with greater mTBI lifetime incidence in SOF Soldiers. **Methods:** Participants in this cross-sectional study included 210 male SOF combat Soldiers (age=33.0±4.0yrs) who self-reported mTBI history [range: 0 to 10; mean: 2.3±2.9 mTBI; n=90 (42.9%) with no mTBI history; n=120 (57.1%) with mTBI history]. Diffusion and structural MRI scans were obtained on 3T scanners. Structural volumes were segmented and parcellated using FreeSurfer 7.2 to create seed regions for fiber tracking. Probabilistic tractography was applied to post-processed diffusion weighted volumes. Structural connectivity networks were seeded with an 82-region cortical and subcortical atlas. Connectivity matrices were generated to compute global efficiency, density, and vulnerability. Global efficiency quantifies efficient communication by computing the average inverse shortest path length in the network. Density represents the fraction between present connections to possible connections. Vulnerability quantifies

a network's prospective attack tolerance and is computed by the drop in global efficiency if the most vulnerable node is removed. Non-normal network variables were rank transformed. Linear regression models were fit to predict network variables by continuous mTBI history. All statistical tests were 2-sided with an a priori α level $P \leq 0.05$ and standardized regression coefficients are reported. **Results:** Continuous mTBI incidence significantly predicted brain network vulnerability ($F_{1,208}=3.92$, $P=0.049$), density ($F_{1,208}=5.92$, $P=0.016$), and global efficiency ($F_{1,208}=5.68$, $P=0.018$). Negative linear relationships were observed between mTBI incidence, density ($\beta = -0.167$) and global efficiency ($\beta = -0.163$) while a positive linear relationship was found between mTBI incidence and vulnerability ($\beta = 0.136$). **Conclusions:** Adverse differences in structural brain network density, global efficiency, and vulnerability were associated with greater mTBI incidence in SOF Soldiers. Soldiers with greater mTBI incidence had lower network density suggesting whole-brain dysconnectivity may result from repetitive mTBI. Our findings indicate mTBI may impair global efficiency resulting in higher brain energy costs to maintain communication and connectivity along greater path lengths. Greater mTBI incidence was linked to greater vulnerability, indicating that repetitive mTBI may lower physiological tolerance to future injury and accelerate age-related neurodegeneration. Soldiers in this study were clinically recovered from mTBI; therefore, these network alterations persist beyond symptom resolution. Future research should evaluate how structural network properties may be useful biomarkers to determine prospective risks to Soldier health and readiness.

Fellow sponsored by Jason Mihalik, PhD, CAT(C), ATC.

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The Association Between Sleep Duration and Concussion Symptom Severity at Baseline and Post Injury in United States Service Academy Cadets and Midshipmen

Aderman MJ, Roach MH, Malvasi SR, Ross JD, Svoboda SJ, Robb JB, McGinty GT, Jackson JC, Campbell D, Estevez CA, Brodeur RM, VanPelt K, Susmarski A, Broglio SP, McCrema MA, McAllister T, Pasquina PF, Cameron KL: Keller Army Hospital, West Point, NY; DoD-VA Extremity Trauma and Amputation Center of Excellence, Research & Surveillance Division, Fort Bragg, NC; Womack Army Medical Center, Department of Clinical Investigation, Fort Bragg, NC; United States Air Force Academy, USAFA, CO; United States Coast Guard Academy, New London, CT; Synaptex LLC, Lexington, KY; United States Naval Academy, Annapolis, MD; University of Michigan Concussion Center, Ann Arbor, MI; Medical College of Wisconsin, Milwaukee, WI; Indiana University School of Medicine, Indianapolis, IN; Walter Reed National Military Medical Center, Bethesda, MD

Context: Sleep deprivation is common in college students and military Service members. Insufficient sleep has been associated with negative health effects including greater symptom burden on concussion baseline assessments. The purpose of this study was to examine the relationship between sleep duration and symptom severity across concussion management timepoints in service academy cadets and midshipmen. **Methods:** A prospective cohort study was conducted with cadets and midshipmen enrolled at four service academies. Participants were enrolled in the Concussion Assessment, Research and Education Consortium from 2014-2020. Participants underwent baseline concussion testing and reported demographic information (site, academic year, varsity status, sex, and concussion history) during their first year

at their respective academy. Participants who sustained a concussion underwent standardized evaluations at three follow-up timepoints: < 48 hours post-injury, upon initiation of a graduated return to activity (GRTA) protocol, and when cleared for unrestricted return to activity (URTA). Self-reported hours slept the night before each evaluation and concussion symptom severity (range: 0-132) were recorded on the Sport Concussion Assessment Tool (SCAT) at each timepoint. Univariate and multiple linear regression models were used to examine the relationship between sleep duration and SCAT symptom severity while controlling for significant covariates (site, varsity status, sex, psychological status). One-way ANOVA models were used to evaluate differences in SCAT symptom severity by hours slept at each timepoint. Sleep was grouped by quartiles (< 5 hours, ≥ 5 to < 6 hours, ≥ 6 to < 7 hours, ≥ 7 hours) and served as the independent variable for each model. Post-hoc testing was conducted on statistically significant models ($p < 0.05$). **Results:** During the study period, 17,268 participants (25% female; 19.01 ± 1.41 y) completed a baseline assessment and 1,597 (39% female; 20.03 ± 1.48 y) sustained a concussion and completed follow-up assessments. Linear regression models revealed sleep duration was associated with SCAT symptom severity scores across all timepoints: baseline (Coefficient = -2.22; 95% CI = -2.36, -2.07; $p = < 0.001$), < 48 hours post-injury (Coefficient = -2.64; 95% CI = -3.27, -2.00; $p = < 0.001$), GRTA protocol initiation (Coefficient = -0.30; 95% CI = -0.40, -0.20; $p = < 0.001$), and URTA (Coefficient = -0.14; 95% CI = -0.19, -0.09; $p = < 0.001$). After controlling for significant covariates, multiple linear regression models yielded similar results. The ANOVA models revealed those with < 5 hours of sleep reported significantly higher symptom severity than the other groups across all timepoints (Table 1) and a dose dependent relationship between sleep duration and SCAT symptom severity across timepoints. The association between sleep and SCAT symptom severity had the greatest impact at the baseline and < 48 hours post-injury assessments (Table 1). **Conclusions:** A one-hour sleep increase was associated with a 2.2 to 2.6 SCAT symptom severity decrease during baseline and < 48 hours post-injury respectively. Similar results were

observed at GRTA protocol initiation and URTA as well, suggesting that more sleep may be associated with decreased symptom severity across concussion management timepoints. Sleep duration the night before concussion baseline and post-injury evaluations should be considered as it may impact the results of the evaluation.

Fellow sponsored by Kenneth L. Cameron, PhD, MPH, ATC, FNATA.

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Table 1. Mean SCAT symptom severity score by timepoint and quartile for hours slept.

Hours Slept	n	Mean±SD	F	p-value	<i>Post-Hoc Results</i>		
					Group	Mean Difference	p-value
<i>Baseline</i>							
<5 (1)	2042	12.23±15.85	302.60	<0.001	1 vs 2	-2.21	<0.001
≥5 to <6 (2)	4788	10.02±13.35			1 vs 3	-4.90	<0.001
≥6 to <7 (3)	6036	7.33±10.68			1 vs 4	-8.08	<0.001
≥7 (4)	4328	4.15±1.80					
<i><48 Hours Post-Injury</i>							
<5 (1)	140	38.60±23.60	21.38	<0.001	1 vs 2	-7.73	0.004
≥5 to <6 (2)	198	30.87±20.91			1 vs 3	-9.60	<0.001
≥6 to <7 (3)	402	29.00±20.04			1 vs 4	-13.97	<0.001
≥7 (4)	794	24.63±19.89					
<i>GRTA Protocol Initiation</i>							
<5 (1)	65	2.82±4.75	14.32	<0.001	1 vs 2	-1.01	0.052
≥5 to <6 (2)	151	1.80±3.10			1 vs 3	-1.51	<0.001
≥6 to <7 (3)	409	1.31±2.83			1 vs 4	-1.88	<0.001
≥7 (4)	855	0.93±2.12					
<i>Unrestricted Return to Activity</i>							
<5 (1)	99	0.71±2.40	9.00	<0.001	1 vs 2	-0.20	1.00
≥5 to <6 (2)	201	0.51±1.46			1 vs 3	-0.41	0.011
≥6 to <7 (3)	512	0.29±1.27			1 vs 4	-0.55	<0.001
≥7 (4)	744	0.16±0.76					

Abbreviations: SCAT=standardized concussion assessment tool; SD=standard deviation

Factors Associated With Return-to-Duty Time Following Musculoskeletal-Related Occupational Disability

Clifton DR, Nelson DA, Choi YS, Edgeworth D, Shell D, Deuster P: Consortium for Health and Military Performance, Department of Military & Emergency Medicine, F Edward Hébert School of Medicine, Uniformed Services University, Bethesda, MD; Henry M. Jackson Foundation for the Advancement of Military Medicine, Inc., Bethesda, MD; Womack Army Medical Center, Fort Bragg, NC; Health Services Policy and Oversight, Office of the Assistant Secretary of Defense for Health Affairs, Defense Health Headquarters, Falls Church, VA

Context: Minimizing musculoskeletal-related occupational disability (MSK-D) is critical to the mission of the U.S. Army. Musculoskeletal conditions account for 2 million medical encounters and 8 million limited duty days among soldiers each year. Prior research has identified potentially actionable risk factors for MSK-D, including elevated body mass index (BMI), tobacco use and physical fitness levels. However, the prior work does not appear to have addressed the impact of these factors on return to duty (RTD) times, which reflect the operational burden of MSK-D on units. The purpose of this study was to identify factors that were associated with RTD times following MSK-D among U.S. Army soldiers. Identifying such factors may inform efforts to improve medical and operational military readiness. **Methods:** We performed a retrospective cohort study on 257,319 Army soldiers by using monthly administrative, medical, and readiness records from the Medical Assessment and Readiness System database housed at Womack Army Medical Center, Fort Bragg, NC. Soldiers whose records were used in the study served on active duty during 2014-2017, experienced MSK-D, and RTD following MSK-D. We assessed relationships between RTD times following MSK-D and various health (e.g., physical fitness, BMI, tobacco use), service (e.g., military occupational specialty, rank,

time in service), and demographic (e.g., age sex, education level) factors. We used multivariable linear regression to assess relationships between these health, service, and demographic factors and time to RTD following MSK-D. MSK-D was defined as a musculoskeletal-related duty restriction on training or combat deployment. RTD was defined as the first removal of duty restrictions. **Results:** Among the 257,319 soldiers whose records were used in this study, the mean RTD time was 2.88 months (standard deviation = 2.32 months, median = 2 months). The greatest associations with RTD times were demonstrated with physical fitness. Soldiers who failed the physical fitness test demonstrated an adjusted RTD time that was 0.35 months longer (95% confidence interval [95%CI]: 0.29, 0.41, $p < 0.001$) than for those scoring 290 or higher. Having a BMI of 30 kg/m² or greater was also associated with an extra 0.14 months (95%CI: 0.11, 0.16, $p < 0.001$) before RTD, compared to soldiers with BMI in the 18.50 to 24.99 kg/m² range. **Conclusions:** The findings revealed strongest associations between physical fitness and RTD times following MSK-D. Specifically, RTD times were 0.35 months longer among soldiers who failed their physical fitness test as compared to soldiers who scored 290 or higher. This study supports ongoing Army initiatives to further improve Soldier physical fitness as a means for improving medical and operational military readiness.

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Army Reserve Officers' Training Corps Cadets Improve Hip Abduction Angle During Jump-Landing Following Dynamic Warm-up Intervention

Ericksen HM, Lally EM, Reckelberg RM, Earl-Boehm JE: University of Wisconsin-Milwaukee, Milwaukee, Wisconsin.

Context: The Army Reserve Officers' Training Corps (ROTC) cadets participate in physically demanding training and as many as 21% may sustain lower extremity overuse injuries. The physically demanding requirements of ROTC cadets require an effective and efficient training program to maximize functional performance while minimizing the potentially negative consequences associated with injuries. A training program focused on single leg balance and jumping exercises could improve cadet's jump-landing mechanics and subsequently lower extremity injury risk. The Dynamic Integrated Movement Enhancement (DIME) program was designed as a warm-up to train athletes and military personnel to avoid high risk movement patterns which may be linked to injury. The DIME has been used previously in military populations but has not been implemented in the ROTC. The purpose of this project was to evaluate jump-landing biomechanics following a 16-session modified DIME warm-up in the Army ROTC. **Methods:** As part of a larger project, seventeen (21.5±3.7yrs; 1.7±0.1m; 73.8±15.3kg) ROTC cadets' knee and hip 3D jump-landing kinematics were evaluated at peak knee flexion during three trials of a standardized jump-landing task. Following the pre-test,

participants were lead through the modified DIME warm-up program by researchers twice per week for a total of 16 sessions. The 10-exercise warm-up included: double leg squat, squat jump, forward lunge, side plank, push-up, straight-leg deadlift, side hop to balance, ice skater, "L" hop, and banded pull through. For the duration of the intervention, participants completed required ROTC physical training workouts three times per week. Following completion of the intervention, participants were post-tested in the same manner as the pre-test. Separate repeated measures ANOVAs were performed for knee and hip flexion and knee and hip abduction angles. P-value was set at 0.05 for statistical significance.**Results:** Participants significantly increased hip abduction angle (F(1,18)=6.75,p=0.018) and decreased knee flexion angle (F(1,18)=6.49,p=0.02) at the post-test. Knee abduction and hip flexion were not significantly different pre to post (p > 0.05, Table). **Conclusions:** Replacing the traditional ROTC warm-up with the DIME 10-minute warm-up demonstrated positive changes in frontal plane kinematics at the hip in ROTC participants. Increased hip abduction during jump-landing could decrease lower extremity injury risk. Results also demonstrated a decrease in knee flexion, which is contrary to the desired effect. The modified DIME warm-up focused on single-leg movements which may explain the positive frontal plane improvements, but undesired sagittal plane results. To improve knee flexion, providing more feedback on sagittal plane kinematics may be necessary. The modified DIME warm-up may provide ROTC cadets with some positive changes, but these may not accompany changes in sagittal plane

kinematics. Interventions may need to include more jump-landing feedback in addition to the warm-up to see positive results in all planes of movement.

Fellow sponsored by Jennifer E. Earl-Boehm, PhD, ATC.

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Table: Pre- and Post-intervention Jump-landing Kinematics at Peak Knee Flexion

	Knee Flexion Angle (°)	Knee Abduction Angle (°)	Hip Flexion Angle (°)	Hip Abduction Angle (°)
Pre- intervention Mean±SD	104.12±15.31 ^o	16.38±15.65 ^o	90.52±21.78 ^o	11.08±7.14 ^o
Post-intervention Mean±SD	98.05±17.10 ^o ^	15.47±9.55 ^o	89.27±24.42 ^o	18.21±8.52 ^o *

* = significantly increased hip abduction p < 0.001
^=significantly decreased knee flexion p=0.05

Movement Control and Star Excursion Balance Test Are Not Related in Collegiate Army Reserve Officers' Training Corps

Sheldon LN, Burland JP, Glaviano NR, Devaney LL, Malone ZC, Podurriel J, Sarnelli M, Mejdolli G, DiStefano LJ: University of Connecticut; Storrs, CT

Context: Musculoskeletal injury is a major problem in the military. Injury risk screenings are often implemented to identify high-risk military personnel who would benefit from interventions. These screenings can be time-consuming and efforts to optimize the efficiency and predictive capabilities of these screenings are warranted. The Star Excursion Balance Test (SEBT) and LESS scores are associated with injury risk and frequently incorporated into screenings. The SEBT task evaluates dynamic balance deficits while the LESS provides a global evaluation of movement control during a sport-specific task. The purpose of this study was to evaluate the relationship between SEBT and LESS scores in a military population. **Methods:** Active collegiate Army Reserve Officers' Training Corps (ROTC) participants (n=17 females, 41 males; age=20.22±1.69 years; height=174±8 cm; weight=73.2±13.0 kg) enrolled in this cross-sectional study. All participants completed a single test session involving the LESS and the SEBT. The LESS was scored using an automated scoring system (Physimax Technologies LTD, Tel Aviv, Israel) integrating an Xbox Kinect camera (Microsoft, Redmond, WA), which are validated against traditional LESS scoring. Medial knee displacement (MKD) is a specific error in the LESS that is calculated by Physimax as a continuous 2-d angle during a jump landing. MKD is commonly reported as an influencing

factor related to lower extremity pathologies, and a focus of therapeutic interventions. Three trials of the SEBT were performed in the following directions: anterior, posteromedial, and posterolateral. Participants were instructed to reach as far as possible in each direction while keeping their hands on their hips. Reach distances were measured (cm) and normalized to participant's limb length in each direction (% limb length). The participants were divided into two groups based on LESS score: good (< 6 errors), poor (≥ 6 errors). A two-tailed t-test was used to compare SEBT distances between LESS groups. Pearson correlation scores were calculated to evaluate the association between MKD and SEBT ($\alpha < .05$). **Results:** There were no significant group differences in reach distance between those rated "good" on the LESS and those rated "poor" (anterior reach p=.204, posteromedial reach p=.349, posterolateral reach p=.332). There was a weak correlation between SEBT scores and MKD (anterior reach $r^2=0.180$, $p=.001$, posteromedial reach $r^2=0.122$, $p=.008$; posterolateral reach $r^2=0.072$, $p=.045$). Participants with lower reach scores demonstrated higher MKD. **Conclusions:** SEBT reach distances did not differ between ROTC cadets who demonstrated good versus poor neuromuscular control, as measured by the total LESS score. This may be because the SEBT and overall LESS measure different constructs related to neuromuscular control. However, when individual components of the LESS were evaluated, such as MKD (a specific possible risk factor for injury), individuals who displayed higher MKD also had lower reach scores.

Fellow sponsored by Lindsay DiStefano, PhD, ATC.

Free Communications, Rapid Fire Presentations: Social Determinants of Health and Working with Diverse Populations

Saturday, June 24, 2023; 11:45 AM-12:40 PM; Room Entry 233

Moderator: Melissa Snyder, PhD, LAT, ATC

Differences in Attitudes Towards Injury Prevention Program Participation Based on Races

Gabriel EH, Bailey J: University of Kentucky, Lexington, KY, and Mercer University, Macon, GA

Context: Injury prevention programs (IPPs) have been very effective at reducing lower extremity injury rates. The limiting factor for the effectiveness of IPPs has been compliance with completing the recommended exercises. There is a potential that race may impact an individual's attitudes towards participation in IPPs. Therefore, the purpose of this study was to determine if there were differences in attitudes towards participation in IPPs within different races in collegiate athletes. **Methods:** Seventy-three Caucasian (Age: 19.70±1.45 years; Height: 169.07±8.83cm; Mass: 68.47±9.96kg) and 38 non-Caucasian (Age: 19.74±1.57 years; Height: 170.65±9.26cm; Mass: 71.67±13.54kg) collegiate female athletes volunteered to participate in the study. The non-Caucasian group was made up of individuals who self-identified as American Indian, Black or African American, Mixed, or Other. Participants were recruited from Division I and III Universities during team meetings. The study design was cross-sectional where the participants completed the Health Belief Model Scale (HBMS) and Theory of Planned Behavior Scale (TPBS) on one occasion. The HBMS and TPBS were used to assess attitudes towards participation in IPPs. The HBMS contains 9 subscales (perceived susceptibility, perceived consequences, fear of injury, perceived benefits, perceived barriers, community-led self-efficacy, individual self-efficacy, general health cues, external health cues) while the TPBS has 5 subscales (perceived benefits,

perceived barriers, perceived social norms, social influence, and intention to participate). Response options ranged from strongly agree (+3) to strongly disagree (-3) on a 7-Point Likert scale. Positive scores for all subscales would indicate an increased likelihood of participation in an IPP except perceived barriers where positive responses would be associated with a decreased likelihood of participation. The independent variable was self-identified race and dependent variables were subscales of the HBMS and TPBS. Total scores and associated median and interquartile range were calculated for each subscale. Mann-Whitney U tests were used to determine if differences between races existed. Effect size was calculated using the following equation (z/\sqrt{n}). Alpha was set at $P \leq 0.05$ for all analyses. **Results:** Caucasian female athletes (0.00 (4.00)) perceived less TPBS barriers to participation in IPPs when compared to Non-Caucasian female athletes (2.00 (3.00); $P=0.003$; $ES=-0.27$). Additionally, Caucasian female athletes (6.00 (4.00)) perceived more community led self-efficacy than Non-Caucasian female athletes (5.00 (4.00); $P=0.009$; $ES=-0.24$). There were no other statistically significant differences in attitudes towards IPP participation between races ($P>0.05$). **Conclusions:** Non-Caucasian athletes perceived more barriers to participation in IPPs and may need to be provided with potential solutions to overcome those barriers. Additionally, Non-Caucasian athletes perceived less community-led self-efficacy indicating they felt less comfortable in participating in an IPP led by a coach, strength coach, or athletic trainer. Further research is necessary to determine which contextual factors, which may include lack of access to individuals in those roles of the same race, contribute to these findings.

Differences in Perceived Barriers Among Professional Master's Athletic Training Students With Different Ethnic Backgrounds

Franklin T, Williams J: Franklin College, Franklin, IN

Context: Supporting the vitality of the profession relies on many things including recruitment and retention of athletic training students (ATs) from diverse backgrounds. Educators must design and deliver didactic and clinical curricula that mitigates barriers to success experienced uniquely by different student groups. The purpose of this study was to explore students' perceived barriers to success and examine differences in perceptions between White and Ethnic Minority ATs. **Methods:** In this cross sectional design, participants who were ATs enrolled in professional master's programs (PMPs) were grouped by their self-reported ethnicity (n=87 White, n=30 Ethnic Minority). Surveys were emailed to all accredited PMPs at the time of study (n=118) and 117 ATs (males=27, females=90, 1st year student=65, 2nd year student=52) completed the anonymous online survey through QuestionPro. The survey included demographic and Likert-type questions from a previously validated instrument. The survey detects students' perceptions of seven factors (sub-scales)—confidence in ability (CONF), peers (PEER), faculty (FAC), diversity (DIV), campus experience (EXE), work issues (WI), and financial aid issues (FinAid)—being barriers to their success. Each sub-scale used a unique 3-point or 4-point Likert scale. Completion of the Likert-type survey questions provided a "score" for each of the seven sub-scales, with

each sub-scale having a different maximum score. Mann-Whitney U Tests were used to compare differences of sub-scale scores between groups (Group 1: Students identifying as White; Group 2: Students identifying as Ethnic Minorities). Effect sizes were computed as $r = z / \text{square root of } N$ where $N = \text{total number of cases}$. Data were analyzed using SPSS (version 27; IBM Corporation, Armonk, NY). Alpha level for all analyses was set a priori at $p < .05$. **Results:** Results are presented in Table 1. Only sub-scale scores of CONF ($U = 992, z = -2.02, p = .044, r = 0.19$), DIV ($U = 803, z = -3.21, p = .001, r = 0.30$), FAC ($U = 995.5, z = -1.99, p = .047, r = 0.18$), and WI ($U = 1765, z = 3.00, p = .003, r = 0.28$) were significantly different between groups. Effect sizes ranged from 0.18 to 0.30 indicating there being a small to medium effect of group membership influencing the differences observed across the sub-scale scores between groups. **Conclusions:** Findings demonstrated ATs with different ethnic backgrounds perceive different factors as barriers to their success. Ethnic Minority ATs, compared to White ATs, reported their lower confidence levels, lower satisfaction with campus diversity and faculty support, and interferences from needing to work as significant barriers to their success. Athletic training educators in PMPs should consider these findings in their efforts to develop student-centered, equitable strategies that support all students' success and diversity of the profession.

One of the authors was a recipient of the D9 Patty and Chuck Kimmel Scholarship Award for this research study.

Table 1. Sub-Scale Scores Between White and Ethnic Minority Athletic Training Students (Median \pm SD)

Sub-Scale (Max score)	White Students (n=87)	Ethnic Minority Students (n=30)	Difference	U	z	p	r	Confidence Intervals (95%)
CONF (15)	14.0 \pm 1.5	13.0 \pm 2.4	1.0	992	-2.02	.044*	0.19	0.66–1.34
PEER (16)	13.0 \pm 2.1	12.0 \pm 1.9	1.0	1103.5	-1.28	.202	0.11	0.64–1.36
EXP (8)	6.0 \pm 1.2	6.0 \pm 1.2	0.0	1052	-1.64	.101	0.15	-0.22–0.22
DIV (12)	10.0 \pm 1.7	9.0 \pm 2.1	1.0	803	-3.21	.001*	0.30	0.66–1.34
FAC (28)	27.0 \pm 2.9	26.0 \pm 4.3	1.0	995.5	-1.99	.047*	0.18	0.35–1.65
FinAid (6)	4.0 \pm .84	4.0 \pm .89	0.0	1261	-.292	.770	0.03	-0.16–0.16
WI (8)	5.0 \pm 1.7	8.0 \pm 1.4	3.0	1765	3.00	.003*	0.28	2.72–3.28

Abbreviations: CONF, Confidence in ability; PEER, Peers; EXP, Campus experience; DIV, Diversity; FAC, Faculty; FinAid, Financial aid issues; WI, Work issues

*significant between student groups ($p < .05$)

Graduate Professional Athletic Training Students' Levels of Comfort, Competence and Perception of LGBTQIA+ Curriculums

Dudley EN, Aronson PA, Pieper LP, Bowman TG: University of Lynchburg, Department of Athletic Training, Lynchburg, VA

Context: Demographic variables that affect the opinions and perspectives of Athletic Trainers about patients who identify as members of the LGBTQIA+ community have been identified. However, the perspectives of Athletic Training students remain unknown. The purpose of this study was to determine the level of comfort, competence, and overall perception graduate professional Athletic Training students have providing healthcare for members of the LGBTQIA+ community. **Methods:** We sent an email to all directors of graduate professional athletic training programs in the United States and asked them to forward recruitment information to students enrolled in their programs. 144 students (116 women, 28 men, age = 23±2.74) completed an online, anonymous, cross-sectional research survey that had been previously validated. The survey assessed 4 dependent variables; comfort, competency, and perceptions of the curriculum regarding patients who identify as LGBTQIA+. Students self-reported their comfort (6 questions) on a 4 point Likert scale (not comfortable, somewhat not comfortable, somewhat comfortable, very comfortable), competence (15 questions) on a 4 point Likert scale (not competent, somewhat not competent, somewhat competent, and very competent), and the quality of education they received from the curriculum during their program (6 questions) on a 4 point Likert scale (strongly disagree, somewhat disagree, somewhat agree,

strongly agree). The 4 dependent variables were examined through 3 independent variables; participant sexual orientation (straight, LGBTQIA+), participant gender identity (man, women, other), and whether or not they had a friend or family member who identified as a part of the LGBTQIA+ community (yes, no). We used Kruskal-Wallis and Mann-Whitney U tests to determine differences in the dependent variables based on the levels of the independent variables and set the alpha value to $P \leq .05$ a priori. **Results:** When examining participant sexual orientation, we found significant differences when comparing levels of self-reported comfort ($P=.004$) and competence ($P=.020$), but no differences on perceptions of curriculum ($P=.326$). There was a significant difference between self reported competence when examining gender identity ($\chi^2=10.088$, $P=.006$) but no difference was reported for self reported comfort ($\chi^2= 3.648$, $P=.161$) or perceptions of curriculum ($\chi^2= .970$, $P=.616$). Individuals self reported comfort ($\chi^2= 20.246$, $P= <.001$) and competence ($\chi^2= 11.492$, $P=.003$) were both significantly different, however no significant difference was found within curriculum perceptions ($\chi^2=.6608$, $P=.719$) when examining if participants knew if a family member or friend identified as a member of the LGBTQIA+ community. **Conclusions:** The majority of participants within our study reported minimal to very little education within their graduate professional Athletic Training curriculum on the LGBTQIA+ community. Based on the results from this study, additional professional education and continuing education can be developed in order to bridge the comfort and competence gap athletic trainers have towards providing care for members of the LGBTQIA+ community.

Fellow sponsored by Tom Bowman, PhD, ATC.

	Sexual Orientation		Gender Identity			Famiy/Friend identify as LGBTQIA+	
	Straight	Other	Male	Female	Other	Yes	No
Comfort	3.14 ± .060	3.51 ± .074	3.04 ± .124	3.24 ± .057	3.46 ± .265	3.32 ± .049	2.62 ± .143
Competency	2.55 ± .046	2.84 ± .121	2.44 ± .085	2.62 ± .051	3.34 ± .201	2.67 ± .050	2.31 ± .067
Cirriculum Perception	2.50 ± .072	2.35 ± .146	2.62 ± .132	2.45 ± .074	2.16 ± .424	2.46 ± .071	2.53 ± .163

Examining Athletic Training Students' Knowledge of the Social Determinants of Health and Their Perceptions of the Influence of the Social Determinants of Health on Patient Cases

Jones BC, Welch Bacon CE, Bay RC, Van Lunen BL, Cavallario JM: A.T. Still University, Mesa, AZ, and Old Dominion University, Norfolk, VA

Context: Social determinants of health (SDH) are described as the conditions in which people are born, live, learn, work, play, worship, and age that affect a wide range of health, functioning, and quality-of-life outcomes and risks. The CAATE added a curricular content standard for ATPs requiring instruction on the SDH; however, athletic training students' (ATS) knowledge and perceptions about SDH are unknown. Therefore, we aimed to examine students' knowledge, comfort, and familiarity with SDH, as well as their perceptions regarding the impact of SDH on patient cases. **Methods:** We used a cross-sectional survey design to capture perceptions from 120 professional ATS attending ATPs in 28 states (90 women, 34 men, 2 non-binary individuals; average age=22.3±2.36 years). Participants included 63 professional undergraduate and 57 professional graduate ATS; 70 ATS completed an immersive clinical experience and 58 ATS completed at least one clinical experience at a non-traditional (hospital, physician practice, or rehabilitation center/clinic) site. With permission, we slightly modified a previously validated 70-item survey regarding AT perceptions of SDH. The modified version consisted of ATS' knowledge of SDH, perceptions of the influence of SDH on patient cases, clinical experience information, and participant demographics, and was piloted with ATS prior

to data collection. Descriptive statistics were used to summarize participant demographics as well as ATS' knowledge, comfort, and familiarity with SDH. Analysis of variances tests were performed to examine differences in ATS' knowledge, comfort, and familiarity with SDH between program types. Spearman's rank correlations were conducted to examine the relationships between ATSs' clinical experience site types and their knowledge, comfort, and familiarity with SDH. **Results:** ATS' self-perceived themselves to be "minimally knowledgeable" (45.6%), "moderately familiar" (44.2%) and "minimally comfortable" (46.5%) with SDH. When presented with a list of factors, ATS most frequently endorsed "social environment" (77.2% of students), "education" (76.4%), and "income and wealth" (74.8%; Table) as SDH. Graduate ATS were significantly more familiar ($p=0.021$) and comfortable ($p=0.009$) with SDH than undergraduate ATS. ATS who completed at least one clinical experience at a non-traditional site were also significantly more familiar ($p=0.007$) and comfortable ($p=0.011$) with SDH than ATSs who did not have a clinical experience at a non-traditional site. **Conclusions:** Our results suggest ATS' perceptions of the impact of SDH on patient cases may be influenced by purposeful clinical education opportunities. It is essential for ATS to have opportunities to work through clinical or simulated patient encounters that involve influential SDH so they gain the knowledge, familiarity, and comfort necessary to provide whole-person healthcare to their future patients. Because ATS largely reported minimal-to-moderate levels of knowledge, comfort, and familiarity with SDH, ATP administrators should examine the current didactic instructional practices offered regarding SDH and ensure ATS have ample clinical education opportunities to observe or manage SDH.

Table. Student endorsement of social determinants of health

		Endorsed (%)	Not Endorsed (%)
Social Determinants of Health	Education	97 (76.4)*	30 (23.6)
	Employment	86 (67.7)*	41 (32.3)
	Health Systems and Services	72 (56.7)	55 (43.3)
	Housing	68 (53.5)*	59 (46.5)
	Income and Wealth	95 (74.8)	32 (25.2)
	Physical Environment	89 (70.1)	38 (29.9)
	Public Safety	62 (48.8)	65 (51.2)
	Social Environment	98 (77.2)	29 (22.8)
	Transportation	52 (40.9)	75 (59.1)
Structural Inequities	Class	79 (62.2)	48 (37.8)
	Gender	70 (55.1)	57 (44.9)
	Racism	57 (44.9)	70 (55.1)
	Sexism	53 (41.7)	74 (58.3)
Other Factors	Genetics	34 (26.8)	93 (73.2)
	Health Behavior	66 (52.0)	61 (58.0)
	Psychosocial Characteristics	70 (55.1)	57 (44.9)

*denotes that graduate professional students endorsed the determinant significantly more frequently than undergraduate professional students ($p < 0.05$).

Mitigating Social Determinants of Health in Athletic Healthcare: Athletic Trainers Are Taking Action

Picha KJ, Windsor Evans CM, Snyder Valier AR, Lewis JH, Welch Bacon CE: A.T. Still University, Mesa, AZ

Context: Social determinants of health (SDH) are increasingly acknowledged within athletic healthcare due to their impact on individual health and wellbeing. Research shows addressing SDH may be more important than the care provided. Athletic trainers (ATs) are uniquely positioned to observe and address SDH among their patients, yet it is currently unknown what actions, if any, ATs take when SDH are observed to be negatively influencing patients' health. Therefore, we explored actions taken by ATs when SDH are perceived to be negatively influencing patient health. **Methods:** This study is part of a larger project. We used a concurrent triangulation mixed-methods approach via an observational card study design. With permission, we modified a previously validated SDH observation card to collect ATs' observations of SDH during patient encounters in the secondary and collegiate/university school settings. Observations were recorded on cards that contained instructions for completion and a table with 4 columns: 1) a list of 19 predetermined SDH, 2) checkbox for SDH observed, 3) checkbox for perceived negative influence of observed SDH on patient health, 4) open box to write in what actions, if any, the AT took to address the observed SDH. Validation of the modified observation card was reconfirmed by conducting a pilot study with certified students from a post-professional athletic training program to establish proof of concept, feasibility, and validity of methods. Cards took approximately 30 seconds to complete and 1 card was completed per patient. Data collection for each AT lasted 1 week. Descriptive statistics were used to characterize quantitative data (AT demographics; frequency of cards completed, SDH observed, and perceived negative influence). Qualitative data (actions reported) were analyzed following

a consensual qualitative research approach, including a multi-phase, deductive thematic analysis among 3 researchers and confirmed by an internal auditor. **Results:** Cards for 1101 patients were completed by 50 ATs (9 men, 41 women; AT experience range = 0-25 years) employed at 27 secondary schools and 23 colleges/universities in 23 states (22.0±8.5 cards completed per AT). ATs observed 1462 social factors and perceived 43% (n=632/1462) of those factors were negatively influencing patient health. The most frequently reported SDH perceived to have a negative influence on patient health were health literacy (n=85/632), behavior health issues (n=78/632), and academic stressors (n=82/632). Actions were reported for 76% (n=481/632) of SDH perceived as negatively impactful. Actions were coded into four emergent themes: counseling and education, referral to others, communication with others, and providing additional resources (Table). The most common action taken by ATs was counseling and education to mitigate health literacy. Least often observed and acted on SDH were poverty, neighborhood safety, and migration/immigration status. **Conclusions:** The results of this study demonstrate ATs ability to mitigate SDH that they observe during interactions with their patients. The themes that emerged align with AT's professional education and training to educate, refer, and communicate with various stakeholders in their patient's health. Health literacy, behavior health issues, and academic stressors were most often perceived to have a negative influence on this population's health and were acted on most often using counseling and education. Future studies should confirm ATs observations of SDH with patient reports and further explore interventions to address SDH that are negatively influencing health in these patient populations.

This abstract is a product of an NATA Research & Education Foundation New Investigator Research Grant (#1819NIP02) titled: Athletic Trainers' Perceptions and Observation of Social Determinants of Health.

Table. Action Taken by Athletic Trainers When Social Determinants of Health Were Perceived to Have a Negative Impact on Health [frequency]

Social Determinant of Health	Observations		Action Taken				
	Observed in a Patient	Perceived as Negative Impact on Patient Health	Counseling and Education	Provide Additional Resources	Referral to Others	Communication with Others	Total
Lack of health literacy	135	85	76	3	1	1	81
Behavioral health issues	118	78	24	4	27	3	58
Academic stressors	237	82	22	13	7	2	44
Transportation issues	92	51	2	34	2	2	40
Insufficient/lack of health insurance	50	43	4	12	15	1	32
Language barrier	73	27	3	3	3	21	30
Poor social support	87	54	20	5	2	3	30
Individual/family life circumstances	110	56	11	4	9	4	28
Food insecurity	32	25	7	14	2	3	26
Access to social medial/emerging technologies	247	26	12	3	3	0	18
Job stressors	79	23	10	5	0	1	16

Athletic Trainers' Observation of Social Determinants of Health at the Point-of-Care in the College/University Setting

Windsor Evans CM, Welch Bacon CE, Snyder Valier AR, Lewis JH, Picha KJ: A.T. Still University, Mesa, AZ

Context: Social determinants of health (SDH) influence a person's health and quality of life yet often fail to be addressed in healthcare systems. Addressing SDH can improve patient outcomes, leading to better patient-centered care. Despite the known effects SDH have on individual and population health, less is known about how SDH present in athletic healthcare and if athletic trainers' (ATs) observe them in practice. The purpose of this study is to understand ATs' observations of SDH among their patients at the point-of-care in the college/university setting. **Methods:** A card study design was used to collect ATs' observations of SDH during patient encounters in the collegiate/university setting and was part of a larger study. Card studies are designed to collect observations at the point-of-care without altering the clinician-patient interaction. Observations were recorded on cards that contained a table with 4 columns, 1) 19 pre-filled SDH, 2) space to identify SDH observed, 3) space for perceived negative effect on the patient's health, and 4) space to describe what actions, if any, were taken to address the SDH. Cards were validated through a pilot study. Cards took approximately 30 seconds to complete, and ATs completed 1 card per patient encounter. Data collection for each AT lasted 1 week, or until 30 cards were completed, whichever came first. Descriptive statistics (ie, frequencies, percentages) were used to characterize the SDH observed by ATs. **Results:** Observation cards were collected for 424 patients, by 23 ATs

(15 women, 8 men; age=28.14±3.75 years; AT experience range=0-20 years), from 19 colleges/universities in 15 states. Seven hundred and twenty-five SDH were observed, with 38.8% (n=281/725; Table) perceived to have a negative impact on patient health. The top three SDH observed were access to social media (n=153/725, 21.2%), academic stressors (n=131/725, 18.0%), and behavioral health issues (n=71/725, 9.8%). Homelessness/poor or unstable living conditions (n=5/725, 0.7%), poverty/near poverty (n=3/725, 0.4%), and educational limitations (n=1/725, 0.1%) were the least commonly observed SDH, and neighborhood safety was not observed at all. Academic stressors (n=49/281, 17.4%), behavioral health issues (n=46/281, 16.4%), and transportation issues (n=32/281, 11.4%) were the top three SDH that had a perceived negative impact on patient health. While less commonly observed, insufficient/lack of health insurance (n=15/18, 83.3%) and food insecurity (n=8/11, 72.7%) had higher percentages of perceived negative impact on patient health when they were observed. **Conclusions:** ATs in the college/university setting are observing SDH and being prepared to address them when perceived to negatively impact health may benefit patients. Preparation to support patients with behavioral health issues and academic stressors is important because these SDH were the most commonly perceived to negatively influence patient health. Future research should explore SDH from a patient perspective and determine best methods of SDH assessment.

This abstract is a product of an NATA Research & Education Foundation New Investigator Research Grant (#1819NIP02) titled: Athletic Trainers' Perceptions and Observation of Social Determinants of Health.

Table. Social Determinants of Health Observations at the Point-of-Care (Frequencies)

Social Determinants of Health	Observed	Perceived Negative Impact
Access to social media/emerging technologies	153	13
Academic stressors	131	49
Behavioral health issues	71	46
Transportation issues	56	32
Lack of health literacy	50	27
Individual/family life circumstances	46	24
Poor social support	39	24
Job stressors	37	11
Language barrier	23	4
Cultural beliefs/values	23	2
Family demands	22	7
Insufficient/lack of health insurance	18	15
Migrant/immigration status	14	2
Substance use/abuse	13	7
Food insecurity	11	8
Homeless/poor or unstable living conditions	5	3
Poverty/near poverty	3	1
Educational limitations	1	0
Neighborhood safety	0	0

Shading indicates a top three value.

Transition to Practice for Diverse Early Professional Athletic Trainers

Smith AD, Moffit D, Lacayo CS, Bowman TG: University of Lynchburg, Lynchburg, VA; Idaho State University, Pocatello, ID; George Mason University, Fairfax, VA

Context: Early professional (EP) Athletic Trainers (ATs) may encounter adjustments and develop individual identities to master a new role, which can be difficult while transitioning from student to autonomous professional. Considering the increase in diversity movements, previous literature lacks content about the transition to practice of credentialed ATs who identify as Black, Indigenous, or People of Color (BIPOC). The purpose of this study was to explore the transition to practice of EP ATs identifying as BIPOC within the first 1-3 years post-graduation. **Methods:** In this qualitative study, 12 participants (10 females, 2 males, age=21.± 2.03 years) who self-identified as BIPOC, worked as full-time ATs, and passed their Board of Certification examination within the past 3 years volunteered to complete recorded virtual interviews via Zoom. We used an interview guide, which we validated by peer (n=1) and expert (n=3) review, to structure data collection sessions. Data saturation guided recruitment and we obtained theoretical redundancy after the final interview. We analyzed data with a phenomenological approach and used multianalyte triangulation (n=2) and peer review (n=2) as credibility strategies. **Results:** Findings suggest lingering effects of the COVID-19 pandemic on professional education. Participants felt they lacked sufficient skills and knowledge for professional practice due to online learning, limited hands-on learning experiences, and reduced clinical education opportunities. Therefore, they needed mentoring during the transition to integrate into the workspace. Specifically, participants noted a preference for racially concordant mentoring to facilitate talking to someone who can better understand BIPOC EPs' experiences. Every participant mentioned they were victims of microaggressions during either their

professional preparation, clinical education, or work environment because of their race, sex, or both. Those who chose to report the incidents felt a lack of support from work supervisors, faculty, peers, and preceptors. Participants felt deficient levels of emotional support from stakeholders when they disclosed challenges associated with their race, sex, or both. In this case, participants leaned on program directors, professors, preceptors, and supervisors. Therefore, participants felt that they needed to rely on outside support from friends and family as coping mechanisms. In addition, participants felt low financial support for their work as many practiced in settings where no AT had been employed previously. The perceived lack of support resulted in job hopping where participants believed they needed to change work settings to find a more supportive environment. Our participants perceived that their transition to practice was stressful compared to non-BIPOC EP ATs due to microaggressions encountered, lack of support (emotional and financial), and the need to job hop in order to find a work environment that fit their needs. **Conclusions:** BIPOC EP ATs require support and guidance as they transition to autonomous clinical practice, especially as they perceived limited learning opportunities due to the COVID-19 pandemic. Since our participants' educational experiences were marred by the pandemic, it is difficult to know if their experiences happened due to the pandemic, their characteristics, or a combination of both. Racially concordant mentoring networks can help BIPOC EP ATs connect with someone who can relate to the unique challenges racially diverse ATs face and facilitate persistence in the profession. Supervisors should create brave spaces where BIPOC EP ATs feel valued and supported, especially when they report instances of microaggressions. Training on justice, equity, diversity, and inclusion should be required for collaborative work environments in an effort to facilitate welcoming environments for all and reduce job hopping by BIPOC EP ATs.

Fellow sponsored by Tom Bowman, PhD, ATC.

Initial Symptom Burden Across Demographic Characteristics For Pediatric Patients Seen For Concussion In a Multidisciplinary Concussion Group

Johnson RS, Nilsson K, Pardue K, Gao Y, Rizvic N, Flint H: Boise State University, Boise, ID; Applied Research Division St. Luke's Health System, Boise, ID; St. Luke's Sports Medicine Concussion Clinic, Boise, ID

Context: Concussions can be disruptive to normal work, academic, social, and familial function, and many pediatric patients may have a protracted recovery. Initial symptom burden is a strong, consistent predictor of recovery time, making symptom assessment integral to understanding and managing concussion. Identifying specific demographic characteristics in pediatric patients that may present with greater initial symptoms could provide more guidance for those at greater risk of protracted recovery.

Methods: This retrospective study reviewed patient data from 1,762 patients between the ages of 6-18 years old seen at a local healthcare system between January 2013 – December 2019. A query was performed in Epic Electronic Medical Records including age, sex, highest level of education completed, mechanism of injury, managing provider specialty, and Rivermead Post-Concussion Symptom Questionnaire Scores (RPQ-3 [first 3 symptoms (0-12)]; RPQ-13 [remaining 13 symptoms (0-52)]). Participant mean age was 14.1±2.7 years old (6-12 years, n=405 [23%]; 13-18 years, n=1357 [77%]), and 44.2% (n=778) were female. Most concussions were sport-related (60.8%; n=1072). Participant education levels included some high school/GED (40.4%; n=712), middle school (37.3%; n=657), elementary school (15.9%; n=281), and associate degree/some college/technical certificate (1.6%; n=29). Almost 30% (n=522) of patients lived in a household with an annual family income of ≤\$63,798 (lower tertile≤\$63,798, middle tertile=\$63,798-82,171; higher tertile>\$82,171). MANOVAs were used

to compare RPQ-3 and RPQ-13 values between demographic variables at patients' initial visit. **Results:** There were significant differences for initial symptom presentation between groups for sex, age, education level, mechanism of injury, and provider specialty. Similar results and patterns were observed for RPQ-3 and RPQ-13 scores across demographic variables. Females (RPQ-3=5.4±2.9; RPQ-13=19.6±11.7) presented with significantly higher RPQ scores than males (RPQ-3=4.0±2.8; RPQ-13=14.3±11.1; p<0.01). Older patients presented with significantly higher RPQ scores than younger patients (ages 13-18 [RPQ-3=4.9±2.9; RPQ-13=17.5±11.6]; 6-12 [RPQ-3=3.9±2.9; RPQ-13=13.7±11.3], p<0.01). Patients with GED/high school/associate degree/technical school (RPQ-3=5.0±2.9; RPQ-13=18.5±11.9) presented with higher RPQ scores than elementary school (RPQ-3=4.2±3.0; RPQ-13=14.5±11.7) or middle school (RPQ-3=4.5±2.9; RPQ-13=15.7±11.2) education level groups (p<0.05). Patients with sport-related concussions (RPQ-3=4.3±2.8; RPQ-13=14.7±10.9) presented with lower RPQ scores than non-sport-related concussions (RPQ-3=5.3±3.0; RPQ-13=20.1±12.2; p<0.05). Patients who saw managing providers from sports and family medicine (RPQ-3=4.3±2.9; RPQ-13=14.4±10.8) presented with lower RPQ scores than those who saw occupational medicine and PM&R as their managing provider (RPQ-3=5.4±3.0; RPQ-13=21.8±11.9; p<0.05). There were no differences between family income groups (lower tertile [RPQ_3=4.8±3.0; RPQ13=17.2±12.3], middle tertile [RPQ-3=4.7±2.9; RPQ-13=17.1±11.4], higher tertile [RPQ-3=4.5±2.9; RPQ-13=17.1±11.4]; p>0.05). **Conclusions:** Females, older children, children with higher education levels, children with non-sport-related concussions, and children who saw occupational medicine and PM&R providers had higher RPQ scores at their initial visit. Understanding these demographic relationships to symptom burden can aid with resource allocation for concussion management and aid providers in giving patients evidence-based guidance on the possibility of having a protracted recovery.

Associations Between Gender, Race/Ethnicity and Healthcare Access and Utilization in Division I Collegiate Student-Athletes

Norcross MF, Johnson ST, Bovbjerg VE, Brown CN: Oregon State University, Corvallis, OR

Context: Systemic inequities exist within the United States healthcare system. Specifically, gender and race/ethnicity influence both healthcare access and the care received. Relatively few studies have assessed healthcare utilization using a lens of diversity, equity, and inclusion in collegiate sports medicine settings. Our purpose was to determine if gender and race/ethnicity are associated with student-athlete healthcare access and utilization. **Methods:** A descriptive epidemiology design was employed using data from the Pac-12 Conference's Health Analytics Program (HAP). HAP data is derived from clinical documentation entered into a common electronic medical record used by all conference members. Study data included de-identified demographic and injury/illness records from 798 female and 1,032 male student-athletes from the gender-comparable sports of basketball, baseball/softball, and cross-country/track who provided authorization for research between August 2016 – November 2021 and for whom race/ethnicity was reported. Injuries coded as "sport-related" were included as cases. The proportions of student-athletes that received athletic training (AT) and physician-level care for at least one sport-related injury at some point during the study period were calculated. For each case, we identified whether the injury resulted in a clinical encounter with physician-level care and if so, whether prescription medication or diagnostic imaging/testing was utilized. Associations between indicators of healthcare access and utilization and gender, race/ethnicity, and their intersection were assessed using χ^2 tests of association ($\alpha \leq 0.05$). **Results:** Of the 5,397 sport-related injuries, 2,828 (52%) were suffered by females and 2,569 (48%) by males.

Black and White student-athletes sustained 1,449 (27%) and 2,856 (53%) injuries, respectively. Due to relatively few injuries in each of the other race/ethnicity groups, the remaining 1,092 injuries (20%) were combined into a single Non-Black/Non-White category. Table 1 summarizes the proportions for each outcome measure stratified by gender and race/ethnicity. Females were more likely than males to have at least one sport-related injury that resulted in an AT (79% vs. 67%, $\chi^2=33.2$, $P<0.001$) or physician (56% vs. 44%, $\chi^2=23.6$, $P<0.001$) encounter, and to have a physician utilize diagnostic testing/imaging (56% vs. 47%, $\chi^2=17.1$, $P<0.001$). Overall, Black student-athletes were less likely than White student-athletes to have diagnostic testing/imaging for a sport-related injury (45% vs. 55%, $\chi^2=14.4$, $P<0.001$). However, when evaluated within gender, this association reached statistical significance for males (40% vs. 53%, $\chi^2=14.0$, $P<0.001$) but not females (51% vs. 57%, $\chi^2=5.9$, $P=0.052$). **Conclusions:** Female student-athletes were more likely to have accessed AT and physician services, which is consistent with healthcare utilization research in other settings. While no inequities in access to a physician or medication utilization were identified, diagnostic imaging/testing was utilized significantly less often for male and Black student-athletes. This may be due to differences in injury patterns and student-athlete race/ethnicity distributions among sports, but future work should evaluate whether these inequities persist when controlling for these factors.

Fellow sponsored by Cathleen N. Brown Crowell, ATC.

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Table 1. Frequencies (n), Proportions (%) and 95% Confidence Intervals (CI) for Indicators of Healthcare Access and Utilization Stratified by Gender and Race/Ethnicity

Student-athletes with at least one sport-related injury resulting in a(n)...		Females				Males				Females and Males Combined					
		<i>n</i>	%	95% CI		<i>n</i>	%	95% CI		<i>n</i>	%	95% CI			
Athletic Training encounter	Black	125	77.6%	70.4%	83.8%	Black	145	70.7%	64.0%	76.9%	Black	270	73.8%	68.9%	78.2%
	White	366	78.7%	74.7%	82.3%	White	421	65.6%	61.9%	69.3%	White	787	71.1%	68.3%	73.7%
	Non-B/W	139	80.8%	74.1%	86.4%	Non-B/W	123	66.5%	59.7%	73.2%	Non-B/W	262	73.4%	68.5%	77.9%
	All Females	630	78.9%	76.0%	81.7%	All Males	689	66.8%	63.8%	69.6%	Total	1319	72.1%	70.0%	74.1%
Physician encounter	Black	93	57.8%	49.7%	65.5%	Black	99	48.3%	41.3%	55.4%	Black	192	52.5%	47.2%	57.7%
	White	255	54.8%	50.2%	59.4%	White	276	43.0%	39.1%	46.9%	White	531	48.0%	45.0%	51.0%
	Non-B/W	96	55.8%	48.1%	63.4%	Non-B/W	81	43.8%	36.5%	51.3%	Non-B/W	177	49.6%	44.3%	54.9%
	All Females	444	55.6%	52.1%	59.1%	All Males	456	44.2%	41.1%	47.3%	Total	900	44.4%	42.1%	46.7%

Sport-related injuries resulting in a...		Females				Males				Females and Males Combined					
		<i>n</i>	%	95% CI		<i>n</i>	%	95% CI		<i>n</i>	%	95% CI			
Physician encounter	Black	279	37.6%	34.1%	41.2%	Black	293	41.4%	37.8%	45.2%	Black	572	39.5%	36.9%	42.0%
	White	587	39.1%	36.7%	41.7%	White	526	38.8%	36.2%	41.4%	White	1113	39.0%	37.2%	40.8%
	Non-B/W	214	36.5%	32.6%	40.6%	Non-B/W	221	43.7%	39.4%	48.1%	Non-B/W	435	39.8%	36.9%	42.8%
	All Females	1080	38.2%	36.4%	40.0%	All Males	1040	40.5%	38.6%	42.4%	Total	2120	39.3%	38.0%	40.6%

Sport-related injuries seen by a physician resulting in...		Females				Males				Females and Males Combined					
		<i>n</i>	%	95% CI		<i>n</i>	%	95% CI		<i>n</i>	%	95% CI			
Prescription medication	Black	42	15.1%	11.1%	19.8%	Black	48	16.4%	12.3%	21.1%	Black	90	15.7%	12.8%	19.0%
	White	78	13.3%	10.6%	16.3%	White	92	17.5%	14.2%	21.0%	White	170	15.3%	13.2%	17.5%
	Non-B/W	45	21.0%	15.8%	27.1%	Non-B/W	40	18.1%	13.0%	23.8%	Non-B/W	85	19.5%	15.8%	23.6%
	All Females	165	15.3%	13.1%	17.6%	All Males	180	17.3%	15.1%	19.7%	Total	345	16.3%	14.7%	17.9%
Diagnostic Imaging or testing	Black	143	51.3%	45.2%	57.3%	Black	116	39.6%	34.0%	45.4%	Black	259	45.3%	41.1%	49.5%
	White	333	56.7%	52.6%	60.8%	White	278	52.9%	48.6%	57.2%	White	611	54.9%	52.0%	57.8%
	Non-B/W	133	62.1%	55.3%	68.7%	Non-B/W	99	44.8%	38.2%	51.6%	Non-B/W	232	53.3%	48.6%	58.1%
	All Females	609	56.4%	53.4%	59.4%	All Males	493	47.4%	44.3%	50.5%	Total	1102	52.0%	49.9%	54.1%

Non-B/W: Race/Ethnicity reported as other than Black or White

Free Communications, Rapid Fire Presentations: Therapeutic Interventions for Lower Extremity Injuries

Saturday, June 24, 2023; 8:55 AM-9:50 AM; Room 234-236

Moderator: Jennifer Earl Boehm, PhD, LAT, ATC

A Diaphragmatic Breathing Intervention for Improving Diaphragm Contractility in Collegiate Soccer Players With a Lateral Ankle Sprain History

Mizumoto K, Terada M, Isaka T:
University of Kentucky, Lexington, KY,
and Ritsumeikan University, Kusatsu,
Shiga, Japan

Context: Recent studies found that breathing patterns and diaphragm contractility are altered in athletic populations with lateral ankle sprain (LAS). The proper ability of the diaphragm to contract and modulate intra-abdominal pressure is essential for postural stability. Our previous work has demonstrated that a diaphragmatic breathing (DB) intervention improves breathing patterns and dynamic postural control in individuals with a LAS history. In addition, diaphragm contractility changes significantly from supine to seated and standing positions as postural demands increase. To date, however, no research has investigated the effectiveness of the DB intervention in improving diaphragm contractility in different test positions in athletic populations with LAS. Therefore, the purpose of this study was to investigate the effect of the DB intervention on diaphragm contractility in athletes with a LAS history. **Methods:** Thirty-eight male collegiate soccer players with LAS history volunteered for this randomized-controlled trial

and were randomly assigned to a 6-week DB intervention (n=17; age=20.1±1.1yrs; height=176.5±7.0cm; mass=69.8±8.4kg) or control (n=21; age=20.5±1.2yrs; height=172.6 ±6.3cm; mass=66.7±5.9kg) group. The DB intervention group performed twelve 30-minute DB sessions over 6-weeks alongside their normal training. The control group continued their normal training. Diaphragm contractility of the right and left hemispheres was assessed before and after the 6-week intervention period using ultrasonography in supine, sitting, and standing positions. The transducer was positioned perpendicularly at the midaxillary line, over the intercostal space between the 8th and 9th ribs on both sides. Diaphragm thickness at the end of resting inspiration and expiration was measured and used to calculate diaphragm contractility. Two-way repeated ANOVAs with Bonferroni post hoc analyses were used to analyze the diaphragm contractility. A significance level of P<0.05 was set a priori. Cohen's d effect sizes using the pooled standard deviations were calculated, along with 95% confidence intervals (CI) for each pairwise comparison to determine the magnitude of difference in diaphragm contractility between independent variables. **Results:** A significant group-by-time interaction was found for the left-hemisphere diaphragm contractility in the supine (P<.001) and sitting (P<.001) positions, as well as for the right-hemisphere diaphragm contractility in the sitting (P=.018) and

standing (P=.002) positions. In the intervention group, diaphragm contractility of the left hemisphere was significantly higher at post-intervention testing compared to pre-intervention in supine (P<.001) and sitting (P<.001) positions. Diaphragm contractility of the right hemisphere was significantly higher at post-intervention testing compared to pre-intervention in the sitting (P=.022) and standing (P=.004) positions. No significant differences between the pre-intervention and post-intervention values in any outcome measures were found in the control group (P>.05) (Table 1). **Conclusions:** A 6-week DB intervention produced improvements in diaphragm contractility in any test positions in male collegiate soccer players with a LAS history. Implementing a 6-week DB program in athletes with a LAS history may be effective for improving diaphragm function.

This study was supported by the Japan Society for the Promotion of Science, Grant in Aid for Early-Career Scientists (#20K19433: Awarded to Terada M).

Table 1. Diaphragm Contractility (Means ± Standard Deviations) of the Right and Left Hemispheres within the Intervention and Control Group in Supine, Sitting, and Standing Positions.

		Left Diaphragm Hemisphere		Right Diaphragm Hemisphere	
		DB Intervention Group	Control Group	DB Intervention Group	Control Group
Supine	Pre-Intervention	16.42±12.40	18.94±14.03	21.16±18.29	16.77±21.28
	Post-Intervention	33.23±22.21	12.97±15.52	27.77±22.56	21.27±13.65
	P Value	<0.001	0.157	0.308	0.452
	Effect Size (95%CI)	0.93 (0.21, 1.62)	-0.40 (-1.01, 0.21)	0.32 (-0.36, 0.99)	-0.25 (-0.85, 0.36)
Sitting	Pre-Intervention	29.23±21.13	32.59±21.77	43.00±23.48	36.87±14.89
	Post-Intervention	60.27±34.80	23.23±24.40	56.66±27.00	31.31±16.69
	P Value	<0.001	0.149	0.022	0.299
	Effect Size (95%CI)	1.08 (0.34, 1.77)	-0.41 (-1.01, 0.21)	0.54 (-0.16, 1.21)	-0.35 (-0.95, 0.26)
Standing	Pre-Intervention	32.81±23.79	32.91±17.33	33.09±24.69	38.36±16.08
	Post-Intervention	47.43±32.58	32.97±19.60	55.30±27.84	28.21±20.07
	P Value	0.036	0.993	0.004	0.137
	Effect Size (95%CI)	0.51 (-0.18, 1.18)	0.00 (-0.60, 0.61)	0.84 (0.12, 1.52)	-0.56 (-1.16, 0.07)

DB: Diaphragmatic Breathing; 95% CI: Confidence Intervals

Is it Time to Change Directions in Return-to-Sport Testing After ACL Reconstruction?

Birchmeier TB, Baez SE, Collins K, Genoese F, Walaszcek MC, Kuenze CM: Michigan State University, East Lansing, MI; University of North Carolina, Chapel Hill, NC; University of Virginia, Charlottesville, VA

Context: Single leg hop limb symmetry (LSI $\geq 90\%$) is a commonly used metric to inform return to sport decisions following ACL reconstruction (ACLR). However, preplanned single leg hop assessments may not be representative of unplanned changes of direction (COD) in sport that result in ACL injury. Compared to healthy controls, individuals 9 months post-ACLR, perform unplanned COD with less knee flexion and greater vertical ground reaction force (vGRF), two biomechanical risk factors for ACL injury. Thus, preplanned, unidirectional assessments may not readily identify those at risk of a second ACL injury. Hence, it is necessary to assess whether knee biomechanics during unplanned COD differ between those who meet limb symmetry (LSI $\geq 90\%$) recommendations and those who do not. The purpose of this study was to compare ACLR limb peak knee flexion angle and peak vGRF during an unplanned crossover drop jump (uXDJ) in individuals with symmetrical (LSI $\geq 90\%$) and asymmetrical (LSI $< 90\%$) single leg hop distance. We hypothesized that the symmetrical group would exhibit greater knee flexion and lesser vGRF than the asymmetrical group. **Methods:** Nineteen participants (Female=10; age=19.2 \pm 4.2 years; months post-ACLR=6.6 \pm 0.8) completed 3 trials of the uXDJ on the ACLR limb. Biomechanical

data were collected using 3D motion capture and an embedded force plate. During the uXDJ, participants jumped on a single leg from a 30-cm box positioned 40 cm from the force plate then hopped at a 45° angle either away from or toward one of two light-emitting sensors, activated by a motion-sensitive trigger. Only trials in which the participant hopped in the direction opposite the working limb were reported. Participants completed 3 trials of the single (SH) and triple hop (TH). Hop distance (cm) was averaged across trials and normalized to leg length (cm). LSI was calculated by dividing the ACLR limb hop distance by that of the contralateral limb and multiplying by 100. Participants were classified as symmetrical if LSI was $\geq 90\%$ on both hop assessments. The Mann-Whitney U with effect sizes were used to assess differences between the symmetrical and asymmetrical groups in knee flexion (°) and vGRF normalized to body weight (xBW). We corrected for multiple comparisons by dividing the a-priori alpha-level $p \leq 0.05$ by the number of comparisons ($\alpha = 0.025$). **Results:** Between group comparison results are reported in Table 1. There were no between group differences in knee flexion or vGRF. **Conclusions:** Individuals with ACLR dichotomized based on single leg hop symmetry did not exhibit between group differences in unplanned COD knee biomechanics. Participants performed the uXDJ with less knee flexion and greater vGRF compared to previously published data in healthy individuals. Thus, unplanned COD assessment may be necessary to identify individuals at risk of a second ACL injury before returning to sport.

This project was supported by an NATA Research & Education Foundation Doctoral Student Grant (Award#1920DGP06).

Table 1. Between Group Comparison During an Unplanned Crossover Drop Jump

	Symmetrical Group	Asymmetrical Group	<i>p</i>	Effect Size
n	6	13		
Single Hop LSI	102.00% \pm 7.28%	80.40% \pm 9.35%		
Triple Hop LSI	98.40% \pm 3.53%	81.40% \pm 3.53%		
Knee Flexion (°)	48.70 \pm 13.69°	46.23 \pm 17.94°	0.32	0.31
vGRF (xBW)	3.92 \pm 0.39	3.45 \pm 0.48	0.04	0.62

LSI=limb symmetry index; vGRF=vertical ground reaction force; BW=body weight; effect size categories: < 0.3 =small; 0.3 - 0.5 =medium; > 0.5 =large

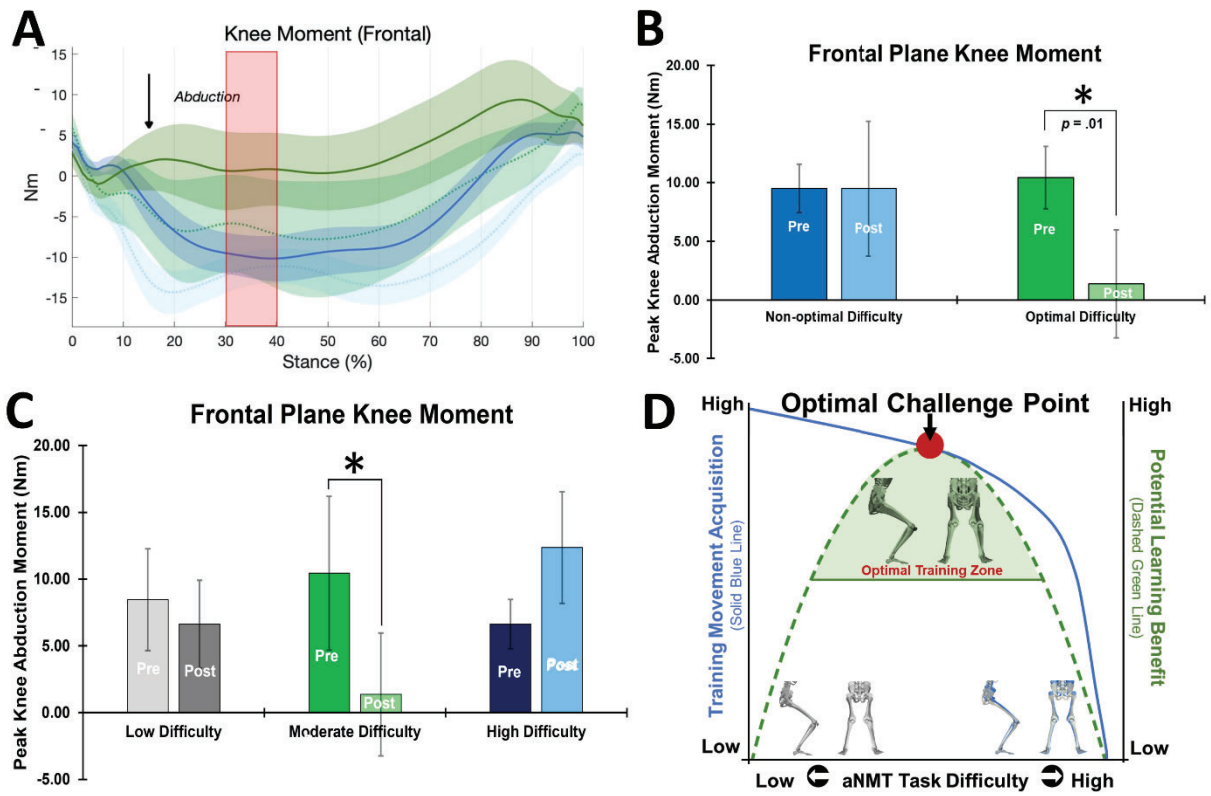
Real-Time Biofeedback Perceived as Moderately Difficult Maximizes Transfer of ACL Injury-Resistant Biomechanics

Hogg JA, Diekfuss JA, Myer GD:
Emory Sports Performance And
Research Center (SPARC), Flowery
Branch, GA, and University of Tennes-
see at Chattanooga, Chattanooga, TN

Context: The challenge point framework maintains that moderately difficult practice conditions are superior to high or low difficulty for the retention and transfer of motor skills. With the emergence of real-time visual biofeedback modalities to supplement traditional practice environments by guiding movement during neuromuscular training (NMT), an athlete's perceived difficulty when interacting with these emergent technologies is unknown. An informed application of the challenge point framework targeting self-reported biofeedback difficulty could optimize transfer of ACL injury-resistant biomechanics. The purpose of this study was to determine the influence of athletes' perceived difficulty interacting with real-time visual biofeedback on transferred injury-resistant landing biomechanics. **Methods:** Twenty-five high-school female soccer athletes (15.0 ± 1.5 years; 165.7 ± 5.9 cm; 59.4 ± 10.6 kg) completed six weeks of NMT augmented with real-time visual biofeedback (aNMT). The aNMT biofeedback involved participants completing a prescribed exercise (e.g., double leg squat) while interacting with an interactive visual stimulus displayed on a projector screen changing in real-time to correspond with athlete movements. Each week, participants self-reported their perceived difficulty of the biofeedback (7-point Likert; greater scores = greater perceived difficulty). Athletes were tertiled into one of three difficulty groups, determined by averaging weekly ratings: low ($n=8$; $1.31 \pm .63$), moderate ($n=9$;

$2.52 \pm .30$), or high ($n=8$; $3.35 \pm .34$). Athletes completed drop vertical jump testing pre and post training. Bilateral peak external knee abduction moment (pKAM) from 30% to 40% of stance phase was used as the outcome of interest. To test the challenge point hypothesis, low and high difficulty athletes' pKAM data were classified into a non-optimal difficulty group ($n=16$) and compared to the optimal difficulty group (moderate difficulty: $n=9$). A 2(group) \times 2(time; repeated) mixed ANOVA. Statistical significance was set at $p < .05$. **Results:** There was a significant main effect for time ($F(1.00,23.00)=4.75$, $p=.04$, partial $\eta^2=.17$) with all athletes demonstrating significant reductions in pKAM from pre ($9.84.65 \pm 11.91$ Nm) to post ($6.56 \text{ Nm} \pm 12.27$ Nm) training with aNMT biofeedback. The main effect for time was superseded by a significant group \times time interaction ($F(1.00,23.00)=4.70$, $p=.04$ partial $\eta^2=.17$). The optimal group significantly reduced pKAM from pre (10.43 ± 17.26 Nm) to post ($1.36 \text{ Nm} \pm 13.79$ Nm) aNMT ($t(8)=2.66$, $p=.01$, Cohen's $d=.58$), whereas changes in pKAM in the non-optimal group were not significant ($p > .05$) (Figure 1). **Conclusions:** These data support the challenge point framework and indicate that athletes who report moderate difficulty with real-time visual biofeedback during NMT is ideal for superior motor skill transfer, as opposed to reporting either too much ease or extreme difficulty. Clinicians and researchers may consider tailoring or 'adapting' experimental biofeedback to be appropriately challenging for each athlete (moderate difficulty). Reducing cumulative time dedicated to tasks perceived as either 'too easy' or 'too hard' may lend support for more efficient personalized training environments tailored for each athlete.

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The Impact of Supervised Rehabilitation and Re-Injury of Lateral Ankle Sprains on Health-Related Quality of Life in the General Population

Ohrnberger E, Kosik KB, McCann RS, Gribble PA: University of Kentucky, Lexington, KY, and Old Dominion University, Norfolk, VA

Context: There is an increased risk for re-injury throughout the first 12 months after an acute lateral ankle sprain (LAS). Prior research has demonstrated that those with ankle sprain history have decreased Health Related Quality of Life (HRQoL). Supervised rehabilitation after LAS is assumed to restore HRQL outcomes and minimize other long-term deficiencies, but supporting evidence is lacking. The purpose of this study is to determine the impact of supervised rehabilitation on HRQoL throughout the first 12-months post-injury. **Methods:** Fifty participants (M:18; F: 32; age: 21.56 \pm 9.21yrs; height:171.96 \pm 11.93cm; mass:74.82 \pm 17.88kg) volunteered to participate in a survey-based study after sustaining an acute LAS. Participants were enrolled within one week of the acute LAS occurring and did not have an associated fracture or surgery. From survey responses, participants were classified into two groups: those who self-reported they had participated in supervised physical rehabilitation with a health care professional (SUP; n=31), or those who did not (NoSUP; n=19). At the 12-month follow up, participants completed an online survey that included the Short Form-8 (SF-8) questionnaire and a question regarding if they have had a recurrent LAS in the past year on the same affected side. Ten participants reported an additional

LAS, and 40 participants reported no additional LAS. Independent sample t-tests were used to compare the SF-8 scores of General Health, Physical Component, and Mental Component between 1) SUP and NoSUP groups, and 2) those who did or did not report or an additional LAS within 12 months. Significance was set a priori at $p < 0.05$. **Results:** There were no significant differences between the SUP and NoSUP groups in General Health ($p = 0.31$), Physical Component ($p = 0.15$) or Mental Component ($p = 0.37$) scores. Those that reported an additional ankle sprain had significantly lower General Health (LAS:50.89 \pm 10.99; No LAS:58.29 \pm 7.22; $p < 0.01$) and Physical Component Scores (LAS:52.16 \pm 8.55; No LAS:56.41 \pm 4.96; $p = 0.02$); but there were no differences in Mental Component scores ($p = 0.28$) between the additional LAS and no additional LAS groups. **Conclusions:** Those with an additional LAS within 12 months of an acute injury report worse general health and physical HRQoL scores, but participation in supervised rehabilitation did not seem to affect SF-8 scores. A limitation of this study is that the researchers do not know the details of the rehabilitation plans that were implemented with those who completed supervised rehabilitation. It is possible that the standard of care with SUP may not have addressed HRQoL effectively. The 20% of individuals that sustained an additional ankle sprain by the 12-month follow-up were found to have worse HRQoL. Further research is needed to understand the role of formalized rehabilitation for LAS and how to optimize rehabilitation protocols to improve comprehensive outcomes.

Fellow sponsored by Phillip Gribble, PhD, ATC, FNATA.

The Effects of Transitioning Between Surface Types on Impact Loading During Running

Sebastian N, Garcia MC, Ford KR, Murray AM, Norte GE, Bazett-Jones DM: University of Toledo, Toledo, OH, and High Point University, High Point, NC

Context: Running on less stiff surfaces (e.g., dirt, grass) is thought to reduce impact loading (e.g., tibial acceleration, shock attenuation), but the evidence does not support this perception. Runners encounter multiple different surfaces while running however, there is limited research investigating transitioning between surfaces. The aim of our study was to investigate if impact loads change when transitioning between surfaces of different stiffnesses. We hypothesized that when transitioning from 1) pavement to grass, there would be a decrease in tibial acceleration and an increase in shock attenuation, and 2) grass to pavement, there would be an increase in tibial acceleration and a decrease in shock attenuation. **Methods:** We enrolled 15 long-distance runners ($F=8$, $M=7$, age= 30.7 ± 7.8 y, height= 1.72 ± 0.07 m, mass= 72.7 ± 13.0 kg, running experience= 11.4 ± 7.3 y). Participants ran over a 30 m runway that consisted of 15 m of grass and 15 m of pavement with a transition zone in the middle at a comfortable, self-selected speed (3.44 ± 0.40 m/s). Five successful trials were collected when transitioning from grass to pavement and five from pavement to grass. Triaxial IMUs were secured to the medial distal tibia and forehead. Resultant accelerations from the last step on the first surface and the initial

step on the second surface were calculated from triaxial accelerations. Shock attenuation was calculated by finding the difference between the tibia and forehead (0%=no shock attenuation, 100%=full shock attenuation). We performed two-way repeated measures ANOVAs with pairwise comparisons to compare tibial acceleration and shock attenuation among the surface (grass, pavement) and transition types (on, off). We set significance at $P < .05$ and calculated partial eta-square (η^2) effect sizes. **Results:** We observed a significant surface type by transition type interaction for shock attenuation ($P=.04$, $\eta^2=0.02$) where shock attenuation was greater when transitioning on grass compared to off grass ($P < .01$, Figure 1). We observed no significant interaction or main effects for tibial acceleration ($P=.20-.70$, $\eta^2 < .01$, Figure 1). **Conclusions:** Transitioning between pavement and grass did not influence tibial acceleration, similar to what has been observed during steady-state running on surfaces of different stiffnesses. However, shock attenuation was 3.8% greater when transitioning onto grass compared to off grass. Since grass is less stiff but more uneven than pavement, runners may adjust their leg stiffness when preparing to transition to a more uneven surface. Runners are encouraged to continue running on the surface they prefer as transitions between surface and surface stiffness do not appear to meaningfully influence impact loads. Future studies may want to investigate leg stiffness during surface transitions and continue investigating transitioning between surface types in different populations (e.g., injured runners, runners of different experience levels).

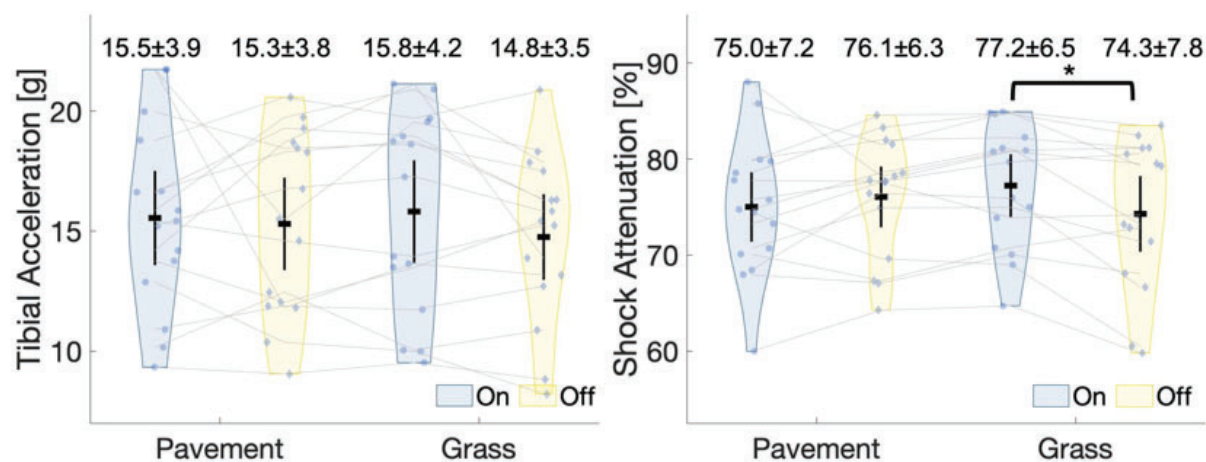


Figure 1. Comparison of tibial acceleration and shock attenuation when transitioning between different surfaces. “Off” indicates the surface the participant transitioned off from, “on” indicates the surface the participant transitioned onto. Each dot represents a participant.

*Statistically significant ($P < .05$).

Whole Body Vibration Improves Knee Kinetics During Landing in Those With ACL Reconstruction

Dewig DR, Lepley AS, Nilius A, Padua DA, Pietrosimone BG, Wikstrom EA, Blackburn JT: University of North Carolina at Chapel Hill, Chapel Hill, NC; Rockefeller Neuroscience Institute, West Virginia University, Morgantown, WV; University of Michigan, Ann Arbor, MI

Context: Secondary ACL injury is fairly common following ACL reconstruction (ACLR), occurring in up to 23% of patients. Aberrant landing biomechanics (e.g. larger internal adduction moments) have been suggested as contributors to ACL injury risk. Importantly, landing biomechanics are altered following ACLR (e.g. smaller sagittal plane knee moments) thus heightening the possibility of reinjury. Additionally, quadriceps dysfunction is a common consequence of ACL injury and influences landing biomechanics. Whole body vibration (WBV) has been demonstrated to improve quadriceps function and gait biomechanics in those with ACLR, but its influence on landing biomechanics is unknown. We hypothesized that an acute bout of WBV would improve landing biomechanics associated with secondary ACL injury risk. **Methods:** Thirty-six volunteers (27F, 9M) who were cleared to return to unrestricted physical activity following primary unilateral ACLR, but were no more than 5 years removed from surgery, were enrolled in this laboratory-based, repeated-measures crossover study. Participants were also required to possess quadriceps dysfunction (isometric quadriceps peak torque < 3x body mass) on the surgical limb. Participants completed two testing sessions separated by 1 week during which normalized peak knee moments (xBody Weight*Height) were assessed during single- and double-leg landing tasks before and following either a Control or WBV

intervention. Both tasks were performed from a 30 cm box located half the participant's height away from embedded force plates. Participants were instructed to "stick the landing" during single-leg landings and to jump as high as possible immediately upon landing during double-leg landings. The intervention consisted of 6 1-minute bouts of standing in a mini-squat position on a vibration platform while WBV (2g, 30Hz) or the Control (no vibration) intervention was applied. One-way repeated-measures ANCOVAs controlling for time post-ACLR and the "Pre-" value for each condition were conducted to compare change scores (Change=Post-intervention – Pre-intervention) for each outcome between the conditions. **Results:** The change in peak internal knee extension moment in the ACLR limb during double-leg landing was greater following WBV compared to Control (WBV= +0.003 95% CI[-0.001, 0.008], Control= -0.005 95% CI[-0.009, -0.001]; P=0.019). Additionally, the peak internal adduction moment in the uninvolved limb during single-leg landing was reduced following WBV compared to Control (WBV= -0.002 95% CI[-0.005, 0.001], Control= +0.002 95% CI[-0.001, 0.005]; P=0.039). There were no other significant condition effects for knee kinetics during either landing task (P = 0.053-0.973). **Conclusions:** WBV improved knee kinetics that are often altered post-ACLR and potentially related to ACL injury risk in both the ACLR and uninvolved limb. Secondary ACL injury is a prevalent concern in either knee following ACLR, thus evaluating novel modalities aimed at mitigating modifiable risk factors is imperative. Future research should focus on evaluating the repeated effects of WBV on long term outcomes post-ACLR.

Fellow sponsored by Troy Blackburn, PhD, ATC.

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Motor Unit Recruitment During Low Load Exercise With Blood Flow Restriction Therapy

Stephens SL, Hertel J, Saliba SA:
University of Virginia, Charlottesville,
VA

Context: Low-load exercise with blood flow restriction therapy (LL-BFRT) has been speculated to enhance muscle strength, size, and function by metabolically stimulating a greater number of motor units during exercise, despite a low production of mechanical tension. Unfortunately, this proposed mechanism of LL-BFRT has not been substantiated at the motor unit level. Therefore, the aim of this study was to compare motor unit recruitment (MUR) between LL-BFRT and low-load (LL) exercise without blood flow restriction in healthy adults. We hypothesized that LL-BFRT would increase MUR compared to standard LL exercise. **Methods:** Twenty-eight healthy, physically active adults (age=20.46±1.54years; sex=22 females, 6 males; height=164.19±9.88cm; mass=64.15±7.96kg) were recruited via convenience sampling and participated in this laboratory-based crossover study. The primary independent and dependent variables were the exercise condition (LL-BFRT vs. LL) and number of motor units recruited, respectively. Exercise conditions were completed in a randomized order on an isokinetic dynamometer. Both conditions consisted of 4 sets of isokinetic knee extension and flexion exercise (30x15x15x15 repetitions) at approximately 20% of the individual's peak knee extension and flexion torque and a single 30-second maximal isometric fatigue trial at 90-degrees of knee flexion. Thirty seconds of rest was provided following each set of exercise and 5-minutes of rest

was provided after the first condition. A pneumatic tourniquet cuff was inflated to 60% of an individual's limb occlusion pressure during the LL-BFRT condition. MUR was assessed at the distal one-third of the dominant limb's vastus lateralis using a Trigno Galileo EMG device (Delsys Inc., Natick, MA). Following data collection, raw EMG signals were processed and decomposed using NeuroMap software (Delsys Inc., Natick, MA). An accuracy threshold of ≥80% was set for all identified motor unit action potential waveforms. To control for the amount torque exerted during each exercise, the number of motor units recruited was divided by the average peak knee extension torque during each condition and set. Differences in MUR were examined using a 2 (condition) x 4 (set 1-4) repeated-measures ANOVA. A paired samples t-test was used to compare MUR during the isometric fatigue trial between conditions. Alpha was set a priori to 0.05. **Results:** A greater number of motor units were recruited during the LL-BFRT condition compared to the LL condition between conditions (Mean Difference [MD]=2.89, p=0.011), sets 1-4 (p < 0.001), and the isometric fatigue trial (MD=4.12, p < 0.001) when controlling for average knee extension torque (Figure 1). **Conclusions:** The inclusion of BFRT during LL knee extension and flexion exercise increased motor unit activation of the vastus lateralis in healthy adults compared to standard LL exercise. While these results support our hypothesis, and a potential benefit of LL-BFRT, additional research is warranted to further explore the underlying mechanisms associated with usage of LL-BFRT during patient care.

Fellow sponsored by Susan A. Saliba, PhD, ATC, FNATA.

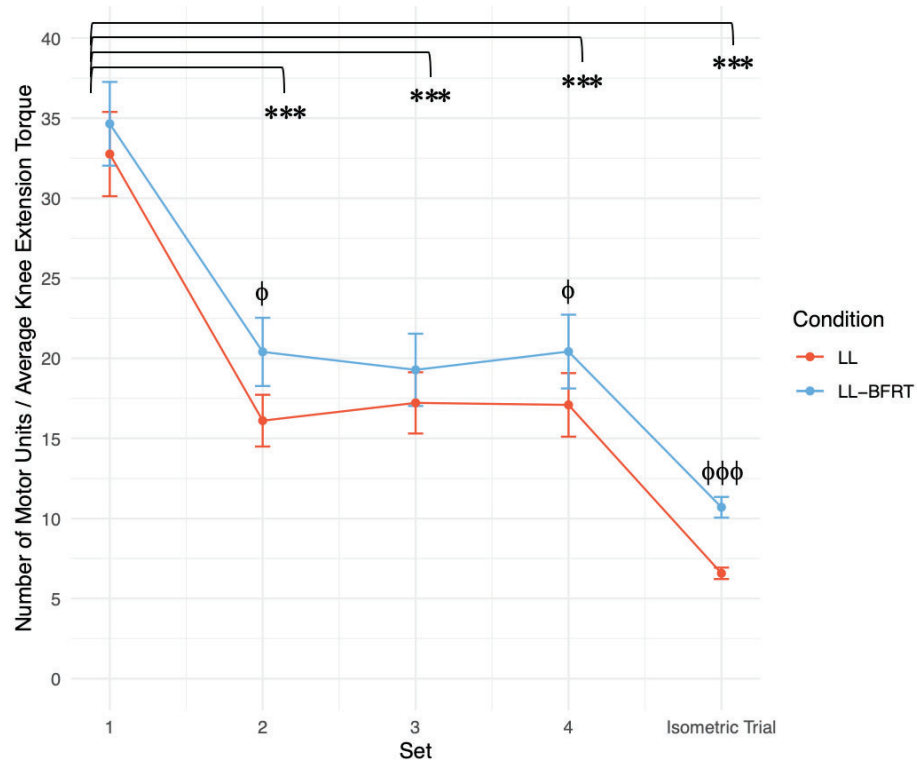


Figure 1. Motor unit recruitment by condition and set controlling for average knee extension torque. Significant differences between exercise conditions are represented as ϕ and $\phi\phi\phi$ for $p<0.05$ and $p<0.001$, respectively. Significant differences between exercise sets are represented as *** for $p<0.001$.

Free Communications, Rapid Fire Presentations: Care and Return-to-Activity of Lower Extremity Conditions

Saturday, June 24, 2023; 11:45 AM-12:40 PM; Room Entry 236

Moderator: Kimmery Migel, DPT, PT, OCS

A Case of Posterior Ankle Impingement In a Collegiate Level Soccer Player: Type 3 Case Study

Becker L, Stevenson P, Norkus SA:
Quinnipiac University, Hamden, CT,
and Yale University, New Haven, CT

Background: Posterolateral ankle impingement typically presents as pain on the posterolateral aspect of the ankle that worsens with plantar flexion and passive or active great toe flexion. Typically, the condition is caused by repetitive low-grade trauma into plantar flexion. This is a type 3 case study on posterolateral ankle impingement in a collegiate soccer player. **Patient:** The patient is a male collegiate soccer goalkeeper diagnosed with posterolateral ankle impingement. He initially complained of anterolateral ankle pain that moved into the posterolateral aspect of his leg during the fall season of 2020. The patient had an X-ray and MRI in 2020, at which time a peroneal resection was recommended. The patient also presented with Os trigonum. The patient underwent surgery in February of 2021 and completed rehabilitation that summer. The pain persisted, however, after being released. **Intervention & Treatment:** Mid-September of 2021, the patient briefly found pain relief in noxious stimulation. In October 2021, the team physician diagnosed the injury as posterolateral ankle impingement. Rehabilitation consisted of strengthening both the gluteus maximus and medius, eccentric biased calf exercises and manual strengthening of the ankle. The eccentric exercises and manual strengthening exercises were performed with silicon cups on the working muscles. Additionally, a custom tape job was designed like a talar sling in combination with a reverse Achilles to reduce any symptoms the patient may have been experiencing. The athlete was

also prescribed diclofenac by the team physician for pain and inflammation. **Outcomes or Other Comparisons:** Posterolateral ankle impingement is most common in dancers; however, we identified it in a soccer keeper as a result of excessive kicking. In 2018 about 27% of injuries from dance involved the ankle with over half of them being posterior ankle impingement syndrome or flexor hallucis longus tendinopathy (Rietveld et. al). The presence of Os trigonum may cause symptoms, however, the presence of the Os trigonum often remains asymptomatic. In October 2021, the athlete opted for conservative treatment rather than surgical intervention. The athlete continued to rehabilitate through the spring of 2022. In September of 2022, the athlete decided to pursue surgery post-season to pursue a professional career but will continue conservative treatment to play in the fall of 2022 season. **Conclusions:** This case of posterolateral ankle impingement presented with both anterolateral and posterolateral ankle pain and no pain with great toe flexion. Typically, there is no anterolateral ankle pain and there is also pain with passive and active great toe flexion. Treatment of previous cases typically included cortical steroid injections to continue play, whereas this case was treated with rehabilitation. There is no standardization to conservative treatment of posterolateral ankle impingement in athletes, so the rehabilitation was based on the patient's presentation. **Clinical Bottom Line:** Although not as common, posterolateral ankle impingement can occur in any athletic population, not just dancers. Through properly taping the ankle to decrease the symptoms and properly rehabilitating the injury, posterolateral ankle impingement can be treated conservatively to enable the athlete to continue play. It is important for clinicians to understand the extent of the injury and how best to rehabilitate it to decrease the symptoms.

Left Ankle Fracture Bimalleolar Equivalent and a Left Ankle Syndesmosis Disruption: Type 4 CASE Study

Lacy B: Marshall University,
Huntington, WV

Background: The patient is a male football player. At the time of the injury and treatment, the patient was 16 years of age. The patient had no medical history pertinent to this injury and treatment other than an allergy to amoxicillin. The athletic trainer who was involved in the immediate care of the patient reported that the mechanism of injury consisted of the patient's leg being fallen on by another football player during the game concurrent with an inversion roll. The athletic trainer also reported gross deformity and a distal pulse. Due to the gross deformity, the athletic trainer did not complete any special tests but splinted the patient and immediately referred the patient to a hospital. **Differential Diagnosis:** Deltoid ligament sprain, syndesmosis sprain, fibular fracture, tibial fracture, lateral malleolus fracture, medial malleolus fracture, ankle dislocation, talus fracture. **Intervention & Treatment:** Both pre- and postoperative diagnoses were a left ankle fracture bimalleolar equivalent and a left ankle syndesmosis disruption. The patient received X-rays at the ER in which the doctor found a pronation external rotation type of fracture with a Weber C fibular fracture. Also found was a fracture to the posterior medial malleolus which appears to be an avulsion. External rotation and posterior translation of the fibula in the ankle mortise were also discovered. The procedure completed by the physician was a left ankle fracture open reduction internal fixation and fixation of the syndesmosis. The physician utilized

an 8-hole one-third tubular plate over the lateral aspect of the fibula. Screws were then placed proximally and distally with the plate made into a hook shape which went around the tip of the lateral malleolus. The screws were also used to fixate the syndesmosis. The physician then used the TightRope device from Arthrex to reduce the syndesmosis. X-ray then showed concentric mortise. After the procedure, the patient was taken to the recovery room in stable condition and has had no known complications. **Uniqueness:** Tibial fractures are extremely rare in the pediatric age range making up less than 1% of all fractures. The pairing of syndesmosis sprains and tibial shaft fractures is also rare with an occurrence of 2-3%. Syndesmotoc sprains themselves have an incidence rate of 2.09%. Weber C fractures have been shown to compose 19% of ankle fractures so while not entirely unheard of, the patient's ankle fracture type is uncommon. The mechanism of this injury is uncommon in that Weber C fractures generally occur during an eversion ankle sprain. Predisposing factors were that the patient was male and had a high BMI. **Conclusions:** The athlete suffered a Weber C fracture, syndesmosis sprain, avulsion, fracture of the posterior medial malleolus, external rotation, and posterior translation of the fibula. The physician used open reduction techniques including a TightRope device to reduce the fracture and properly re-place the ankle mortise and syndesmosis. Clinical take-home messages include the need for proper splints and splinting skills, the importance of not immediately ruling out a certain type of injury solely because it is uncommon, understanding the correct place to which you ought to refer a patient and the importance of correct knowledge of the anatomical structures in the area being investigated.

When an Ankle Injury Isn't Just a Sprain
Gray PA: University of Kentucky,
Lexington, KY

Background: A 13 year-old male athlete with no history of injuries, was playing in a middle school football game when he was tackled while running the ball and the opposing player landed on his left foot. He had immediate pain in his ankle and was unable to walk after the incident. He described a sharp pain on the medial aspect of his ankle and had swelling over this area as well. Upon initial exam there was notable swelling over the medial ankle, without bruising. TTP over the tibiotalar joint, also over the deltoid ligament distribution and the ATFL distribution. ROM was limited in all planes and strength was also limited in all planes. Negative bump test, negative anterior drawer although this caused pain. Unable to ambulate. Sensation intact, distal pulses intact. **Differential Diagnosis:** Triplane Ankle Fracture, Deltoid ligament tear, Pilon Fracture, Tibial Fracture, Maisonneuve fracture, Juvenile Tillaux fracture, ATFL Sprain **Intervention & Treatment:** We were able to get the athlete seen by a Sports Medicine Physician the day following the injury. The physician was able to perform an exam with similar findings to the athletic trainer and sent the patient for a 3-view ankle X-ray and bilateral weight bearing X-rays of the ankle. Findings showed a Juvenile Tillaux fracture of the left distal tibial epiphysis and physis. The patient was recommended to be non-weight bearing and his case was discussed with a pediatric

orthopedic surgeon who recommended getting a CT scan as well. The CT scan confirmed the X-ray findings of Juvenile Tillaux Fracture. The athlete was placed in a cast for four weeks, then was transitioned to a walking boot for four weeks. Following this he was able to start physical therapy and return to football specific exercises at 12 weeks. **Uniqueness:** A Juvenile Tillaux fracture is a traumatic ankle injury in the pediatric population - a Salter-Harris III fracture of the anterolateral distal tibia epiphysis. This is usually seen in children that are nearing skeletal maturity, so in a slightly older age range around 12-14. This type of fracture is caused by an avulsion of the anterior inferior tibiofibular ligament. The typical mechanism of action for this injury is a supination-external rotation injury. Management depends on level of displacement, if there is less than 2mm of displacement it can be treated non-operatively, however if there are more than 2mm then it will need surgery. This is a very rare injury, accounting for only 3-5% of pediatric ankle fractures. **Conclusions:** The 13 year-old male, middle school football athlete had an in game injury to his left ankle. It was important that an athletic trainer was present even at this middle school event to provide an initial evaluation and get the athlete quickly in to see a Sports Medicine physician. This athlete had a difficult to diagnose ankle fracture at the growth plate that could have required surgery, making this a can't miss diagnosis. Growth plate injuries are common in this patient population and its important to be able to distinguish between a possible fracture and an ankle sprain.

**Multi-Ligament Knee Reconstruction
Revision to Optimize Patient Outcomes**
McMillan CM, Martin BM, Vidal AF:
The Steadman Clinic, Vail, CO, and
The Steadman Philippon Research
Institute, Vail, CO

Background: Multiligament knee injuries (MLKI) include a spectrum of knee pathologies and often occur because of knee dislocations, often disrupting > 3 ligaments, including ACL, PCL, and posterolateral corner (PLC). Knee dislocations are uncommon pathologies and are estimated to only account for 0.02% of all orthopedic injuries. MLKIs are anatomically heterogeneous and lack consensus recommending timing of surgical intervention, and post-operative rehabilitation. The patient's post-operative rehabilitation progression must protect repaired structures; however, overly conservative recommendations may lead to arthrofibrosis.⁵ Barfield et al. published a literature review in 2015 summarizing the surgical interventions and outcomes of MLKI.³ They concluded that there is insufficient evidence to suggest specific surgical techniques for acute versus staged intervention. This type-1 CASE study reviews the surgical management of an MLKI requiring revision surgery to address recurrent instability and stiffness. **Patient:** A 32-year-old active female presented for 3rd opinion for recurrent left knee pain, stiffness, and multidirectional instability (MDI). Pertinent previous history included a traumatic knee dislocation from skiing. Initial surgical intervention 2-weeks after injury consisted of ACL reconstruction with bone-tendon-bone allograft, MCL repair with internal brace, medial meniscus repair, and PCL reconstruction with allograft. Post-operative rehabilitation included 2-weeks of immobilization and 6-weeks of NWB. Nine-weeks post-op, patient presented

with 40° knee flexion and lacked 5° extension and underwent manipulation under anesthesia with lysis of adhesions (LOA). The patient subsequently achieved 0° of knee extension and 128° of knee flexion. Soon after, patient reported frequent knee instability, increased pain, and weakness. Physical examination confirmed MDI. MRI conducted 5-months status-post revealed deficient ACL and MCL, lateral posterior horn root tear, tibial plateau cartilage lesion, and synovitis. **Intervention & Treatment:** Patient consented to staged revision surgery to address the recurrent instability and stiffness. The first stage involved arthroscopic LOA, bone grafting, hardware, and internal brace removal, and MACI biopsy. Twelve-weeks elapsed to allow bone graft healing. A successful second stage involving revision ACL reconstruction with quad tendon autograft, MCL reconstruction using allograft, and novel MACI implant resurfacing the tibial plateau lesion. Continuous passive motion (CPM) started day 1 post-surgery beginning at 0-30° of flexion. CPM was advised TID increasing ROM for 28 days achieving 130° of flexion. Patient was NWB for 2-weeks and toe-touch weight-bearing weeks 2-6. **Outcomes or Other Comparisons:** The patient underwent successful revision surgery restoring static stability to the knee joint. Barfield et al. reported current lack of consensus on definite treatment recommendations likely due to heterogeneity and infrequency of MLKI injury profile. The primary acute surgical intervention failed in this case, and a staged revision was needed. Primary surgical techniques are controversial, no conclusive outcomes have been reported. The authors believe that physician experience plays a role in the outcomes of these complex cases. This case highlights the importance of early ROM to prevent knee arthrofibrosis. Limited preoperative ROM may lead to higher rate of arthrofibrosis. The initial conservative ROM

for the patient's primary surgery was likely to protect the PCL reconstruction. Post-operative ROM may successfully be achieved with use of CPM device, protecting the graft. **Conclusions:** Knee stiffness and instability post-surgery can be multifactorial. Optimal treatment of these complex MLKI remains controversial. This case represents the importance of early ROM and proper surgical planning. A multidisciplinary approach is imperative to ensuring optimal patient outcomes. Athletic trainers play an integral part in the multidisciplinary patient care team and may contribute to pre-and post-operative management to ensure optimal patient outcomes. **Clinical Bottom Line:** Evolving surgical approaches and techniques, heterogeneity of injuries, acute vs staged surgical intervention, and associated post-operative rehabilitation remains a topic of debate in treatment of MLKI. A patient-specific multidisciplinary approach in the medical decision-making process may help improve patient outcomes and reduce risk of poor outcomes.

**Indirect Inferior Patellar Pole
Transverse Fracture in a Male Collegiate
Basketball Athlete: A Case Report**
Freer SM, Rendeiro D: Palmer Trinity
School, Miami, FL, and Fort Hood,
Fort Hood, TX

Background: A male collegiate basketball athlete, 18 years old, felt pain in his right knee when jumping for a rebound. Able to ambulate on his own immediately afterward, the athlete was evaluated off the court. His right knee exhibited point tenderness on the anterior-medial aspect of the knee, medial joint line, and proximal patellar tendon. He had near full active and passive range of motion of his knee. Graded manual muscle testing of the quadriceps (3/5), hamstrings (4/5) were performed. The Lachman, anterior drawer, and pivot shift tests were negative for laxity and pain; however, the McMurray's and Steinman's tests were positive for anterior knee pain. The athlete did not return to play on the day of injury. Following the game, the athlete received conservative treatment including ice, electrostimulation, and a compression wrap. The athlete demonstrated the ability to walk independently without significant gait deviation. He returned to the athletic training room within 48 hours to follow up with a noticeable antalgic gait and reported having difficulty with walking and weightbearing. He was unable to actively contract his quadriceps or perform a straight leg raise, and had limited active and passive flexion of his knee. There was minimal swelling and tenderness on palpation of the inferior pole of his patella and proximal patellar tendon. The examiner deferred special tests given the lack of range of motion, as well as the presence of swelling and pain. Girth measurements were compared bilaterally revealing approximately a 2-centimeter increase on the affected side. The athlete was referred to an orthopedic physician for further evaluation and radiological tests. Radiographs revealed a

transverse fracture of the right inferior patellar pole. Magnetic Resonance Imaging (MRI) confirmed a 2-to-3-millimeter gap at the fracture site. **Differential Diagnosis:** Inferior patellar avulsion fracture, patellar tendon tear **Intervention & Treatment:** The surgical plan of care consisted of open reduction and internal fixation of the fractured patella. Given the location of the fracture, a tension band technique was unable to be performed. Therefore, the patella was surgically repaired as an avulsion fracture. Physical therapy followed surgical intervention. **Uniqueness:** The patella, the largest sesamoid bone in the human body, adds to the efficacy of the quadriceps contraction by increasing the moment arm from the center of the knee. Given this function, the patellar-femoral joint is subjected to large compressive forces as well the patella is subject to high tensile forces during quadriceps contractions. The combination of these compressive and tensile forces has implications for both mechanism(s) of injury and methods of treatment, for athletic populations. Fractures of the patella account for approximately 1% of all skeletal injuries, and occur more frequently in patients who are 40 to 50 years old. It is safe to assume that with a fracture of the patella, deviation from normal gait and range of motion is evident. On the contrary, the athlete in this case was able to ambulate on his own and demonstrated near full active and passive range of motion initially after injury. **Conclusions:** The indirect mechanism of injury to the athlete in this case report is consistent with other such injuries reported in the literature. Uniquely, the athlete had near full range of motion and was able to walk without significant deviation immediately following his injury. Yet 48 hours later, the athlete was unable to actively contract the quadriceps or lift his leg, and had difficulty bearing weight. Surgical intervention was performed followed by physical therapy. The athlete resumed full athletic participation the next basketball season without any complications.

**Development of an Eating Disorder
After Anterior Cruciate Ligament
Rupture and Reconstruction Surgery:
A Type 3 CASE Study**

Perrero EA, Meyer CM, Hand
AF: University of South Carolina,
Columbia, SC

Background: This case study highlights how one injury exacerbated the onset of a diagnosed eating disorder (ED), illustrating the importance of approaching healthcare from the International Classification of Functioning, Disability and Health (ICF) model to encompass all aspects of a patient's life and well-being. **Patient:** The patient is a 14-year-old competitive cheerleader and sprinter. Her past medical history includes bilateral Osgood-Schlatter's Disease 12 years ago and bilateral medial tibial stress syndrome that has persisted for 11 years. She had no previous evaluation or diagnosis of mental health conditions. Upon initial evaluation, the patient stated she ruptured her anterior cruciate ligament (ACL) during a tumbling pass at cheerleading practice. In the months following ACL reconstruction, the patient experienced significant weight and muscle loss despite best efforts to exceed progression expectations. During a rehabilitation session with the athletic trainer (AT), the patient expressed concerns of constant numbness located along her right tibia and foot and the inability to dorsiflex upon ambulation. After a week with no resolution, the AT referred to a sports medicine physician for possible foot drop. Upon exam, the physician was concerned about eating disorder (ED) signs and symptoms (rapid decline in body weight and muscle mass, low body temperature and blood pressure, brittle nails, baggy clothes, dressing in multiple layers). **Intervention & Treatment:** The patient was referred to a dietician and therapist and encouraged to establish consistent visits, ultimately attending both sessions weekly. She continued rehabilitation sessions for her ACL reconstruction but was not cleared for cardiovascular activity. Her AT concentrated on increasing lower extremity and core strength 2-3 times a week, while the patient participated in

pre-season track conditioning and cheer practices training upper body and core an additional 3 times per week. The patient followed up with the primary care physician (PCP) to complete an echocardiogram and lab work. She began seeing her PCP approximately once a month to oversee the care plan. Treatment goals focused on weight restoration, prevention of further ED symptoms, and return to activity. **Outcomes or Other Comparisons:** According to the ACL rehabilitation protocol, typical patients would have progressed more quickly in their goals than this patient's timeline, specifically increasing quadriceps control, muscle bulk and tone, and sport-specific movements. This patient was unable to begin progressions along the usual timeline due to concerns with energy expenditure and significant decreases in weight and muscle mass later recognized as ED signs and symptoms. **Conclusions:** Due to the patient's ED diagnosis, she was unable to begin the typical return-to-play (RTP) protocol until 9 months post-operation, rather than the predicted 6 months. If there was no intervention regarding her ED symptoms, the development of ED likely would have been more prolonged and extensive treatment could have been required. This case highlights underlying complications that affected a multitude of aspects in her daily life. It is also important to note that the patient's delay in RTP was not due to the diagnosis of an ACL tear, but her progression of ED. **Clinical Bottom Line:** EDs are complex illnesses. It is crucial to develop relationships with patients to notice behavioral, emotional, and physical changes that could indicate the presence of an underlying condition. Utilizing specialized resources and a multi-person healthcare team can help ensure your patients are receiving the best care for their overall well-being. Though this case highlights how one condition amplified the onset of another, it is crucial to consider other factors such as family, social, and school likely influenced the beliefs and actions that led to the diagnosis of an ED. The patient tearing her ACL contributed to her thoughts and behaviors that presented as an ED, but these also delayed her recovery from her ACL tear.

Proximal Tibiofibular Synostosis in a Female Soccer Athlete

Roth A, Bortz C, Wilkenfeld DA:
Moravian University, Bethlehem, PA,
and Muhlenberg College, Allentown,
PA

Background: Osteochondromas are the most prevalent benign bone tumor, occurring mostly in the long bones of the leg, thigh and arm. Representing 20-50% of benign tumors, osteochondromas are rarely symptomatic. Most symptomatic cases are linked to posttraumatic conditions or idiopathic causes. Although conservative management is recommended, surgical removal may be necessary for recalcitrant cases. Type 3 clinical CASE study. **Patient:** Patient is a 20-year-old female Division-3 soccer player who presented to her AT complaining of insidious onset right posterolateral knee pain. Past medical history of a right medial malleolus fracture, multiple ipsilateral inversion ankle sprains, bilateral medial tibial stress syndrome, and polycystic ovary syndrome. Patient was point tender over anterior tibialis and fibularis muscles, reported pain with active dorsiflexion and inversion, passive eversion, and pain without weakness during anterior tibialis and fibularis tertius MMT. Differential diagnoses included fibularis strain and anterior tibialis strain. After initial treatments failed, she was referred to the team physician 2-months after onset. Radiographs revealed increased bone density at the fibular head, indicative of a healing fracture. MRI confirmed diagnosis of a fibular head stress

fracture. Patient was placed NWB in a walking boot for 8-weeks and began a rehabilitation program with her AT focused on pain modulation and general ankle and hip strengthening. Due to persistent pain, a CT scan and second MRI were ordered 7-months after initial onset. CT revealed a proximal tibiofibular synostosis secondary to an osteochondroma. **Intervention & Treatment:** Patient was given a tall walking boot to wear PRN and resumed rehabilitation as previously described. A cortisone injection within the interosseous space was administered 8-months after initial onset, however her pain persisted. 2-months later she underwent a resection of the osteochondroma and neuroplasty of the common fibular nerve. Although outcomes for this type of surgery are generally positive, postoperatively the patient reported posterolateral knee pain and radiating pain into her foot despite continued therapeutic interventions including nerve desensitization therapy. 4-months postoperatively she developed a foot drop and has since failed to make a full RTP. **Outcomes or Other Comparisons:** In this case, the patient continued experiencing pain and developed foot drop postoperatively. Although fibular nerve lesions and symptomatic osteoarthritis are reported complications of surgery, resection of the fibular head is a commonly performed surgical technique for symptomatic proximal tibiofibular synostosis. Most of the previously documented cases are idiopathic, with no real causal events in the patients' medical history. Repetitive microtrauma is thought to be a possible mechanism for proximal tibiofibular synostosis in patients who do not report specific trauma, such

as this case. **Conclusions:** This case report presents the treatment of a proximal tibiofibular synostosis caused by an osteochondroma in a female soccer player. When symptomatic, the clinical presentation of osteochondromas may differ greatly, making accurate diagnosis difficult. As was the case with this patient, common symptoms include knee pain and pain with ankle dorsiflexion. Although diagnosis can be made through radiographs, this case highlights limitations of this imaging modality. CT or MRI are recommended for making a definitive diagnosis and for determining whether surgical intervention is necessary. Conservative treatment is recommended for patients with few symptoms, but surgical intervention is recommended when conservative treatment fails. The most common procedures include excision of the synostosis, arthrodesis of the proximal tibiofibular joint, and resection of the fibular head. **Clinical Bottom Line:** While proximal tibiofibular synostosis caused by an osteochondroma is uncommon, clinicians should be aware of the potential causes, common clinical presentation, and diagnostic imaging required to make a definitive diagnosis. Often mistaken for muscle strains or sequelae of lateral ankle sprains, osteochondromas of the proximal tibia and fibula should be considered as a differential diagnosis in patients presenting with posterolateral knee or ankle pain.

Novel Intervention for a Fibular Head Dislocation in a Collegiate Soccer Athlete: Type 4 Clinical Case Study
Solger E, Geist D, Nguyen A: West Virginia University, Morgantown, WV

Background: A 21-year-old, male, college soccer athlete with no major medical history, injured his proximal tibiofibular joint while attempting to slide tackle during a training session. The mechanism of injury was described as an externally rotated fixed foot, combined with dorsiflexion and full knee flexion. The chief complaint was lateral knee and medial ankle pain. Initial examination revealed an obvious deformity over the proximal aspect of his fibula, no ecchymosis, and no swelling. Both knee and ankle range of motion were restricted due to pain. Patient was point tender over the fibular head and medial ankle. Initial numbness and tingling were appreciated but subsided within a few minutes. Patient denied any cold sensations in his foot or toes. Capillary refill and dorsal pedis pulse were present bilaterally. While fibular head dislocations are rare, there are no evidence-based rehabilitation protocols specific to this injury. This case study presents the case of a fibular head dislocation and a rehabilitation protocol with the patient returning to full activity in 7 weeks. **Differential Diagnosis:** Fibular fracture, fibular dislocation, medial ankle sprain, ankle syndesmosis sprain. **Intervention & Treatment:** The patient was placed in a walking boot and used crutches for ambulation. Initial treatment involved radiographs to rule out fibular fracture. Radiographs were negative for a fibular fracture but identified a fibular head dislocation. The dislocation was reduced in the emergency department by

the team physician. Upon relocation, pain was significantly reduced. There was no apparent injury to common peroneal nerve upon relocation. The patient was placed in a straight knee immobilizer, walking boot, and crutches for ambulation and instructed to be non-weightbearing for 1 week. The continued treatment plan included pain management including cryotherapy, application of compression with horseshoe pad, cold compression system, contrast bath, warm water immersion, and blood flow restriction rehabilitation. After 1 week, the knee immobilizer was replaced with a hinged knee brace with a 90-degree flexion stop. Patient was permitted to toe-touch-weight bear with crutches and a walking boot. The patient progressed with gait retraining using an underwater treadmill and/or anti-gravity treadmill with no exacerbation of symptoms. After 2 weeks, the hinged knee brace, walking boot, and crutches were discontinued, and the treatment plan included progression to achieve full knee flexion as tolerated and normal gait patterns. The patient began jogging in an underwater treadmill after 2 weeks with no issues. Three weeks post-injury, both knee and ankle ranges of motion returned to normal limits and manual muscle testing revealed 5/5. The patient was able to perform a double leg and single leg calf raise with no issues or complaints. The patient began functional activities on the field at 4 weeks post-injury and progressed to full training status. During the two-week progression back to full training, external loads (acceleration, deceleration, top speed, sprint distance, intensity), via a wearable GPS tracking device, were monitored and compared to pre-injury load to assist in return to sport decisions, along with patient feedback. The patient returned to sport, with no restrictions or complaints, at 7

weeks post-injury. **Uniqueness:** The prevalence of fibular head dislocations is less than 1% of all knee injuries. Due to the low rate of injury, evidence-based rehabilitation protocols are not available to help guide clinicians when providing interventions. **Conclusions:** Fibular head dislocation injuries present themselves in a manner which makes accurate determination of the extent and severity of the injury difficult to establish from the clinical examination alone. Accurate diagnosis may require radiographs to rule out fracture if suspected. Return to participation for fibular head dislocation cases may require more than 6 weeks to return to pre-injury participation levels.

Hamstrings Strength and Morphological Adaptations to a 4-Week Eccentric Exercise Protocol in Individuals With ACL Reconstruction: A Preliminary Case Series

Norte GE, Murray AM, Sherman DA, Rush JL, Glaviano NR: University of Toledo, Toledo, OH; Live4 Physical Therapy and Wellness, Acton, MA; Boston University, Boston, MA; Harvard University, Cambridge, MA; University of Connecticut, Storrs, CT

Context: Individuals with ACL reconstruction via hamstrings tendon autograft (ACLR-HT) exhibit deficits in hamstrings muscle volumes, which may perpetuate knee flexor weakness years after surgery. Such impairments also contribute to perceptions of knee instability, aberrant joint loading, and higher rates of second ACL injury compared to those with alternative graft sources. Eccentric exercise can improve hamstrings strength and muscle volumes in uninjured individuals, yet the translation of these findings to those with ACLR-HT are unclear. Our purpose was to investigate the effects of a Nordic Hamstring Exercise (NHE) protocol on eccentric strength and muscle volumes in this population. We hypothesized that strength would improve over the duration and that muscle volumes would be greater upon completion of the intervention. **Methods:** Seven individuals (3F, age: 22.0 ± 2.3 years, height: 173.8 ± 12.5 cm, mass: 85.6 ± 24.6 kg, time from surgery: 53.6 ± 29.5 months, Tegner Activity Scale: 6.7 ± 0.8) with primary, unilateral ACLR-HT participated in this case series. MRI-derived hamstrings muscle volumes were quantified before and after a standardized, progressive 4-week NHE protocol (10 supervised sessions, 26 sets, and 206 repetitions) performed in a research laboratory as part of a larger clinical trial. Average peak eccentric hamstrings force

(N) was quantified from all repetitions completed during each session using a NordBord device. Individual and total muscle volumes of the injured limb were obtained via 1.5 Tesla MRI spanning iliac crest to tibial tuberosity. Data processing was automated and muscle volumes were normalized to the product of mass and height ($\text{cm}^3/\text{kg} \cdot \text{m}$). Paired t-tests were used to compare outcomes before and after the intervention ($\alpha=.05$). Percentage change scores ($\Delta\%$) and Cohen's d effect sizes were calculated for descriptive purposes. A global rating of change (GROC, -7-to-7), rating of perceived exertion (RPE, 6-20), and volume of exercise completed are reported descriptively. **Results:** Strength and volumetric outcomes are reported in Figure 1 for each participant. Average peak eccentric hamstrings force increased throughout the intervention (242.3 ± 44.2 to 298.1 ± 62.2 N, $\Delta 22.7\%$, $p=.002$, $d=1.0$). Biceps femoris short head volume increased upon completion of the intervention (0.64 ± 0.09 to 0.69 ± 0.07 $\text{cm}^3/\text{kg} \cdot \text{m}$, $\Delta 7.2\%$, $p=.039$, $d=0.5$). Total hamstrings ($p=.128$, $d=0.3$), biceps femoris long head ($p=.112$, $d=0.3$), semimembranosus ($p=.851$, $d=0.0$), and semitendinosus ($p=.220$, $d=0.1$) did not statistically change. All participants completed 100% of the protocol with a mean RPE of 12.6 ± 2.7 across all sessions, and reported a mean GROC in knee function of 4.3 (range: 2-6). **Conclusions:** Individuals with ACLR-HT demonstrated a large magnitude improvement in eccentric hamstrings strength over the duration of a 4-week NHE protocol. Although a moderate increase in biceps femoris short head volume was observed, medial hamstrings volumes did not change at the group level, which challenges previous reports in uninjured populations. The individualized nature of volumetric responses to NHE suggest a need for responder analyses in future clinical trials.

This study was funded by the Great Lakes Athletic Trainers' Association.

Free Communications, Rapid Fire Presentations: Recovery and Beyond: Patient Outcomes After Concussion

Saturday, June 24, 2023; 10:20 AM-11:15 AM; Room Entry 239

Moderator: Thomas Bowman, PhD, ATC

Sleep Duration is Associated With Recovery Time After Concussion in United States Military Service Academy Cadets and Midshipmen

Malvasi SR, Aderman MJ, Roach MH, Ross JD, Svoboda SJ, Robb J, McGinty G, Jackson J, Campbell D, Estevez CA, Brodeur RM, VanPelt K, Sumarski A, Broglio SP, McCrema MA, McAllister T, Pasquina PF, Cameron KL: Keller Army Hospital, West Point, NY; DoD-VA Extremity Trauma and Amputation Center of Excellence, Research & Surveillance Division, Fort Bragg, NC and Womack Army Medical Center, Department of Clinical Investigation, Fort Bragg, NC; United States Air Force Academy, CO; United States Coast Guard Academy, New London, CT; Synaptex LLC, Lexington, KY; United States Naval Academy, Annapolis, MD; University of Michigan Concussion Center, Ann Arbor, MI; Medical College of Wisconsin, Milwaukee, WI; Indiana University School of Medicine, Indianapolis, IN

Context: Patients may experience cognitive, emotional, and sleep-related symptoms post-concussion. Sleep-related symptoms, including sleep disturbances, may delay recovery. Therefore, the purpose of this investigation was to examine the association between sleep duration and recovery time post-concussion in military service academy cadets and midshipmen.

Methods: A prospective cohort study was conducted among participants enrolled in the Concussion Assessment, Research and Education (CARE) Consortium at four U.S. Service Academies. All CARE participants report standardized demographics which included site, sex, varsity sport status and concussion history at baseline. Participants who sustained

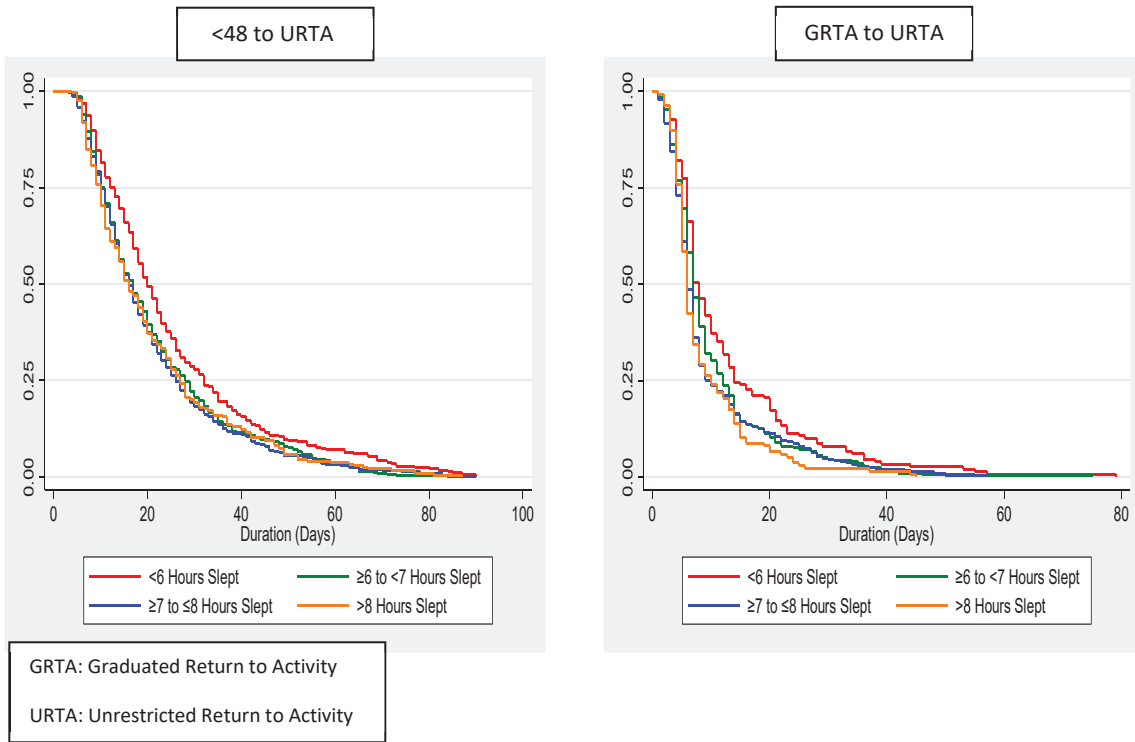
a concussion were evaluated at standardized post-injury time points. Sleep duration the night before assessment was self-reported on the Sport Concussion Assessment Tool (SCAT) within 48 hours of injury (<48) and at the initiation of a graduated return to activity (GRTA) protocol. Time elapsed, in days, from initial injury to unrestricted return to activity (URTA) was also recorded. The primary outcome of interest was recovery time. We examined the association between sleep duration recorded <48 hours post-injury and time to URTA. Additionally, we examined the association between sleep duration recorded at the initiation of the GRTA protocol and time to URTA. Participants were divided into quartiles based on sleep duration (<6 hours, ≥6 to <7 hours, ≥7 to ≤8 hours, and >8 hours) recorded at each time point. Kaplan-Meier survival estimates were calculated for time to URTA. Univariate and multivariable Cox proportional-hazards regression models were used to estimate hazard ratios (HR) and 95% confidence intervals (95%CI) for sleep as a continuous variable and by sleep quartile. Multivariable models controlled for site, varsity status, sex, and concussion history. **Results:** During the study period, 1,403 participants (39% female, 19.5±1.5y, 175.0±14.6cm, 73.9±15.0kg) sustained a concussion. For each additional hour of sleep reported within 48 hours of injury, participants were cleared for URTA 4% faster (HR=1.04, 95%CI: 1.02-1.07, p=0.002). Those in the lowest quartile for sleep duration (<6 hours) took significantly longer (25%-31%) to reach URTA when compared to those in the upper three quartiles (Figure 1). Similar to the <48 hour model, for each additional hour of sleep reported at the initiation of the GRTA protocol, participants were cleared for URTA 10% faster (HR=1.10, 95%CI: 1.05-1.14, p<0.001). Similarly, those in the lowest quartile for sleep duration (<6 hours) took significantly longer (23%-48%) to reach URTA compared to those in the upper three quartiles (Figure 1). Comparable results were observed in multivariable models. **Conclusions:** Sleep

duration recorded within 48-hours of injury and upon initiation of the GRTA protocol was associated with recovery time post-concussion. Participants who reported <6 hours of sleep at both time points took significantly longer to reach the URTA milestone. Sleep may be an important factor to monitor to optimize recovery following concussion.

Fellow sponsored by Kenneth L. Cameron, PhD, MPH, ATC, FNATA.

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Figure 1. Kaplan-Meier Survival Estimates for Recovery Time by Sleep Quartiles



The Effect of Mechanism of Injury on Clinical Recovery Trajectories in Children and Adolescents With Concussion

Teel EF, Gagnon IJ: Concordia University, Montréal, QC, Canada, and McGill University, Montréal, QC, Canada

Context: Mechanism of concussion varies in pediatric populations, with younger cohorts less likely to be injured through sport-related causes. Adolescents and young adults injured through motor vehicle crashes have worse neurocognitive outcomes and longer recoveries compared to sport-related mechanisms, but the effect of mechanism on injury (MOI) on clinical outcomes remains poorly defined. Our objective was to determine the effect of MOI on clinical recovery trajectories in children and adolescents with concussion. **Methods:** A total of 531 young (5-7 years), 1280 school-age (8-12 years), and 1245 teenage (13-17 years) children were recruited from pediatric emergency departments (PED, $n=9$) within 48hrs of concussion. Participants were categorized into sport, fall, and other mechanisms based on self-reported injury history. Participants completed age-appropriate versions of the Post-Concussion Symptom Inventory (PCSI) and Pediatric Quality of Life Scale (PedsQL). The PCSI was completed in the PED and at 1, 2, 4, 8, and 12-weeks post-injury, while the PedsQL was completed at 4, 8, and 12-weeks following concussion. PedsQL (higher scores indicate better quality of life (QoL)) and PCSI change (total post-injury minus pre-injury symptom scores, higher scores indicate worse symptoms) scores were analyzed.

Persistent Post-Concussion Symptoms (PPCS) were defined as three new/worse symptoms on the PCSI relative to pre-injury scores at the 4-week assessment. Multivariable linear mixed models evaluated the effect of MOI, time, and their interaction on PCSI and PedsQL scores. PPCS was analyzed using Chi-Square tests. **Results:** For PCSI score, a main effect of time was observed for 5-7 (PED: 6.6(4.7); 12-Weeks: 0.5(2.1), $p<0.001$), 8-12 (PED: 11.1(6.2); 12-Weeks: 0.9(3.4), $p<0.001$), and 13-17 (PED: 36.2(21.9); 12-Weeks: 4.0(10.5), $p<0.001$) groups, with symptoms decreasing over time. The risk of PPCS was significantly decreased for individuals who sustained a sport-related concussion (23.6% experienced PPCS) compared to other mechanisms (Falls: 27.2%, Other: 39.4%; $p=0.01$) in the 8-12 age group only. Main effects of MOI and time were observed on PedsQL scores for the 8-12 (MOI: $p=0.009$, time: $p<0.001$) and 13-17 (MOI: $p=0.04$, time: $p<0.001$) age groups, such that the sport group had higher overall QoL and QoL generally increased throughout the study period. No significant findings on the PedsQL were observed for 5-7-year-olds ($p>0.05$). **Conclusions:** MOI does not affect clinical recovery trajectories in young children, but sport-related concussions are related to slightly improved clinical presentation (higher quality of life and/or reduced risk of PPCS) compared to falls and other injury mechanisms in older pediatric cohorts. Future studies should continue investigating the effect of MOI on clinical recovery to determine if individuals sustaining concussions through specific mechanisms require different rehabilitation approaches or clinical management strategies to promote recovery.

Changes in State Anxiety Throughout Concussion Recovery in College-Aged Individuals

Pollard-McGrandy AM, Zynda AJ, Klein LA, Loftin MC, Tracey AJ, Covassin T: Michigan State University, East Lansing, MI

Context: Previous research suggests that 13% of individuals who incurred a concussion display clinical levels of post-injury anxiety. Specifically, state anxiety is considered a temporary emotional response to an adverse event that can result in feelings of apprehension and nervousness. State anxiety has been found to be increased during the acute phase of a concussion and in those with a history of baseline depression symptoms. However, the literature has not investigated levels of state anxiety throughout concussion recovery. Therefore, the purpose of this study was to examine state anxiety in college-aged individuals following a concussion and throughout recovery compared to healthy controls. **Methods:** A prospective cohort study of college-aged individuals with and without concussion was conducted in a university laboratory setting. Participants with concussion were included if they were diagnosed with concussion within 5 days of enrollment and were free of neurological disease. Participants with concussion were age- and sex-matched to healthy controls who had not sustained a concussion within the past year. The State Trait Anxiety Inventory (STAI) was administered within 72 hours of injury (day 0), 5 days post-enrollment (day 5), and at the time of full medical clearance (FMC). Healthy controls were tested following the same timeline as their matched concussed

participant. Descriptive statistics were calculated for demographic and medical history characteristics in both groups. Mann-Whitney U-tests and 2 x 3 repeated measures analysis of variance (ANOVA) were used to investigate differences in state anxiety between concussion and control groups across recovery. Statistical significance was set at $p < 0.05$. **Results:** A total of 52 college-aged individuals completed the study, 26 with concussion (mean age = 19.58 ± 1.6 years) and 26 controls (mean age = 19.62 ± 1.57 years). No significant differences in demographic or medical history characteristics were found between groups (Table 1). State anxiety was significantly higher in the concussion group compared to the control group at day 0 (concussion: 44.1, SE=2.1; control: 26.5, SE=1.9; $p < 0.001$), day 5 (concussion: 37.2, SE=2.4; control: 25.1, SE=2.1; $p = 0.001$), and FMC (concussion: 33.9, SE=2.2; control: 24.4, SE=2.0; $p = 0.004$). For state anxiety, there was a significant group x time interaction ($F(2,76) = 5.69$, $p = 0.005$, $\eta^2 = 0.13$), indicating that the change in state anxiety scores over time was significantly different depending on group membership. **Conclusions:** College-aged individuals with concussion experienced significantly higher levels of state anxiety across recovery compared to healthy controls. High levels of stress, uncertainty of concussion recovery timeline, and feeling isolated could be attributed to increased levels of state anxiety. Clinicians should screen for and manage state anxiety following concussion to mitigate the burden of post-injury anxiety on recovery.

Fellow sponsored by Tracey Covassin, PhD, ATC, FNATA.

Table 1. Demographic and Medical History Characteristics of Concussion and Matched Control Groups of College-Aged Individuals.

Variable		Concussion (n=26)	Control (n=26)	P-value
Age (years)		19.58 (1.6)	19.62 (1.57)	0.90
Gender	Male	17 (65.4%)	17 (65.4%)	1.0
	Female	9 (34.6%)	9 (34.6%)	
Prior concussion	Yes	9 (34.6%)	4 (15.4%)	0.15
	No	10 (38.5%)	16 (61.5%)	
	Not reported	7 (26.9%)	6 (23.1%)	
Headaches/Migraines	Yes	1 (3.8%)	1 (3.8%)	1.0
	No	24 (92.4%)	24 (92.4%)	
	Not reported	1 (3.8%)	1 (3.8%)	
Learning disorder	Yes	0 (0%)	3 (11.6%)	0.07
	No	25 (96.2%)	22 (84.6%)	
	Not reported	1 (3.8%)	1 (3.8%)	
ADD/ADHD	Yes	2 (7.6%)	0 (0%)	0.13
	No	21 (80.8%)	25 (96.2%)	
	Not reported	3 (11.6%)	1 (3.8%)	
Depression/Anxiety	Yes	3 (11.6%)	1 (3.8%)	0.29
	No	22 (84.6%)	24 (92.4%)	
	Not reported	1 (3.8%)	1 (3.8%)	

Continuous variables are reported as means (SD) and categorical variables are reported as frequencies (percent).

Do Late-Season Concussions Take Longer to Recover From?

Hill TM, Williams K, Perry G, Jacob J, Prosak O, Amedy A, Anesi T, Terry D, Zuckerman S: Vanderbilt University School of Medicine, Nashville, TN

Context: Sport-related concussion (SRC) is a public health concern among youth athletes. While many studies have investigated modifying factors that may prolong outcomes after SRC, a few have studied the role of seasonality, as defined by time of injury during a season. In a cohort of high school football players, we sought to investigate the effect of seasonality on 1) initial symptom burden, and 2) recovery, defined as time to symptom resolution, return to learn (RTL), and return to play (RTP). **Methods:** A retrospective, single-institution, cohort study of high school football athletes ages 14-18-years-old who sustained a SRC from 11/2017-04/2022 was conducted. Season duration was determined using the Tennessee Secondary School Athletic Association (TSSAA) calendar. Seasonality, as defined by the time of injury during a season, was categorized into one of three groups: early-season (7/20-8/31), mid-season (9/1-10/13), and late-season (10/14-12/04). The primary outcomes included initial Post-Concussion Symptom Scale (PCSS) score, time to symptom resolution, time to RTL, and time to RTP. Descriptive statistics, analysis of variance (ANOVA), Mann Whitney U tests, and multivariate linear regressions were performed. Regression covariates included: history of learning disorders, psychiatric condition, migraines, family history of psychiatric conditions/migraines, initial PCSS score, and number of prior concussions. **Results:** Of 273 high school football players, 97 (35.5%) sustained a

SRC during early-season, 107 (39.2%) during mid-season, and 69 (25.3%) during late-season. ANOVA analysis showed no significant differences between three groups regarding their initial PCSS score [early-season (19.3 ± 18.7), mid-season (19.0 ± 20.3), late-season (21.1 ± 21.4); $F(2,248)=0.23$, $p=.79$]. Additionally, no differences were seen between groups for time to symptom resolution [early-season ($11.5 \text{ days} \pm 12.9$), mid-season ($18.9 \text{ days} \pm 25.4$), late-season ($25.5 \text{ days} \pm 27.0$); $F(2,65)=2.218$, $p=.12$], time to RTL [early-season ($5.3 \text{ days} \pm 4.8$), mid-season ($6.1 \text{ days} \pm 14.4$), late-season ($7.2 \text{ days} \pm 15.8$); $F(2,101)=0.18$, $p=.84$], and time to RTP [early-season ($13.5 \text{ days} \pm 11.8$), mid-season ($20.9 \text{ days} \pm 25.8$), late-season ($23.0 \text{ days} \pm 22.8$); $F(2,64)=1.34$, $p=.27$]. Mann Whitney U test showed significant difference in time to symptom resolution between early-season vs. late-season [$t(43)=-1.80$, $p=.03$]. Multivariable linear regression found that late-season SRCs were associated with longer time to symptom resolution ($\beta=.439$, $p=.03$). Initial PCSS was the only other variable that was associated with longer symptom resolution ($\beta=.52$, $p<.001$). **Conclusions:** Seasonality was predictive of time to symptom resolution, as such that concussions occurring later in the season showed a longer time to symptom resolution. Seasonality did not affect time to RTL and RTP. Future research should examine other sports to investigate the role of seasonality on recovery.

Scott Zuckerman serves as an unaffiliated neurotrauma consultation for the U.S. National Football League. Douglas Terry receives honoraria from REACT Neuro, Inc as well as HitIQ and has a consulting practice in forensic neuropsychology. For remaining authors none were declared. None of the other authors have any disclosures.

Post-Injury Outcomes Following Non-Sport Related Concussions in Adolescent Athletes

Roby PR, Master CL, Arbogast KB: Children's Hospital of Philadelphia, Philadelphia, PA, and University of Pennsylvania, Philadelphia, PA

Context: Non-sport related concussions (non-SRC), including mechanisms such as motor vehicle crashes, falls, and intentional and unintentional impacts to the head, comprise approximately 20% of concussions sustained by collegiate athletes and demonstrate worse clinical outcomes relative to sport-related concussions (SRC). Though non-SRC occur outside a sport setting, athletic trainers still play a critical role in the treatment and management of non-SRC sustained by athletes. There is currently limited research examining non-SRC in adolescent athletes. Therefore, the purpose of this study was to investigate group differences in clinical outcomes and symptoms following non-SRC relative to SRC in adolescent athletes. **Methods:** An observational study design was used to examine clinical signs and self-reported symptoms in athletes reporting to a specialty care concussion center with either a non-SRC or SRC. Athletes aged 13-18 years were included if they reported for an initial visit within 28 days and participated in organized sport in the last year. Primary clinical data collected included the presence of post-injury memory loss, loss of consciousness (LOC), sleep changes, driving changes, and having returned to school, exercise, and sport. Self-reported symptoms were measured by the Post-Concussion Symptoms Inventory (PCSI).

Injury proportion ratios (IPR) were used to compare the proportion of injuries by mechanism for memory loss, LOC, sleep and driving changes, and having returned to school, exercise, and sport. The IPRs not including 1.00 in the 95% confidence interval were considered statistically significant. Mann-Whitney U tests were used to assess group differences in symptom count and severity. **Results:** A total of 2,860 athletes (females=1569(54.9%), non-SRC=813(28.4%), age=15.2±1.5 years) were included in the final analysis. Non-SRC mechanisms included being struck by or against an object (35.6%), fall (30.6%), motor vehicle-related injury (either passenger or pedestrian) (17.1%), unintentional contact with a person (7.7%), assault (6.4%), and other (2.6%). Relative to SRC, a higher proportion of athletes with non-SRC reported with memory loss (IPR=1.30, 95%CI=1.05-1.61), LOC (IPR=2.40, 95%CI=1.85-3.11), and sleep changes (IPR=1.24, 95%CI=1.04-1.48). The IPRs for driving changes, and having returned to school, exercise, or sport were not statistically significant. Non-SRC reported with greater symptom count ($p<0.001$) and severity ($p<0.001$) relative to SRC (Table 1). **Conclusions:** Adolescent athletes with non-SRC reported with worse clinical signs with 28 days following concussion relative to athletes with SRC. This may be due to lack of sideline or school-related care typically given by athletic trainers when the injury occurs in sport. Our findings suggest that athletic trainers should closely monitor athletes reporting with non-sport mechanisms in order to improve injury management and prognosis. Non-SRC remain a largely understudied group of head injuries. It is critical to continue examining these injuries

to better inform clinical management and implement prevention strategies aimed at reducing concussion occurring outside of sport.

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Table 1. Demographic information and primary post-injury outcomes for adolescent athletes with sport-related and non-sport related concussion.

	Total	Sport-Related Concussion	Non-Sport Related Concussion
Sample size, n(%)	2860	2047 (71.6%)	813 (28.4%)
Sex, n(%)			
Female	1569 (54.9%)	1037 (50.7%)	532 (65.4%)
Male	1291 (45.1%)	1010 (49.3%)	281 (34.6%)
Age, mean(SD)	15.2 (1.5)	15.2 (1.5)	15.3 (1.5)
Post-Concussion Symptom Inventory			
Symptom Count, median(IQR)	12 (7-17)	11 (6-16)	14 (9-18)
Symptom Severity, median(IQR)	31 (13-53)	27 (11-49)	41 (21-63)

SD: Standard deviation; IQR: Interquartile range

Return-to-Learn After Sport-Related Concussion in Middle School, High School, and Collegiate Athletes: Does School-Level Matter?

Jo J, Williams KL, Hill TM, Perry GM, Prosak OL, Amedy A, Anesi TJ, Terry DP, Zuckerman SL: Vanderbilt Sports Concussion Center, Vanderbilt University Medical Center, Nashville, TN; Department of Neurological Surgery, Vanderbilt University Medical Center, Nashville, TN; Vanderbilt University School of Medicine, Nashville, TN

Context: Effectively returning athletes to academics after sport-related concussion (SRC) is an important yet understudied topic. We sought to: 1) describe patterns of return-to-learn (RTL) among athletes by school-level (i.e., middle school, high school, college), and 2) evaluate the predictive value of school-level on RTL duration. **Methods:** A retrospective, single-institution, cohort study of adolescent athletes 12-23-years-old who sustained a SRC from 11/2017-04/2022 was conducted. Descriptive analysis and analysis-of-variance (ANOVA) were used to compare RTL duration across school levels (middle school, high school, college). A multivariable linear regression was performed to evaluate for predictive value of school-level on RTL duration. Covariates included: sex, race/ethnicity, learning disorder, psychiatric condition, migraines, family history of psychiatric conditions/migraines, initial

Post-Concussion Symptoms Scale (PCSS) score, and number of prior concussions. **Results:** Of 936 total athletes, 116 (12.4%) were in middle school, 798 (85.3%) were in high school, and 22 (2.4%) were in college. Mean RTL times (in days) were: 8.0 ± 13.1 (middle school), 8.5 ± 13.7 (high school), and 15.6 ± 22.3 (college). One-way ANOVA showed statistically significant difference between groups [$F(2,1007)=6.932$, $p=.001$]. A Tukey post hoc test revealed a longer RTL duration in collegiate athletes when compared to middle school ($p=.003$) and high school athletes ($p<.001$). There was no difference between middle school and high school athletes ($p=.935$). Multivariable linear regression model showed that collegiate athletes had longer RTL duration compared to other school-levels ($\beta=0.14$, $p<.001$). The only other statistically significant predictor of RTL duration was initial PCSS score ($p<.001$). **Conclusions:** RTL duration was longer in collegiate athletes when compared to other school-levels. Future studies should investigate how different school structures may affect the RTL process and necessary accommodations.

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Sleep Symptoms Associated With Sport-Related Concussion Symptom Recovery

Bretzin AC, D'Alonzo BA, Wiebe DJ:
University of Michigan, Ann Arbor, MI, and University of Pennsylvania, Philadelphia, PA

Context: Evidence suggests athletes may experience difficulties with sleep after sport-related concussion (SRC). However, limited research investigates sleep symptoms in males and females following SRC, and compares symptom resolution time for males and females with and without sleep symptomatology. We explore associations between athlete sex and sleep symptoms, and compare time to symptom resolution between student-athletes with and without subjective sleep symptoms, adjusting for total symptom experience. **Methods:** We included collegiate athlete SRC data from a prospective cohort study and surveillance system from 2013-14/2019-20. Prior to data collection, we obtained institutional review board approval and athlete consent. Athletic Trainers document sport-related concussion characteristics including symptom experience throughout recovery and symptom resolution time into the online study database. Three sleep symptoms (i.e., fatigue, drowsiness, difficulty sleeping) are recorded among 22 symptoms included in the athlete's symptom experience. We computed a total symptom score excluding the three sleep symptoms. We describe athletes' subjective symptom experience including those with each of the three sleep symptoms, and separately test for associations between men and women and symptom reporting above and below the median symptom total and each sleep symptom with chi-square analyses ($p \leq 0.05$). We assess time from injury to symptom resolution among athletes with

and without the three sleep symptoms, examining Kaplan Meier curves with Logrank test ($p < 0.05$) separately for men and women. **Results:** We included 1,740 SRC (women: $n=722$; men: $n=1,018$) and found significant associations between men and women and fatigue ($\chi^2(1)=6.65$; $p=.010$), and between high and low symptom scores and fatigue ($\chi^2(1)=338.63$; $p<0.001$), drowsiness ($\chi^2(1)=329.45$; $p<0.001$), and difficulty sleeping ($\chi^2(1)=231.81$; $p<0.001$). For men, Kaplan Meier Curves displayed differences in median days to symptom resolution and each of the sleep symptoms ($p's < .001$). The range in median days to symptom resolution ranged from 10-12 days for SRCs with the presence of each of the sleep symptoms paired with total symptoms above the median, and from 4-5 days in the absence of each of the sleep symptoms paired with total symptoms below the median. For women, we identified differences in median symptom resolution time and each of the sleep symptoms adjusting for overall symptom presence ($p's < 0.001$). Women exhibiting sleep symptoms paired with total symptoms above the median had median symptom durations ranging from 11-14 days; those with lower symptom scores and no sleep symptoms each had a median of 6 days for symptom resolution. **Conclusions:** Symptom resolution was shortest in men and women with symptom scores below the median paired with no fatigue, drowsiness, or difficulty sleeping. In contrast, symptom resolution time was longest in men and women with sleep symptoms paired with higher overall symptom scores. Therefore, sleep may be a modifiable target for treatment during SRC recovery.

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Sleep/Affective Symptoms and Symptom Resolution Time following Sport-Related Concussion in National Collegiate Athletic Association Sports: 2014/15-2018/19

Boltz AJ, Rao N, Bretzin AB, Beisecker L, Collins CL, Broglio SP, Chandran A: Datalys Center for Sports Injury Research and Prevention, Indianapolis, IN; Michigan Concussion Center, School of Kinesiology, University of Michigan, Ann Arbor, MI; Department of Emergency Medicine, University of Michigan, Ann Arbor, MI ;Matthew Gfeller Center, Department of Exercise and Sport Science, University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Sport-related concussions (SRCs) are caused by biomechanical forces directed to the head/neck, and result in wide-spread neuronal depolarization. The ensuing neurometabolic cascade can disrupt homeostatic processes associated with sleep and mood. Consequently, interruptions to sleep can impede the body's ability to respond to this elevated state of neuroinflammation. Moreover, changes in affect may also present as function to changes in sleep resulting in a unique clinical profile. Emerging evidence suggests changes to sleep and affect following SRC, independently, are associated with protracted recovery. However, it is unclear if symptom resolution time (SRT) is influenced by sleep/affective symptom endorsement. Therefore, we explored predictors of SRT as a function of sleep/affective symptom endorsement from SRCs in National Collegiate Athletic Association (NCAA) sports. **Methods:** SRC exposure and injury records with complete symptom inventories collected by the NCAA Injury Surveillance Program between 2014/15-2018/19 academic years were analyzed. Sleep symptoms (drowsiness, and insomnia) and affective symptoms (hyperexcitability and irritability) were measured dichotomously. Summary statistics [frequencies (%)] were used to describe sample

characteristics in athletes who endorsed sleep/affective symptoms. Ordinal logistic regression assessed odds of longer SRT (≤ 14 -, 15 - 28 -, >28 - days/did not resolve) with greater counts of sleep/affective symptoms after adjusting for covariates [sex (female, male), event type (practice, competition), mechanism (player-, other-contact), injury history (new, recurrent), class year (freshman, sophomore, junior, senior, other), and other non-sleep/affective-related symptoms endorsed (≥ 4 , ≤ 3)]. Adjusted Odds ratio (ORAdj.) estimates with 95% confidence intervals (95% CI) excluding 1.0 were deemed statistically significant. **Results:** Overall, 1421 SRCs were examined, and most had ≥ 1 sleep/affective symptom (54.2%). The most prevalent sleep/affective symptom was drowsiness (36.8%), followed by insomnia (21.5%) and irritability (21.5%). Among SRCs where ≥ 1 sleep/affective symptoms were endorsed, 22.7% of SRCs were reported with ≥ 3 sleep/affective symptoms. Odds of longer SRT were higher in SRCs with greater counts of sleep/affective symptoms (ORAdj.= 1.17, 95%CI= 1.03, 1.34). **Conclusions:** Clinicians should be aware of the presentation of sleep and affective symptoms following SRCs in their athletes as odds of longer SRT was associated with greater counts of sleep/affective symptoms. Future studies may consider leveraging sleep-duration and -quality assessments with concurrent behavioral assessments to fully appraise impairments to sleep and affect following SRC.

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Lesser Trochanter Stress Fracture in a Collegiate Cross Country Runner: A Case Report

Gallegos DM, Peebles RL, Volpi JD, Warner BJ, Cage SA: The University of Texas at Tyler, Tyler, TX; UT Health East Texas, Tyler, TX; The University of Texas Health Science Center, Houston, TX; Grand Canyon University, Phoenix, AZ

Background: A 19-year-old male collegiate cross country runner reported to the athletic training staff complaining of pain and stiffness in his right hip and leg following a long run three days earlier. After abstaining from physical activity the day after injury, the patient had to discontinue a run two days after the initial onset of symptoms due to pain posterior to the greater trochanter. The patient attempted swimming to relieve his symptoms, but did not experience any improvement. The patient reported no neurological symptoms and no previous history of hip injuries. During resisted range of motion testing, the patient exhibited weakness with right hip abduction. A physical exam also revealed palpable tenderness and spasm at the myotendinous junction of the gluteus medius. At this time, the patient was referred to the team physician for further evaluation. **Differential Diagnosis:** Gluteus medius strain, trochanteric bursitis, acetabular labrum pathology. **Intervention & Treatment:** At the initial medical evaluation, the team physician agreed with the athletic trainer's initial diagnosis of a gluteus medius strain. The patient was restricted from running for the following week and began pelvic stability exercises, and stationary cycling or swimming was suggested to maintain

cardiovascular fitness. The patient was reevaluated in the athletic training clinic the following week. During reevaluation, the patient reported no significant improvements in symptoms, and was instructed to continue with the previous restrictions until symptoms improved. After four weeks of cross training, hip and core strengthening, and conservative treatment including cupping therapy failed to relieve symptoms, the patient was referred for an MRI. The MRI revealed bone marrow edema in the lesser trochanter of the femur consistent with a stress fracture. The radiologist also noted inflammation of the iliopsoas tendon with no disruption of tendon fibers. With the new diagnosis, the team physician restricted the patient to swimming with a buoy for cardiovascular activity for the following two weeks. The patient began swimming and low intensity core and hip strengthening consisting of planks and hip abduction and adduction exercises while avoiding hip flexion and extension at the end of his rest period. At follow-up one month after final diagnosis, the patient reported no pain with day-to-day walking. The patient also noted some soreness after exercise, but no sharp pain. Given the reduction in symptoms, the team physician cleared the patient to begin stationary cycling and elliptical every other day to begin improving cardiovascular fitness. As symptoms improved, the patient began to gradually increase the duration and frequency of cardiovascular activities. Two and a half months after final diagnosis, the patient reported no pain with running for short distances, and had regained strength with right hip abduction. During this follow-up visit, the patient was cleared to begin a walk-to-run program. Throughout the competitive season for outdoor track and field, the patient continued to regain cardiovascular endurance. However, the patient was unable to

compete in competitions due to deconditioning. **Uniqueness:** While stress fractures account for roughly 15% of injuries in running athletes, the majority of the injuries occur in the sacrum, inferior pubic rami, and femoral neck. Given the rarity of stress fractures to the lesser trochanter, the final diagnosis was delayed due to the symptoms mimicking those of a gluteus medius strain. **Conclusions:** When caring for patients, it is critical to evaluate and reevaluate progress during treatment and rehabilitation. In the event a patient does not appear to be progressing as expected, referral to the team physician for further evaluation is critical to ensure optimal patient related outcomes

Quadriceps Tendon Reconstruction With Posterior Tibialis Allograft Following Failed Extensor Mechanism Allograft Reconstruction On A 67-Year-Old Male: Level 3 Case Study

King CL, Cafferky NL, Seiter MN: Vail Summit Orthopaedics and Neurosurgery Research and Education Foundation, Vail, CO

Background: Extensor mechanism injuries following total knee arthroplasty (TKA) are a complication occurring in 1%-12% of patients, with complete rupture occurring in 0.7%-2.7% of patients. This injury can be devastating due to complicated management. Injuries to the extensor mechanism following TKA typically occur during surgery or post-operatively. Surgical causes include tendon injury during exposure, improper patellar resection, or damage to the blood supply following injudicious lateral retinaculum release or multiple prior surgeries. Post-operative causes include tissue necrosis, component malalignment, and trauma. There are multiple treatment options for extensor mechanism rupture following TKA including observation, direct primary repair with or without graft, or reconstruction with allograft tissues. However, these treatment options have high failure rates. **Patient:** The patient is a 67-year-old male with a complex history involving his left knee. He underwent a TKA 2 years prior to treat severe osteoarthritis, followed by an extensor mechanism reconstruction after a post-operative patellar tendon rupture. The patient initially presented to our clinic following an additional trauma that disrupted his previous graft. A second extensor mechanism allograft reconstruction was completed. He returned to clinic

10 weeks post-operatively, reporting a fall. The patient demonstrated a 50-degree loss of knee extension. Radiographic imaging showed a significant low-riding patella. The attachment of the previous graft was palpated on superior pole of the patella. Physical examination and imaging studies indicated a disruption of the proximal quadriceps tendon graft site. **Intervention & Treatment:** The patient consented to a quadriceps tendon reconstruction with posterior tibialis allograft. During exposure, it became evident that the previous sutures had torn at the proximal extent of the allograft and had not healed to the quadriceps tendon. A direct repair of allograft tendon to native quadriceps tendon was performed. Next, the posterior tibialis allograft was routed through the patellar tendon at the inferior pole and anchored into place. The allograft posterior tibialis tendon was routed up both sides of the patella and anchored to the allograft quadriceps tendon's superior pole attachment. The posterior tibialis allograft was routed through the patient's native quadriceps tendon. After closure, the patient was placed in a hinged knee brace, locked in extension, and limited to partial weightbearing for 12 weeks. **Outcomes or Other Comparisons:** At 6 weeks post-operatively, the patient discontinued his knee brace prematurely and started ambulating, weightbearing as tolerated. The patient demonstrated knee ROM of 0-95 and active quadriceps activation against gravity with a 30-degree extension lag. Additionally, he had a palpable step-off at his repair site, but his patella is stable. Concerns were addressed with patient regarding not abiding by his post-operative protocol. However, the patient stated he does not plan on using his knee brace. The patient will continue active quadriceps extension, but that is the limit to his strengthening. **Conclusions:** Extensor

mechanism injury following TKA is a devastating injury that does not have a "gold standard" of treatment or promising outcomes. In this case, the patient had undergone numerous extensor mechanism repairs and reconstructions, each procedure replacing more native tissue with allograft tissue. Despite allograft tissue's high susceptibility to rejection due to immuno-incompatibility, allografts are currently the most common tissue utilized. There is a lack of research that compares the outcomes between different techniques of extensor mechanism injury treatment. More evidence is needed to explore how to reduce the failure rate of extensor mechanism injuries reconstructions/repairs. **Clinical Bottom Line:** Further understanding of extensor mechanism injury management is pertinent because typical patient population is expanding as history of knee surgery significantly lowers the average patient age of those undergoing TKA. Increased prevalence of this procedure may increase complications, like extensor mechanism injury and providers will likely be presented with this injury at an increased and younger rate.

Atypical Presentation of Morel-Lavallée of the Patella in High School Football Athlete: Level 3 CASE Study
Castillo B, Houston E, Williams A:
Florida International University, Miami, FL

Background: Level 3 case study of a 16-year-old high school football player who sustained a Morel-Lavallée lesion. A Morel-Lavallée lesion is a shearing of the hypodermis from the underlying fascia. A closed degloving typically occurs at the hip joint near the greater trochanter from acute blunt force trauma. The space created from the shearing force will fill with blood, lymph, and a necrotic fat pad indicated via diagnostic ultrasound and MRI. This case was unique due to the irregular occurrence at the patella. Other indicators of the injury are fluctuations of a mass (water) on the injury site. **Patient:** The patient's mechanism of injury involved sliding on the turf during a football game with direct trauma to his patella. On examination, the patient was positive for pain, immediate swelling, and pitting edema at the anterior portion of the knee. Lachman and valgus stress tests were performed on physical exam, with negative results. Signs and symptoms from the clinical evaluation indicated a lesion after reviewing all clinical examination findings. X-ray and MRI were performed and confirmed a Morel-Lavallée lesion of the patella. Differential diagnoses were meniscus tear and tibial plateau fracture. **Intervention & Treatment:** The initial treatment included aspiration of bursae within the knee by a team physician. The patient performed a daily

treatment that included heat and interferential current therapy for pain and swelling. The patient returned to play in approximately two weeks. Treatment for closed degloved injuries at the patella, out of 24 players from 1 National Football League, 14 (52%) were treated with a compression wrap, cryotherapy, and therapeutic range of motion exercises. Thirteen of the players (48%) were treated with one aspiration of the patella, while 6 players (22%) were treated with multiple aspirations for reoccurring sero-sanguineous fluid buildup. Three athletes were treated with doxycycline sclerodesis after 3 aspirations failed to resolve the reoccurring fluid buildup. **Outcomes or Other Comparisons:** The patient recovered in approximately 2 weeks. Compared to the literature, 27 National Football League players had an average of 16.3 days of the resolution, 1.5 practices missed, and 0.1 games missed. Fourteen of the players did not have their knees aspirated, and they experienced 10.6 days of the resolution, 1.0 missed days of practice, and 0 games missed. The other 13 players whose knees were aspirated had a resolution of 23.7 days, 2.0 days of missed practice, and 0.2 missed games. **Conclusions:** This case examines the rare occurrence of the Morel-Lavallée lesion at the patella. Due to the clinical presentation of symptoms occurring at the knee, X-ray and MRI were elected to confirm clinical findings. The patient successfully returned to the sport in 2 weeks. **Clinical Bottom Line:** Athletic Trainers need to be aware that the mechanism of shearing force, with a combination of rapid swelling and pitting edema in the anterior portion of the knee, can be indicative of a Morel-Lavallée lesion.

Bio-Mesh Treatment of Sports Hernia in a Male Collegiate Soccer Player: Level 3 CASE Study

Mendez BI, Hussin AM, Williams A:
Florida International University, Miami, FL

Background: A type 3 clinical CASE Study. Patient was diagnosed with a sports hernia on his RLQ. A sports hernia is a strain or tear of any soft tissue (muscle, tendon, ligament) in the lower abdomen or the groin area. Pathology is commonly seen in high-performance athletes. Some common treatments are physical therapy, laparoscopy repair with bio-mesh, and platelet-induced plasma therapy. In this case, the patient underwent a laparoscopy with a biological mesh. **Patient:** The patient is a 22-year-old, male soccer player, with 18 years of experience in the sport. Patient has a previous history of lower right quadrant (LRQ) pain. They had previously found calcium deposits in ligaments of his RLQ and the was treated for using shockwave, magnetolith, and laser. The patients pain returned, and an MRI revealed a sports hernia in his RLQ and a mass in his LLQ, later diagnosed as an inguinal hernia. Both hernias had an insidious onset. On August 26, 2022, a double laparoscopy (right and left side) with biological mesh was performed to repair both the sports hernia and the inguinal hernia found on his LLQ. **Intervention & Treatment:** Initial pain was treated using shockwave, laser, and magnetolith to relieve the pain from the calcium deposits found on the ligaments in his RLQ. Patient was cleared to return to play, but a few weeks later an MRI uncovered a sports hernia on his LRQ and was referred for surgery. In preparation for surgery, the patient underwent core pre-habilitation, which included abdominal exercises and hip and knee mobility. In

addition, laser and gratin interventions were used. On August 26, 2022, a double laparoscopy with biological mesh was performed bilaterally. **Outcomes or Other Comparisons:** There are both nonoperative and operative treatments to fix sports hernias. Non-operative treatment is rest followed by physical therapy, which has a 40%-100% success rate, but leads to surgery if pain doesn't subside after two months of intervention. Another non-operative treatment option, platelet-rich plasma treatment, has been effective in recovery of high-level athletes. Lastly, there are various operative treatment options, such as laparoscopic repair with biological mesh, which was used on this patient. This type of surgery is the most common repair for sports hernias, with positive outcomes. More research is needed to confirm long-term effectiveness of this treatment. In this case, the surgeon decided to perform a laparoscopy with biomesh due to its simplicity in procedure supported in previous previous literature. **Conclusions:** Patient returned to play after a month post-op. He began feeling pain a week after he returned to activity, which led to the decision to delay further activity and re-start rehabilitation. Given the setback and the lengthiness of his recovery, potential in delay of recovery may impacted the implementation of laparoscopic surgery with biomesh application. Platelet-rich plasma therapy has allowed the patient to return to play in 21 days after initial treatment. **Clinical Bottom Line:** The literature is unspecified with implementation of mesh material for repair for sports hernias. The literature has supported biomeash material as the ideal treatment, with positive outcomes within the sport population. It is important to understand that every surgery has its side effects and might not be the absolute solution to the injury. Other treatment options should always be taken into consideration.

Management of a Posterior Cortical Tibial Stress Fracture in a DI Cross Country and Track and Field Athlete
Kealy MC, Fitzpatrick SG,
Henrichs JW: University of Illinois,
Urbana-Champaign, IL, and Carle
Foundation Hospital, Urbana, IL

Background: An 18-year-old female Division I distance runner presented with calf tightness at the end of August 2021. The athlete had no history of bony stress injuries but did have a history of an eating disorder and amenorrhea. She also reported having the same calf tightness symptoms her junior and senior years of high school. Following a week of treating this as a sciatic nerve, the athlete was referred to the team physician for further evaluation. **Differential Diagnosis:** Lumbar radiculopathy plexopathy, transient left leg weakness, compartment syndrome, tibial bony stress injury. **Intervention & Treatment:** This athlete was initially referred to the team physician on September 27th, 2021. Due to radiating leg pain and mild improvement with McKenzie type exercises, a lumbar X-Ray and MRI without contrast were ordered. The X-Ray was done on September 27th, 2021, and the MRI on September 28th, 2021. Neither showed any abnormalities, and the athlete's pain was not improving. A compartment pressure test was performed on October 25th, 2021, and findings were normal. An EMG was ordered and performed on October 29th, 2021, and findings were also normal. After two months of treating the athlete with some sporadic days of improvement, an X-Ray for the left leg on November 2nd, 2021 revealed a posterior cortical tibial stress fracture. Six weeks later, a follow up

x-ray was performed on December 13th, 2021. The stress fracture was still visible without significant change. The next follow up x-ray was performed on January 14th, 2022 and showed continued healing but a partially visible fracture line. The next x-ray was performed on February 14th, 2022 and showed a slightly less visible fracture line consistent with appropriate interval healing. The athlete had been taking calcium and vitamin D supplements, training on the Alter-G treadmill and in the pool as tolerated and doing resistance training as tolerated up to this point. In February 2022 after 3 months of no running and increased awareness, the athlete had her first ever menstrual cycle. A CT scan without contrast was ordered to evaluate healing and was performed on March 21st, 2022. Minimal bowing deformity and a faint fracture line were still visible; however, no new or acute findings were present. At this point, the athlete was cleared to slowly begin a ground running progression. A final x-ray was performed on May 2nd, 2022. This x-ray showed a mostly healed stress fracture, with no visible changes in comparison to the x-ray in February. Care was continued throughout the summer at the athlete's home with her family physician. **Uniqueness:** Although tibial stress injuries are common in high capacity long distance athletes, posterior proximal tibial stress injuries are fairly uncommon. The athlete also presented with symptoms that are typical for a neuropathy, and was able to run for a few months on the injury. **Conclusions:** In cases of insidious onset lower leg pain or muscle tightness, early advanced imaging should be considered to rule out or confirm bony involvement. In this case, imaging was not indicated early on as the athlete did not show signs of a bony stress injury.

Presentation of Gastrointestinal Symptoms in a Collegiate Football Player: A Type 4 CASE Study
Elson CC, Locke JT, Powden CJ:
University of Indianapolis, Indianapolis, IN, and Marian University, Indianapolis, IN

Background: A 19-year-old freshman Caucasian collegiate male football wide receiver presented to the ATF on 8/10/2022 complaints of right upper quadrant abdominal pain and nausea. Prior to preseason training camp, the patient had seen several physicians regarding his symptoms. His initial physician contact was mid-March, for consistent abdominal pain and nausea, where he was diagnosed with Cannabinoid Hyperemesis Syndrome (CHS). CHS is a condition that leads to repeated, severe bouts of vomiting in daily long-term users of marijuana. The patient ceased marijuana usage but didn't experience reductions in abdominal symptoms. In July, he experienced a bout of non-stop vomiting leading to an emergency department visit in Chicago, IL. He was then diagnosed with Cyclic Vomiting Syndrome (CVS). CVS is a disorder that causes sudden, repeated episodes of severe nausea and vomiting. On 8/8/2022 he self-referred for heightened symptoms during his journey back to campus for the semester and was prescribed Esomeprazole, Ondansetron, and Metoclopramide. On 8/10/2022 the patient was referred to the team physician after reporting abdominal symptoms to the athletic training staff (8/8/2022). **Differential Diagnosis:** CVS, CHS, Gallbladder sludge, Cholecystitis. **Intervention & Treatment:** A diagnostic ultrasound imaging was completed with the team physician, diagnosing the patient with sludge in his gallbladder. He was cleared to RTP with no restrictions on 8/11/2022 with a referral for a surgical consult. The patient continued to practice as tolerated. The athletic training staff worked to manage his symptoms by advising rest, bland foods, daily check-ins regarding symptoms, and activity limitation during bouts of increased symptoms. During this time the patient stated a

continuation of their symptoms as management techniques did not seem to offer relief. After surgical consult, the patient was scheduled for a Cholecystectomy by a gastrointestinal (GI) general surgeon, on 8/25/22. Patient was advised post-surgery to consume liquid like foods and to be aware of post-operative diarrhea initially. Long-term he was advised to avoid fatty or greasy foods. The athletic training staff started a gradual RTP a week after surgery. Initially this consisted of a light jogging and running protocol. He was then progressed to agility and sport-specific movements during practice. At four weeks, he was able to participate in practice with repetition restrictions. On 9/21/22, the patient was able to participate fully with no restriction. Upon physician recommendations, if the patient had any abdominal pain that he would need to rest, have no contact practice for 2 days, and go through a RTP protocol again. The patient did not have any setbacks during his RTP process. **Uniqueness:** Cholecystectomy surgery is more common in females than males and the average age for males is 51 years old. Our patient represents a deviation from the norms as he is a young male. Additionally, his initial diagnosis, CHS and CVS, are common, but in 35-year-old males, again representing a deviation in age. Lastly, further consultation with a gallbladder specialist in Indiana provided the recommendation that patient should have underwent surgery earlier due to his age, sport, and severity of symptoms. Delays in proper gallbladder evaluation and treatment can increase the risk of sepsis, jaundice, and or cancer. **Conclusions:** This case study provides valuable information to athletic trainers as GI conditions are not regularly managed by the profession. It is important to be aware of the symptoms of CHS and CVS as they can occur in a wide range of populations and result in debilitating symptoms. Additionally, it is valuable to properly identify the severity of symptoms and with the correct provider to ensure that all treatment options are considered. Delayed care for these conditions can increase the risk for more serious conditions, further highlighting the importance of proper diagnosis and management.

Acute Kidney Rupture in a Secondary School Football Player: A Type 4 Clinical CASE Study
Mendres TL, Cohen GW: PT Solutions, Tampa, FL, and University of South Florida, Tampa, FL

Background: The patient was a 16-year-old male football athlete. He had no prior history of kidney pathology or injury. The athlete was conscious and responsive to verbal cues when approached by the athletic trainer during the first quarter of a game after he was tackled while jumping in the air to catch a pass and unable to leave the field on his own power. He complained of pain in the anterolateral right upper quadrant and reported getting the wind knocked out of him. **Differential Diagnosis:** Initial field assessment found point tenderness to palpation with rigidity at the site of the direct blow, which was to the anterolateral aspect of the upper right quadrant, and increased pain over the right vertebrochondral ribs. There was no observed shortness of breath or difficulty breathing. When exiting the field under the assistance of the medical staff, the athlete vomited twice. The sideline evaluation revealed no rigidity of the abdominal region upon palpation and pain was reported to be localized to the upper right quadrant and vertebrochondral ribs. The athlete's pulse was recorded at 15-minute intervals. His pulse was, on average, 75 beats per minute and strong. Rib fracture was ruled out through special testing and palpation. The athlete denied any shoulder pain consistent with Kehr's sign. He was removed from further play and reported no change in symptoms while on the sideline. At half-time the athlete's parents requested to take their child home to make him more comfortable. Since internal organ injury

was unable to be ruled out, the athletic trainer asked the parents to assess the athlete's urine color prior to leaving the athletic trainer's care. The parents assessed the athlete's urine and the color was reported it to be bright red, and the athlete was immediately referred to emergency care for a suspected kidney injury. **Intervention & Treatment:** Upon arrival to the emergency room the athlete resumed vomiting and underwent a computerized tomography scan. The results of the scan indicated that the athlete had suffered a ruptured kidney. He was referred to the intensive care unit at a children's hospital for observation where he remained for two days while kidney bleeding persisted. The athlete was then moved to a regular room, developed recurring fevers, and increased hematuria when ambulating. A ureteral stent was inserted to help manage fluid accumulation. One-week post-injury, liver enzymes were still elevated but the bleeding had stopped. The athlete was allowed to return to learn 17 days post-injury. **Uniqueness:** Although the blunt force mechanism of injury associated with this case is not uncommon, the incidence rate for kidney laceration, in secondary school athletes, is 1 in every 1.46 million athlete exposures. **Conclusions:** This case highlights the need for athletic trainers to investigate their competency with the diagnosis and management of traumatic abdominal injury. Although kidney laceration has similar presentation to other abdominal injuries, it is important for the athletic trainer to differentiate and recognize what key features necessitate an immediate referral. Acute renal failure can result in long-term chronic kidney disease, cardiovascular impairment, decreased kidney function, or death. Therefore, early diagnosis and treatment of a kidney laceration is essential for normal life sustaining function.

**Delayed Diagnosis and Nonunion of
4th Metatarsal Fracture in D1 Football
Player: A Type 3 CASE Study**
Helf MB, Ostrowski JL: Moravian
University, Bethlehem, PA

Background: Isolated injury to the base of metatarsals 2-4 are less common than 1st and 5th metatarsal fractures.¹ Nondisplaced metatarsal fractures typically heal with conservative management, often involving supportive shoes and progressive weight bearing,² while displaced or nonunion fractures require surgical intervention. This type 3 CASE will present atypical presentation and management of a fourth metatarsal fracture. **Patient:** Patient is an 18-year-old collegiate football cornerback who presented with chief complaint of left foot pain. He reported landing awkwardly during a drill and had difficulty weight bearing. He denied feeling pops or snaps, or previous foot injury. No visible swelling or discoloration; pain was located over the lateral aspect of the foot, over the base of the fifth metatarsal. All other palpations and motion testing were within normal limits. He had full 5/5 strength of all foot and lower leg muscles. Metatarsal squeeze test was positive with pain over the dorsal lateral foot. Distal neurovascular was intact. The patient received x-rays on-site immediately post-injury, which demonstrated a non-displaced 4th metatarsal fracture with concern for an occult 5th metatarsal fracture. Despite these findings the patient continued to deny previous injury. **Intervention & Treatment:** The patient was placed in a controlled ankle movement (CAM) boot and was non-weight-bearing (NWB) on crutches. Anti-inflammatories and acetaminophen were alternated for pain management. A CT scan the following day showed a nondisplaced fracture at the base of the fourth metatarsal with sclerotic edges and cortical thickening, indicative of incomplete / partial healing of a previous fracture. Mild irregularity was noted at the base of the fifth metatarsal, suggesting a healed fracture. He remained NWB in a CAM boot and crutches. Rehabilitation began with strengthening of intrinsic foot muscles then progressed to gentle

weight bearing exercises with little improvement in function or symptoms. He received repeat x-rays every 2 weeks to evaluate for signs of healing. When x-rays 4 weeks post-injury revealed no healing, surgical intervention was recommended. Around this time force plate testing was performed and revealed increased midfoot loading, which is believed to have contributed to the incomplete fracture healing. Five weeks post-injury, open reduction with internal fixation of the fourth metatarsal nonunion fracture was performed with iliac crest bone graft and plasma-rich-protein injection. **Outcomes or Other Comparisons:** The patient remained NWB in boot and crutches for four weeks post-surgery; during this time he performed NWB hip, knee, and ankle exercises. At this time he has been cleared to begin weight-bearing exercises. Fourth metatarsal fractures are typically treated conservatively with a short leg walking cast for 4-6 weeks, or a NWB cast for 3 weeks followed by a short leg walking cast for 3 weeks. Repeat x-rays after one week are recommended to examine the fracture position. If the position has not changed, the patient should increase weight bearing status progressively, and two-week x-rays should demonstrate signs of healing. If the position of the fracture does change, or if there are no signs of healing within four weeks, the patient may need surgical stabilization of the bone. **Conclusions:** Metatarsal base fractures are prone to nonunion. Early diagnosis, close monitoring including repeated x-rays, and limited weight bearing are crucial to promote healing, inhibit sclerotic tissue formation, and limit the likelihood of surgical intervention. Foot posture index may help identify foot postures (supinators, mid stance pronators) that could impede fracture healing in the foot, and orthotics should be strongly considered for these individuals. Surgical intervention should be considered for displaced fractures, or for fractures that remain nonunion after four weeks. **Clinical Bottom Line:** Delayed diagnosis or improper monitoring of metatarsal fractures can result in delayed healing or nonunion. Protected weight-bearing and weekly x-rays may decrease the need for surgical intervention.

Posterior Hip Dislocation in a Healthy High School Football Player: A Type 4 CASE Study

Strouse AM, Ostrowski JL, Ostrowski JA: Moravian University, Bethlehem, PA, and St. Luke's University Health Network, Bethlehem, PA

Background: A 17-year-old male high school running back with no pertinent past medical history presented with traumatic right hip pain. The patient was injured during a tackle. Immediate on-field observation revealed the patient supine with hip fixed in flexion, adduction, and internal rotation. Pain was located over the posterolateral lower back and hip, described as sharp shooting pain into the lower leg, and rated 10/10. Distal neurovascular examination was intact. Due to the location and severity of pain, and the fixed position of the femur, no additional on-field evaluation was performed and the emergency action plan (EAP) was activated. **Differential Diagnosis:** Posterior hip dislocation, femoral neck fracture. **Intervention & Treatment:** The on-field physician diagnosed the patient with a posterior femoroacetabular dislocation and attempted reduction, which was unsuccessful. Emergency medical services (EMS) were on-site and were called to the field. The patient was placed on a spine boarded with the extremity manually held in position by the athletic trainer. The patient was transported via ambulance to a local Level One Trauma Center. Plain film radiographs revealed a right posterior hip dislocation with no associated fracture. Sedation was administered and the dislocation was reduced via closed procedure. Post-reduction radiographs confirmed anatomical joint position as well as absence of femoral neck or acetabular fractures. The patient was discharged that night and instructed to be non-weight bearing with bilateral axillary crutches for the next 4-weeks, and to follow-up with the team physician. The patient underwent MRI of the right hip approximately 3 weeks post-injury to assess for onset of avascular necrosis (AVN) and potential associated soft tissue injury. The MRI did not show

any signs of AVN but did reveal a small labral tear as well as a small intra-articular loose body. Upon consultation with an orthopedic surgeon, operative management was deferred due to the lack of symptoms at this time. The patient gradually progressed with range of motion and strengthening exercises, to running, cutting, and non-contact sports activities without symptoms.

Uniqueness: Posterior traumatic hip dislocation in adolescents is uncommon, with only 2-5.5% occurring during sport activities. Owing to the force required to dislocate the femoroacetabular joint, dislocations most commonly occur from car accidents (70-84%) and falls from significant heights. Associated injuries may include acetabular, femoral, or pelvic fractures; femoral head cartilage damage; neurovascular compromise; and soft tissue disturbance. Early recognition and prompt reduction of the femur is essential for successful management and decreases the potential for long-term complications, including femoral head AVN. In this case, early recognition by the athletic trainer and appropriate on-field stabilization and referral resulted in decreased time to reduction. Following relocation of the femoroacetabular joint no significant post-traumatic damage to surrounding joint structures was found to have occurred, which allowed the patient to successfully and expediently progress with his recovery and rehabilitation. **Conclusions:** This case presents an occurrence of posterior hip dislocation in a healthy, young patient. The prompt recognition of the injury by the athletic trainer and early activation of the EAP (including on-site EMS) resulted in minimal time to joint reduction and decreased risk of secondary complications. Posterior hip dislocations are rare but possible in high school football given the high intensity of the sport. Although an uncommon occurrence, a plan for management of hip dislocations in the EAP is pertinent for the health of the athlete. This includes availability of proper equipment and early access to EMS. Knowledge of the signs and symptoms of a posterior hip dislocation as well as appropriate stabilization factors are important to reduce the risk of complications.

Isolated PCL in a 23-Year-Old Division 1 Collegiate Football Defensive Back

Player: Type 2 Clinical CASE Study

Homer M, Pollard-McGrandy AM, Worley J, Dufon S, Smith L, Zita A, Mollitor E, Rice L, Roskelly J, Belhomme T, Scott R, Nogle S, Covassin T: Michigan State University, East Lansing, MI

Background: Posterior cruciate ligament (PCL) accounts for 3.5% of acute knee injuries, however, an isolated PCL is more infrequent, with an incidence of 2 per 100,000 people. Literature on the National Football League (NFL) combines from 2009-2015 found that 3% of the players who participated had a PCL injury with the most common being a running back followed by offensive lineman. Conservatively treated a typical return to sport (RTS) for an isolated PCL is about 4-6 months. However, with the use of blood flow restriction (BFR) and the PCL Jack brace, it is possible to decrease RTS in isolated PCLs. **Patient:** A 23-year-old, male, Division 1 collegiate football player, fifth-year senior, with no previous right (R.) leg injuries, collided with two other players and fell to the ground during a game. During an on-field evaluation by the team athletic trainer (AT), athlete presented with R. knee pain, but also stable ligaments. Athlete was placed in a Donjoy

Play Maker and successfully completed sideline functional assessment and returned to the game. After a few plays, athlete returned to the sideline saying his R. knee “did not feel right”. Athlete was taken for further examination and showed a positive posterior drawer. Athlete was pulled from the game and placed in a knee immobilizer and on crutches. Imaging revealed no fractures, but an MRI revealed a grade 2 isolated PCL. **Intervention & Treatment:** The team physician and AT decided that the athlete will be immobilized in a PCL Jack brace for the first week of rehabilitation with a heavy focus on quadriceps activation (i.e., Russian Stimulation) and non-weight bearing (NWB) strengthening. BFR was performed 6 days a week, for the first 2 weeks. The second week of rehabilitation, NWB strengthening exercises progressed. Week 3, BFR was reduced to 4 days per week with the addition of Normatec boots (i.e., compression) and Therm X (cold compression). The PCL Jack brace was unlocked to 90 degrees flexion and weight bearing exercises were started. The AT incorporated passive and active stretching along with the introduction of cardiorespiratory fitness (i.e., biking, walking on anti-gravity treadmill). Week 4, the athlete successfully progressed to 80% body weight at 12 miles per hour (MPH) on the anti-gravity treadmill and started sport specific agility drills. Global positioning system (GPS) and countermovement jump force plate statistics were used to determine progression

and full return to practice. Throughout aspects of rehabilitation the athlete wore the PCL Jack brace and continued wearing it after RTS. **Outcomes or Other Comparisons:** The addition of the PCL Jack brace is unique to its added resistance of posterior tibial translation on the femur. The typical athlete takes 4-6 months to RTS following an isolated PCL injury. The athlete in this case presented was able to RTS 4 weeks after the initial injury with the use of BFR, the PCL Jack brace, and the antigravity treadmill therapy. **Conclusions:** Isolated PCLs treated conservatively can take up to 6 months before RTS. However, with the use of BFR, the PCL Jack brace, and the anti-gravity treadmill allowed the athlete to RTS at an accelerated rate. It is important to consider other factors involved, such as, early diagnosis of the injury, decision of the medical staff to use BFR, bracing options, and 6 days per week rehabilitation regimen. Adherence to the rehabilitation program was essential for progression each week. **Clinical Bottom Line:** Incorporating BFR and the PCL Jack brace into isolated PCL conservative rehabilitation protocol could afford athletes an earlier RTS. However, more research needs to be conducted to confirm the full benefits of the combination of BFR and the PCL Jack brace.

Avascular Necrosis in Tibial Sesamoid Bone in a Healthy Male Lacrosse Collegiate Athlete: A Level 3 CASE Study

Savino JT, Bartolotta D, Norkus S:
Quinnipiac University, Hamden, CT

Background: Avascular Necrosis (AVN) is bone death that occurs from temporary or permanent loss of blood supply. Some of the common causes of AVN are trauma, microtrauma, injury, and excessive use of alcohol. The purpose of this level 3 case study is to present the case of avascular necrosis in great toe sesamoid bones in a healthy collegiate athlete. **Patient:** The patient is a 22-year-old, male, Division 1 Lacrosse Player. During a preseason game, the patient reported being stepped on by an opposing player. Evaluation identified pain on his left hallux, swelling and ecchymosis around the 1st MTP joint line. He was tender to palpation at the medial MTP joint line and sesamoid bones, active great toe flexion and extension was painful, as well as pain with the end range of passive great toe extension. The patient was immediately treated for pain and inflammation, and was referred to an orthopedic. Radiographs were ordered, which came back negative. **Intervention & Treatment:** Treatment consisted of pain management and removal from play until pain resolution. After 4 weeks, the patient was released for practice and competition to tolerance. Upon return to play, he immediately reported

an increase in symptoms, including inflammation, pain, and occasional sensation deficit. Reevaluation revealed joint inflammation, tenderness at the MTP joint and sesamoid bones. The patient was referred to a foot specialist, who ordered an MRI. Six weeks after initial presentation, an MRI confirmed development of AVN of the tibial sesamoid bone on the left hallux.

Outcomes or Other Comparisons: The patient underwent a sesamoidectomy to excise the medial sesamoid bone approximately 2 months after initial presentation. He was in a soft cast for 2 weeks, then a boot with crutches for 3 weeks. The patient was cleared to begin jogging 2.5 months after surgery. **Conclusions:** It is important to understand the amount of blood that is received by the sesamoid bones to understand the chances of developing AVN. The sesamoid bones are perfused from the first plantar metatarsal artery, supplies 63% and 58% of the tibial and fibular sesamoid bones respectively. The literature has reported that both traumatic and non-traumatic events are both potential causes for the development of AVN, but research suggests microtrauma is the more common cause. The cause of injury to this patient was acute trauma. Understanding the patient's sport, and presentation of injury are vital in ruling AVN as a possible differential diagnosis. Reevaluation is crucial because worsening symptoms could indicate development of AVN. Finally, a MRI is needed to confirm this as a diagnosis. Surgical intervention is the most effective way to treat

AVN of the sesamoids with a sesamoidectomy being the most common surgery performed. Patients who received a sesamoidectomy have a 94% rate of return to sports. However, there is also a high risk of long-term complications due to the biomechanical changes to the first MTP joint's functioning. **Clinical Bottom Line:** The case presents the case of a division 1, male, lacrosse player who developed AVN in his tibial sesamoid bone of his left hallux. AVN of the sesamoids is a very rare occurrence compared to other areas such as the femoral neck. It is important to understand that if a patient's symptoms worsen overtime, a clinician needs to consider this as a possible diagnosis. Possible signs that will indicate AVN in the initial evaluation are pain under the first metatarsal head, and pain with moving the great toe into dorsiflexion and plantarflexion. Other signs and symptoms are an increase in pain and difficulty weightbearing, which are assessed during reevaluation. Once AVN has been identified, early treatment and surgical intervention results in better outcomes.

Presentation of a Vastus Medialis Oblique Tendon Rupture in a Collegiate Lacrosse Player: A Type 4 Clinical CASE Study

Schroering LP, Ellis AJ, Powden CJ:
University of Indianapolis, Indianapolis, IN

Background: The patient is a 23-year-old male lacrosse player who suffered a knee injury during the second half of a competition (4/23/2022). He reported going knee to knee with an opponent while making a full speed cut to the goal. The patient felt immediate pain and removed himself from the field with an antalgic gait. On the sideline the patient reported pain on the medial side of the knee, superior to the patella and distal quadriceps muscle belly. Additionally, palpable deformity was present when compared bilaterally just superior to the medial aspect of the patella. No significant edema or apparent ecchymosis was present immediately. MMT for the quadriceps indicated 4+/5 strength and ROM was WNLs. Athlete has no prior injury history to this knee. The patient has a history of chronic bilateral groin strains, calf strains, and lower extremity soft tissue injuries. The team physician was present at the competition and found similar physical findings. **Differential Diagnosis:** At initial evaluation, the athletic trainer and team physician came to the differential diagnoses of a vastus medialis oblique (VMO) rupture and quadriceps contusion with a palpable pocket of swelling. **Intervention & Treatment:** Following the initial evaluation, the patient was treated conservatively for a quad contusion with high suspicion

of a VMO rupture, this included removal from participation and cryotherapy. Treatment following the competition consisted of Gameready and massage to manage pain and swelling. Two days later (4/25/2022), significant swelling and bruising were noticed over the VMO insertion to the quadriceps tendon. The patient was tender to palpation along the distal VMO musculotendinous junction, with a noticeable step off deformity in this area. The patient displayed functional ROM with moderate quadriceps activation. That same day, the patient was seen again by the team physician due to deterioration. He denied popping, clicking, and catching at this time and rated his pain as a 5-6/10. All ligamentous, meniscal, and cartilaginous structures tested negative. An MRI was ordered and completed two days after consultation (4/27/2022) and revealed that the patient had a rupture of his VMO and medial patellar retinaculum. The patient was referred for a consultation with an orthopedic surgeon (4/28/2022) where he was presented with operative and nonoperative approaches to his condition. The patient chose to undergo a surgical repair of his VMO and medial patellar retinaculum. The surgery was completed twelve days after his injury (5/5/2022). Following the surgery, the patient returned home to complete rehabilitation. Recovery was estimated to take roughly three months post-operation to return to unrestricted activity. At this time the patient is completing the initial stages of his rehabilitation at home. The patient is unsure about returning to play at the college level as he was drafted into the National Lacrosse League. **Uniqueness:** Quadriceps ruptures are a relatively rare condition with about 1.37 cases occurring per 100,000 people per year. Furthermore, this

patient presented with signs and symptoms of a quadriceps contusion with visible swelling at the time of injury that masked the VMO rupture. These items in combination contributed to the delayed identification of the final diagnosis and intervention. **Conclusions:** This case presents the clinical progression of an underlying VMO tendon rupture after knee to knee contact to the quadriceps tendon. The overlying contusion and swelling delayed the identification of the VMO tendon rupture and subsequent interventions. This highlights the importance of continued evaluation and collaborations after initial diagnosis. While this case was managed surgically, the patient was given the option of conservative management. The option was presented to the patient to allow them to make the best decision for them personally.

Non-Surgical Rehabilitation of Acetabular Labral Tear Due to Structural Deformity

Velasco JL, Garruto J, Lowy N:
Kean University, Union, NJ

Background: Acetabular labral tears are generally secondary to trauma, dysplasia, capsular laxity, and degeneration. Patients with labral tears chiefly complain about anterior hip or groin pain frequently under the circumstance of femoroacetabular impingement (FAI). The injury is diagnosed through an imaging technique and through arthroscopy. If the torn labrum and the underlying etiology remains untreated, the hip joint may progress to osteoarthritis prematurely. Therefore, the emergence of labral reconstruction seems to account for a more promising outcome despite the long-term follow-up that is needed for a full recovery. Although this condition can be repaired through an invasive surgical procedure, a non-surgical treatment alternative can be more beneficial especially for athletes. This plan of action may emphasize hip and lumbopelvic stabilization, correction of hip muscle imbalance, biomechanical control, and sport-specific functional progression. **Patient:** A twenty-year-old collegiate female athlete. **Intervention & Treatment:** An athlete suffered a left hip labrum tear while competing in both volleyball and tennis in the same season. During the initial evaluation, the athlete was complaining of a dull ache over her left hip with no specific mechanism of injury and no previous history of hip or groin injury. The pain progressively got worse as she continued to

balance between rigorous practices and games with both volleyball and tennis. Playing these two sports lead to an immense amount of stress in the acetabulum joint due to the constant lateral movement. These side-to-side actions may have caused the head of the femur to repeatedly be forced into the acetabulum. Within the first few weeks of competing, the athlete was managing tightness across the entire pelvic region by getting stretched. Occasionally, the dull-aching pain would eventually transition into a sharp shooting pain down the leg especially after a game or practice. She was also point tender over the insertion of her hip flexors at the ASIS, IT band, and TFL region. The hip scouring special test was performed and revealed clicking and discomfort when the hip was passively put into internal and external rotation. **Outcomes or Other Comparisons:** The initial plan of action was to focus on hip mobility exercises and pain modulation. However, since the pain and symptoms got worse over time, the athlete agreed to sit out for the remainder of the season to be properly diagnosed by her doctor. She was sent to get an MRI and X-ray which ultimately revealed a labrum tear in her hip as well as a structural deformity of the head of the femur. According to her doctors, it was believed that the anatomical abnormality in addition to chronic overuse of the hip caused her to tear her acetabular labrum. The athlete had received platelet-rich-plasma (PRP) injections to decrease pain and improve hip functionality along with rehabilitation as an alternative to surgery. **Conclusions:** Although the athlete still has trouble with her hip, she decided to continue the non-operative rehab

route instead of surgery in order to compete in the 2022 fall season for women's volleyball. Yet, as she continued to play through the pain, complications such as tightness and discomfort had emerged from the right hip that may also be due to the structural deformity. **Clinical Bottom Line:** When dealing with an acetabular labrum tear, it is critical to identify the severity of the condition to be able to decide to clear them to play or limit their activities. In this case, there was no mechanism of injury, but instead, an anatomical deformity that could not be controlled. In the end, it comes down to either allowing the athlete to continue to compete and risk the chance of further complications later in life, or discontinuing their athletic career in order to alleviate them of their suffering.

Relationship Between Upper Extremity Segment Length and Elbow Varus Torque in Collegiate Baseball Pitchers

Warner LK, Volpi JD, Galbraith RM, Warner BJ, Cox C, Cage SA: Creighton University, Omaha, NE; UT Health East Texas, Tyler, TX; The University of Texas Health Science Center at Tyler, Tyler, TX; Grand Canyon University, Phoenix, AZ; The University of Texas at Tyler, Tyler, TX

Context: The forces produced during pitching have been associated with an increase in damage to both musculoskeletal and ligamentous structures in the upper extremity. Among baseball pitchers, over half will experience shoulder or elbow pain throughout the course of a competitive season. While rules have been changed to help reduce the risk of injury in baseball pitchers, injury rates continue to climb. It is important to identify predisposing factors for upper extremity musculoskeletal injuries among pitchers to better determine how to mitigate the risk of injury. The purpose of this study was to examine the relationships between height, weight, upper extremity segment lengths, arm speed, and elbow varus torque in collegiate baseball pitchers. **Methods:** We recruited and consented 19 college baseball pitchers (21 ± 2 years, 185.01 ± 6.45 cm, 87.43 ± 8.29 kg). The upper arm, forearm, and middle finger were measured in inches, on the throwing arm, for all subjects as follows: upper arm- from the humeral head to the lateral humeral epicondyle, forearm- from the lateral humeral epicondyle

to the Lister's tubercle of the radius, and middle finger from the third metacarpophalangeal joint to the most distal point of the distal phalanx. Varus torque was measured at the elbow in Nm, and arm speed was measured in degrees per second using a 3D accelerometer (Driveline Pulse, Driveline Baseball, Kent, WA). A total of 9,446 high intent throws were recorded for calculations. High intent throws were identified by the algorithm utilized by the manufacturers of the accelerometer. Pearson's correlations were performed to determine relationships between elbow varus torque, height, weight, and upper extremity segment lengths with significance set at $p < .05$. **Results:** There was a small positive correlation between height and varus torque ($r(17) = 0.534$, $p = .018$). A small negative correlation was found between height and arm speed ($r(17) = -0.466$, $p = 0.044$). A moderate positive correlation between weight and torque was calculated ($r(17) = 0.756$, $p < .001$). There was a small negative correlation between height and arm speed ($r(17) = -0.623$, $p = 0.004$). Finally, a small positive correlation between upper arm length and torque was found ($r(17) = .653$, $p = 0.002$). **Conclusions:** Increased athlete height and weight appear to be associated with increased varus torque at the elbow. Based on these results, increased height and weight may be associated with a decrease in arm speed. Pitchers with a longer upper arm experience more varus torque at the elbow during high intent throws. While factors such as height and limb length are static, it is important to understand their impact on forces experienced at frequently used articulations.

Relationship Between Groin Function and Previous Groin Injuries in Division I Male Soccer Players

Ulrich I, Solger E, Jochimsen KN:
West Virginia University, Morgantown, WV

Context: Groin injuries account for up to 20% of soccer injuries. Clinically, athletic trainers can assess groin function using the Copenhagen 5-Second Squeeze Test (CST). Better performance on the CST (lower groin pain) is related to higher patient-reported groin function (HAGOS Sport) in European soccer players. It is unknown if previous groin injury is associated with performance on the CST. This information may que clinicians on which players might benefit from groin conditioning to help improve groin function and reduce the risk of groin injury during the season. We aimed to examine if preseason and midseason CST and HAGOS Sport scores differed between Division I male soccer players with and without a previous groin injury, and examine the relationship between CST and HAGOS Sport scores at preseason and midseason. We hypothesized that athletes with a history of groin injury would perform worse on the preseason and midseason CST and that, consistent with previous work, better performance on the CST will be related to higher self-reported groin function at both timepoints. **Methods:** NCAA Division I male soccer players self-reported their history of groin injury and completed the HAGOS Sport scale at preseason and midseason timepoints. At both timepoints, a

single clinician performed the CST by placing their forearm between the ankles of the athlete as they performed a maximal isometric contraction for 5 seconds. Athletes rated their groin pain during the test using a verbal Numeric Pain Rating Scale (0 no pain, 10 worst pain imaginable). Following tests for normality, preseason and midseason CST and HAGOS Sport scores were compared between athletes with (INJ) and without (NON) a history of groin injury using Mann-Whitney U tests and the relationship between CST and HAGOS Sport scores was examined using Spearman's rho correlations. **Results:** In 28 Division I male soccer players, 12 (42.9%) reported having a previous groin injury. Preseason and midseason HAGOS Sport scores and midseason CST scores differed between athletes with and without a history of groin injury ($P \geq 0.03$). (Table 1) Preseason CTS scores did not differ between groups ($P=0.12$). CST scores were related with HAGOS Sport scores at preseason ($\rho = -0.53$, $P = 0.004$) and midseason ($\rho=-0.65$, $P<0.001$), such that higher pain on the CST was related to lower patient-reported groin function. **Conclusions:** These data support a positive relationship between athlete perceived groin function and previous history of groin injury. Division I male soccer players with a previous groin injury had consistently worse scores on the HAGOS and scored higher on the midseason CST than those without a previous history of groin injury. Clinically, this information may be used to guide targeted clinical interventions to improve groin function and potentially reduce the risk of re-injury.

Table 1. Preseason and Midseason Copenhagen Squeeze Test and HAGOS Sport Scores between Division I Soccer Players With and Without a History of Groin Injury

Variable of interest	Previous injury (N=12)	No previous injury (N=16)	P-value
Preseason			
CST	2.8 ± 2.6	1.4 ± 1.9	0.12
HAGOS Sport	76.0 ± 25.7	94.7 ± 12.2	0.03*
Midseason			
CST	3.5 ± 2.7	0.9 ± 1.4	0.003*
HAGOS Sport	82.0 ± 24.1	96.9 ± 6.5	0.03*

*Statistically significant $P \leq 0.05$

Effects of Exposure to Strenuous Exercise on Scapular Kinematics in Competitive Swimmers with Glenohumeral Joint Instability

Silverson OA, Gruber CL, Ludewig PM, Staker JL: University of Minnesota Medical School, Department of Rehabilitation Medicine, Division of Rehabilitation Science, Minneapolis, MN, and University of Minnesota, Department of Intercollegiate Athletics, Minneapolis, MN

Context: Frequent participation in loaded, repetitive, strenuous overhead activity can lead to altered shoulder kinematics and ultimately induce pain or discomfort during activity. While previous research suggests that exposure to short bouts of strenuous overhead activity may provoke changes in scapular rotations during arm activity, the magnitude of these effects is unclear. Therefore, our objective was to investigate how three-dimensional (3D) scapular rotations changed during dynamic arm elevation before and after exposure to a strenuous bout of shoulder exercise in competitive swimmers with glenohumeral joint instability. We hypothesized that exposure to strenuous exercise would induce altered 3D scapular rotations during arm elevation. **Methods:** Twenty-three competitive swimmers (17 females, age: 20.7 +/- 4.8 years, 6 males, age: 33.8 +/- 19.6 years) participated in this repeated measures study occurring in a biomechanics laboratory. Glenohumeral joint

instability was determined based on a previously validated clinical examination and patient-reported symptom survey. Shoulder kinematics during scapular plane abduction (SAB) were recorded with dynamic biplanar video radiography before and after participants performed a strenuous exercise protocol of 15 repetitions of resisted (two pounds) SAB and humerothoracic external rotation and internal rotation in a 90/90 position. Participants completed consecutive rounds of exercise until a 5/10 on a 0-10 rate of perceived exertion scale was reported. Three-dimensional participant-specific bone models of the humerus, scapula, and thoracic cage were derived from low-dose computed topography images and used for 2D/3D shape-matching motion tracking. Highly accurate measures of scapulothoracic upward, internal, and posterior rotation (error <1.6 degrees) were independently compared between timepoints (pre-/post-exercise) with a two-way repeated measures analysis of variance (ANOVA) for each scapular rotation at five different angles of humerothoracic elevation (30, 60, 90, 120, 150 degrees) (alpha <0.05). **Results:** There were no interaction effects between timepoint and the humerothoracic elevation angle for any of the three scapular rotations. A significant main effect of timepoint (p = 0.014) existed for scapular internal rotation (2.48 degrees less after exercise) across the total range of motion. No significant main effects of timepoint for scapular upward rotation or posterior tilt were found (Table 1). **Conclusions:** Strenuous exercise induced altered scapular internal rotation during SAB,

thus partially supporting our hypothesis. These findings suggest that participation in short bouts of strenuous shoulder exercise may have a small effect on the magnitude of scapular rotations in competitive swimmers during dynamic activity. Participation in overhead activity for longer time periods with higher loads could result in larger changes in scapular rotations. Results from this analysis could be used by clinicians treating overhead athletes to consider the effects of training load and duration on shoulder movement characteristics. Future research should consider the effects of strenuous shoulder exercise on glenohumeral joint kinematics in swimmers with glenohumeral joint instability.

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3. American Society of Biomechanics Student Grant-in-Aid: "Kinematics of shoulder instability." PI: Oliver A Silverson.
4. University of Minnesota Grant-in-Aid: "Mitigating the Impact of Shoulder Movement Dysfunction; A Randomized Controlled Trial." PI: Justin L Staker.

Table 1: Main Effect of Exercise on Scapular Rotations

Scapular Rotation	Pre-exercise Mean (SD)	Post-exercise Mean (SD)	Difference in means	p-value (p < .05)	95% Confidence Interval	Effect Size (Cohen's d)
Upward rotation (-)	-30.92 (14.12)	-31.93 (14.45)	-1.01	0.612	-2.91 - 4.92	0.071
Internal rotation (+)	28.18 (6.74)	25.70 (7.74)	-2.48	0.014*	0.51 - 4.49	0.344
Posterior rotation (+)	2.08 (9.22)	2.05 (9.36)	-0.03	0.984	-2.52 - 2.57	0.003

All values reported in degrees except for p-values, confidence intervals, and effect size.

(-) Scapular rotation in the negative direction = more upward rotation.

(+) Scapular rotation in the positive direction = more internal or posterior rotation, respectively.

SD: standard deviation.

*Indicates a statistically significant difference between timepoints (<0.05).

The Modified Dynamic Integrated Movement Enhancement Warm-Up Improves Dynamic Balance Symmetry in Army ROTC Cadets

Earl-Boehm JE, Ericksen HM, Lally EM, Mach MM, Reckelberg RM: University of Wisconsin-Milwaukee, Milwaukee, WI

Context: Army Reserve Officers' Training Corps (ROTC) cadets participate in rigorous physical training to prepare for the demands of military operations. An unfortunate consequence of physical training is high musculoskeletal injury (MSKI) rates among ROTC cadets. Poor dynamic balance is a known risk factor for MSKI found in ROTC cadets. The Dynamic Integrated Movement Enhancement (DIME) warm-up, previously implemented in the military setting, could improve cadet's dynamic balance but has not been tested within ROTC. The purpose of this project was to determine if a modified DIME warm-up intervention changed dynamic balance in ROTC cadets. **Methods:** Nineteen (11 M, 8 F; 21.4±3.5yrs; 1.7±0.1m; 74.0±15.3kg) ROTC cadets performed the Y-Balance test of dynamic balance using

standard procedures. Cadets then participated in the researcher led modified DIME warm-up twice per week for 8 weeks. The 10-exercise warm-up included full-body dynamic movements and several single-leg balance and hopping exercises. Cadets continued the usual physical readiness training throughout the study. Post-testing occurred the week following the end of the intervention. Right-left(RL) reach distance differences were calculated from the raw scores (cm) for anterior (ANT), posterior-medial (PM), and posterior-lateral (PL) directions, as in previous studies. Maximum composite reach distance was calculated: ((ANT+PM+PL)/3). A repeated measures ANOVA was performed using variables with known relationships to injury risk: ANT-RL difference, PM-RL difference, PL-RL difference, composite RL difference, and normalized ANT reach distance.(P-value < .05) Scores were categorized into high and low risk for descriptive analysis: high risk (> 4cm) or low risk (≤ 4cm) for directional scores, high risk (≥ 12cm) or low risk (< 12cm) for composite score, and high risk (≤ 72%) or low risk (> 72%) for normalized anterior reach distance. **Results:** There was a significantly smaller difference between R and L composite

reach distances after the intervention (p=.034; Pre=6.74±4.98cm ,Post=3.81±3.61cm). There were no significant differences between Pre and Post R-L differences in the ANT, PM, or PL directions or anterior normalized reach. (p>.05, Table) The number of cadets with scores in the high-risk category decreased after the intervention for each score except the anterior normalized reach distance. **Conclusions:** Cadets had more symmetrical dynamic balance following the DIME warm-up intervention, a positive finding given the relationship between asymmetrical reach and MSKI. Based on established cut off scores more cadets were in the low-risk group after the intervention than before. This study found that 86% of cadets fell below the 72% normalized ANT reach distance threshold that was among a multi-factor predictive model for MSKI in the military population. This alarming finding suggests research should continue to investigate additional strategies to improve dynamic balance such as using the DIME warm-up daily in a larger ROTC battalion.

Wisconsin Athletic Trainers' Association, 2021 Research Award

Table: Raw reach distance right-left (R-L) differences and injury risk categories based on established values from the literature.

Raw reach distance differences (cm)				
	Pre-test	Post-test	p-value	
Anterior reach R-L difference	2.3 ± 1.6	1.6 ± 1.2	0.19	
Posteromedial R-L difference	3.1 ± 2.2	2.6 ± 1.9	0.41	
Posterolateral R-L difference	3.8 ± 2.4	2.6 ± 2.1	0.12	
Composite score R-L difference*	6.7 ± 5.0	3.8 ± 3.6	0.03	
Anterior normalized reach distance	62.2 ± 7.3	63.0 ± 6.5	0.44	
Injury risk categories % (n)				
	Pre-test (21)		Post-test (19)	
	High Risk	Low Risk	High Risk	Low Risk
Anterior reach R-L difference**	28% (6)	71% (15)	10% (2)	90% (17)
Posteromedial R-L difference**	43% (9)	57% (12)	32% (6)	68% (13)
Posterolateral R-L difference**	57% (12)	43% (9)	32% (6)	68% (13)
Composite score R-L difference#	19% (4)	81% (17)	5% (1)	95% (18)
Anterior normalized reach distance ^	86% (18)	14% (3)	90% (17)	10% (2)

*Significant difference between Pre and Post test, p<.05

**For directional R-L differences high risk >4cm, low risk ≤4cm. 2 participants did not complete any post-test.

#For composite score differences high risk ≥12cm, low risk <12cm).

^For normalized anterior reach distance was categorized as high risk (≤72%) or low risk (>72%)

Inter-Limb Asymmetry in Lower Body Strength Among Firefighters

Luedke J, Almonroeder T, Dobbs W, Zapp A, Markert A, Erickson J, Jagim A: Sports Medicine, Mayo Clinic Health System, La Crosse WI; 2Physical Therapy, Trine University, Fort Wayne, IN; Exercise & Sport Science, University of Wisconsin – La Crosse, La Crosse, WI; Fire Rescue Wellness, Chicago, IL; La Crosse Fire Department, La Crosse, WI

Context: The degree of side-to-side (inter-limb) asymmetry in lower body strength is commonly examined in athletes, since athletes who exhibit greater asymmetry in lower body strength appear to be more susceptible to musculoskeletal injury. Previous studies indicate, on average, uninjured inter-collegiate athletes exhibit inter-limb lower body strength asymmetries of approximately 6-8% (based on the percent difference between the limbs). However, less is known about the typical degree of inter-limb lower body strength asymmetry exhibited by different tactical athlete populations, such as firefighters. The purpose is to describe the typical degree of inter-limb asymmetry in lower body strength exhibited by firefighters. **Methods:** Seventy-one firefighters (age: 36.5 ± 9.0 years.; height: 1.81 ± 0.06 m; weight: 91.2 ± 13.10 kg; BMI: 27.9 ± 3.8 kg/m²) completed an isometric mid-thigh pull (IMTP) test. The IMTP test involves generating force through their lower body to pull upward as forcefully as possible on a barbell locked at mid-thigh height. The IMTP test is very commonly used to assess lower body strength in athletes. The firefighters who participated in this study completed 2 successful trials of the IMTP

test, with a rest period between trials. During performance of the IMTP test, vertical ground reaction force data were recorded for both limbs using a dual force plate system, which sampled at 1,000 Hz (Hawkins Dynamics, USA). Peak forces were identified for each limb during performance of the IMTP test and a limb symmetry index was calculated by finding the percent difference in the peak forces for the right and left limbs. In this case, a higher symmetry index value reflected greater inter-limb asymmetry, with 0% reflecting perfect inter-limb symmetry (i.e. equal force produced on the right and left limbs). Descriptive statistics and a 95% confidence interval (CI95%) were generated to summarize the degree of inter-limb asymmetry exhibited by the firefighters. **Results:** The mean (\pm standard deviation) peak force limb symmetry index was $19.4 \pm 14.2\%$ (minimum = 0.5%; maximum = 68.5%). The lower bound and upper bound of the 95% confidence interval were 16.1% and 22.7%, respectively (CI95% = [16.1%, 22.7%]). Fifty-one of the firefighters (71.8%) exhibited a limb symmetry index of 10% or greater, which is generally considered a notable degree of asymmetry. **Conclusions:** Overall, the firefighters who participated in this study exhibited a greater degree of inter-limb strength asymmetry compared to what is typically observed in uninjured inter-collegiate athletes. In addition, a large proportion of the firefighters exhibited inter-limb asymmetry of 10% or greater, suggesting that many firefighters exhibit notable side-to-side differences in lower body strength. As a result, it appears that firefighters may benefit from training to promote inter-limb symmetry in lower body strength (e.g. single leg strengthening), in order to reduce their risk of musculoskeletal injury.

Relationships Between Shoulder and Upper Extremity Neuromuscular Function and Patient-Reported Outcomes in Individuals With Glenohumeral Labral Repair

Takeo K, Ingersoll CD, Glaviano NR, Khuder S, Norte GE: University of North Georgia, Dahlonega, GA; University of Central Florida, Orlando, FL; University of Connecticut, Storrs, CT; University of Toledo, Toledo, OH

Context: Patient-reported outcomes are essential to patient-centered healthcare, and serve as important anchors to understand whether impairments in disease-oriented outcomes may be clinically meaningful or not. While known deficits in objective measures of neuromuscular function of the arm and shoulder are reported among individuals with glenohumeral labral repair, translation of these findings to patient-reported outcomes is unclear. Therefore, our objective was to determine the relationships between objective measures of upper extremity neuromuscular function and patient-reported outcomes in individuals with a history of glenohumeral labral repair. We hypothesized that muscle weakness and lesser neural drive to muscles surrounding the glenohumeral joint would associate with worse patient-reported outcomes. **Methods:** Sixteen individuals with a primary, unilateral glenohumeral labral repair at least 6 months after surgery (13 males, 3 females; age: 24.1 ± 5.0 years; time from surgery: 36.7 ± 33.3 months) participated in this cross-sectional study. Mass-normalized shoulder abduction and wrist flexion maximal voluntary isometric contraction (MVIC) torque (Nm/kg), motoneuron pool excitability of the flexor carpi radialis (Hoffmann reflex), corticospinal excitability of the upper trapezius, middle deltoid, and flexor carpi radialis (active motor threshold [AMT, %]) were measured in the involved limb during two visits. The Disability of Arm, Shoulder and Hand (DASH) scores and Oxford Shoulder

Score (OSS) were used to quantify perceptions of shoulder and upper extremity function. The Physical Component Score (PCS) and Mental Component Score (MCS) of the Veteran's Rand 12-Item Health Survey (VR-12) were used to quantify perceptions of global health and well-being. Patient demographics of age (years), current activity level (Tegner Activity Scale), pain (cm, visual analog scale), and time from surgery (months) were also used for analysis. Bivariate correlation coefficients were used to assess relationships between demographics, objective measures of neuromuscular function, and patient-reported outcomes. **Results:** Involved limb wrist flexion MVIC torque was moderately correlated with DASH score ($r = -.523$, $R^2 = .27$, $p = .045$), suggesting that wrist flexor weakness associated with worse upper extremity function. Involved limb AMT of the middle deltoid was moderately correlated with OSS ($r = .570$, $R^2 = .32$, $p = .021$), suggesting that lesser corticospinal excitability associated with worse shoulder function after surgery. Younger age moderately associated with worse global health and well-being (physical: $p = .623$, $R^2 = .39$, $p = .010$; mental: $p = .550$, $R^2 = .30$, $p = .027$). There were no additional relationships observed among the remaining variables (all $p > .05$). **Conclusions:** Wrist flexor weakness (27% variance), lesser corticospinal excitability of the deltoid (32% variance), and younger age (30-39% variance) associated with worse regional and global self-reported function among individuals with glenohumeral labral repair. These findings support the inclusion of outcomes that assess distal muscle strength and adjacent neural drive to inform treatment practices. Future investigations are warranted to identify minimal clinically important differences for these objective measures of neuromuscular function to determine their translation to perceptions of regional and global health and well-being.

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A Pilot Study: The Role of Kinetic Energy in Augmenting Neurobiomarker Expression in Sports Shooting Events
Jones L, Cyphert H, Powell RO, Konz SM: Marshall University, Huntington, WV

Context: Contact sports account for most of the diagnosed concussions. However, sports cause head injuries through non-contact mechanisms. Sudden and repeated impacts or quick shifts in the head position can cause brain slosh, which creates pressure changes in the fluid encompassing the brain. As a result, these pressure changes can create cavitation mechanisms, subsequent brain deformations, and void creation. This pilot study allowed us to expand our research paradigm to understand the role of recoil and energy transfer on the neuronal physiology of those who undergo repeated low-level head acceleration. We questioned if shooting a firearm could result in neurobiomarker expression changes in sports shooters. **Methods:** Eleven participants (5 females, 6 males) with varying levels of shooting experience were recruited using flyers. Each participant (43 YO, 1.77m, 85.50kg, 27.20 BMI) used the same 12-gauge shotgun Winchester model 1300 using ammunition (2 ¾ inches, 1 1/8oz, 8 shot). Each participant shot 25 rounds at airborne clay targets. Clay targets were thrown directly in front of the shooter to minimize shooter rotation. Participants were filmed with a video camera at 120 frames and

analyzed (Kinovea ver. 0.9.5, Roubiax, France) to determine head and gun acceleration. The initial and final positions were recorded in Excel software. Velocity, acceleration, kinetic energy, force, and recoil variables were calculated. Participants were subjected to a venipuncture pre-shooting, 30 minutes-, and 24hr post-shooting. Data are presented as normalized averages, standard error of the mean (SEM), and p-values using a two-tailed t-test. **Results:** Following 25 rounds of 12-gauge sports shooting, an average of 2.65 ± 0.99 m/s² of head acceleration, 0.29 ± 0.16 N of force, and 18.16 ± 7.06 J of kinetic energy with each shot lasting 0.13 ± 0.04 seconds was experienced. Participants experienced an accumulation average of $62.06 \pm 0.23.53$ m/s² of head acceleration, 4.28 ± 3.34 N of force, and 84.86 ± 52.64 J of kinetic energy over 3.04 ± 0.96 seconds. Post-shooting 24hr GFAP levels trended higher. Protein concentrations averaged 4.894 ng/ml pre-shooting and 9.57 ng/ml 24-h post-shooting. In the 6 participants with detectable GFAP, 5 displayed higher 24h GFAP levels compared to the pre-shooting measurement. In addition to GFAP, we also evaluated UCHL1, and there was a statistically significant increase in 24hr UCHL1 levels **Conclusions:** Twenty-five rounds of trap shooting are sufficient to elicit changes in neurobiomarker levels over 24 hours. Head acceleration was low for single shots; however, the accumulated totals for the 25 rounds exceeded traditionally accepted concussion levels.

Relationship Between Trunk Endurance and Biomechanics During a Jump Landing Task in ROTC Cadets

Malone ZC, DiStefano LJ, Devaney LL, Burland JP, Sheldon LN, Virtudes S, Zuk EF, Glaviano NR: University of Connecticut, Storrs, CT

Context: Optimizing physical performance, while minimizing injury risk is important for Reserve Officers' Training Corps (ROTC) cadets. Trunk activation is known to influence lower extremity kinematics and has become a focus for the military, recently being a required measure in military physical fitness testing and is known to influence lower extremity kinematics during drop landing tasks. The landing error scoring system (LESS) is a valid and reliable measure for identifying high-risk movement patterns during a drop vertical jump task in active-duty military populations. However, trunk endurance has not been explored in relation to potential movement errors associated with injury risk. This study aimed to evaluate the relationship between trunk endurance and biomechanics performance during the LESS in ROTC cadets. **Methods:** A cross-sectional study design was used to compare the relationship between trunk endurance and LESS score for 53 ROTC cadets (age: 20.22 years \pm 1.69, height: 174.37 cm \pm 8.46, weight: 73.15 kg \pm 13.04). Trunk endurance was measured with a side plank hold for maximal time in a single trial. The jump landing task was evaluated using a markerless motion capture system (Physimax

Technologies LTD, Tel Aviv, Israel) integrated with an Xbox Kinect camera (Microsoft, Redmond, WA). Total LESS score and errors related to frontal plane motion, specifically medial knee displacement and lateral trunk flexion at peak knee flexion, were scored via an automated scoring system. A larger total score on the LESS indicates increased biomechanical movement errors. Two-tailed bivariate Pearson correlation was used to assess the association between trunk endurance and performance on the LESS, statistical significance was set at $P < .05$. Correlations were defined as weak ($< .4$), moderate (.4-.7) and strong ($> .7$). **Results:** The average plank time for cadets was 88.50 ± 32.23 seconds while the average total LESS score was 5.36 ± 2.07 errors. There was a non-significant weak association between trunk endurance and the total LESS scores ($r = -.244$, $p = .078$), left medial knee displacement ($r = -.177$, $p = .206$), and lateral trunk flexion ($r = -.175$, $p = .209$). There was a weak significant association between lateral trunk endurance and right medial knee displacement ($r = -.307$, $p = .026$). **Conclusions:** The results of this study showed weak to no correlations between trunk endurance and biomechanical errors during LESS in ROTC cadets. Our results show no clinical significance between trunk endurance and total LESS scores; however, looking at individual components of the LESS we found a weak association between trunk endurance and right medial knee displacement. Future research should look at the association between trunk endurance and other individual components of the LESS in the ROTC population.

The Impact of Generalized Joint Laxity on Dynamic Postural Stability and Its Relationship to Sensory System

Park-Braswell K, Keller JR, Thompson AJ: Indiana Wesleyan University, Marion, IN

Context: Generalized joint laxity (GJL) is described as excessive range of joint movements. It is shown that individuals with GJL present an impaired somatosensory system and poor postural stability. These impairments may put those individuals at a higher risk of musculoskeletal injuries. Since postural stability is controlled by the somatosensory, vision, and vestibular systems, individuals with impaired somatosensation may develop compensatory strategies within these systems in order to maintain postural stability. While decreased postural stability in individuals with GJL is well identified, its relationship with sensory utilization is not yet well understood. Thus, the purpose of this study is to determine the differences in dynamic postural stability between GJL and non-GJL (NGJL) individuals, and the relationship between dynamic postural stability and sensory systems. These findings will help clinicians better understand dynamic postural control strategies in individuals who are at high risk of musculoskeletal injuries. **Methods:** Eighteen healthy and physically active college students (20.28 ± 1.07 yr; 71.83 ± 13.0 kg; 1.72 ± 0.11 m) without any previous severe lower leg pathologies or surgeries volunteered for this study. Generalized joint laxity was measured using the Beighton-Horan Joint Mobility Index (BHJMI) to assign participants to either the GJL (BHJMI >5 ; $N=10$) or NGJL group (BHJMI <5 ; $N=8$). Dynamic postural stability measurements were obtained using

the time to stabilization test (TTS) in anterior/posterior and medial/lateral directions following single-leg jump landing tasks. Participants also completed the sensory organization test (SOT) via the computerized dynamic posturography system (CDP), Bertec Inc.® The CDP system examines the equilibrium index while different sensory systems are challenged and provides systemic average sensory scores. Independent t-tests were used to compare the TTS between GJL and NGJL group, and Pearson correlation coefficients were used to assess the relationship between TTS and sensory scores in GJL and NGJL separately. **Results:** Individuals with GJL demonstrated longer time to stabilize compared to NGJL individuals in medial/lateral direction (2.97 ± 0.59 and 2.47 ± 0.63 sec) and anterior/posterior direction (3.88 ± 0.19 and 3.85 ± 0.18 sec). However, there was no statistical significance in either direction ($p=0.11$ and $p=0.73$, respectively). A significant negative correlation between somatosensory score and TTS in medial/lateral direction ($r=-.77$, $p=.009$), and a positive correlation between vestibular score and TTS in medial lateral direction ($r=.73$, $p=.018$) were demonstrated in individuals with NGJL. However, no significant correlation was found between sensory system scores and TTS in GJL group ($p>.05$). **Conclusions:** The study's results indicate a positive relationship between high somatosensation and better dynamic postural stability in healthy individuals without GJL. This relationship is generally understood, however, GJL may negatively impact postural control thereby influencing individuals to develop different sensory utilization strategies to maintain postural stability. Further studies with a larger sample size will assist clinicians and researchers in better understanding postural control strategies in individuals with GJL.

Measures of Arch Height and Mobility Are Not Correlated With Y-Balance Performance

Newsham KN, Vardiman JP: Saint Louis University, St. Louis, MO, and Kansas State University, Manhattan KS

Context: The foot is a complex structure, playing a vital role in body-ground interface in standing and movement. The interplay of stability and mobility is critical to efficient function in many activities, including balance activities. Arch height and arch mobility have been associated with static balance performance. The purpose of this study was to assess the relationship between arch rigidity and dynamic balance performance. **Methods:** A convenience sample participated in this cross-sectional study. Thirty-nine physically active, uninjured, individuals (age 21.6 \pm 2.8 years; 30 females, 9 males) reported to the Integrated Health + Movement Science Lab and were assessed for Arch Height Index (AHI) and Y-Balance performance. AHI is determined by the height of the dorsum of the foot at 50% of foot length / truncated foot length; measured in a seated and standing position. Lower quarter Y-Balance scores (normalized for leg length) were recorded for three directions. Arch Rigidity Index (ARI = AHI standing/AHI seated), and Arch Height Difference (AHD; height of dorsum seated – height of dorsum standing) were calculated. Descriptive analysis included means and standard deviation

and Pearson correlation between arch height and mobility measures and Y-balance performance was calculated. Alpha was set at .05.

Results: Means and standard deviations were obtained for AHI seated .381 (\pm .037), AHI standing .359 (\pm .036); AHD 3.37 (\pm 1.72), ARI .941 (\pm .023) and Y-balance Anterior reach 62.29 (\pm 5.40), Posteromedial reach 99.80 (\pm 7.16) and Posterolateral reach 94.53 (\pm 6.20). Pearson correlation revealed no significant correlations between AHI standing and Y-Balance (Anterior $r(33)$ = -.23, p =.16, Posteromedial $r(33)$ = -.03, p =.85; Posterolateral $r(33)$ = -.28, p =.09), nor ARI and Y-Balance (Anterior $r(33)$ = -.003, p =.98; Posteromedial $r(33)$ = .18, p =.26; Posterolateral $r(33)$ = .09, p =.60), nor between AHD and Y-balance (Anterior $r(33)$ =.19, p =.24; Posteromedial $r(33)$ =.23, p =.16; Posterolateral $r(33)$ = .15, p =.39) **Conclusions:** In this small sample, we found no significant relationship between arch height and dynamic balance, nor did we find a relationship between measures of arch mobility and dynamic balance. We did not capture center of pressure during the dynamic balance testing, potentially missing important influences of arch height and arch mobility on dynamic balance. The potential for compensatory movements within the kinetic chain may limit the reliability of dynamic balance testing absent force plate technology.

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The Prevalence of Symmetry in the Crouching Cheng Shape

Lew JK, Arellano HA, Edwards ML, Havey TH, Hetzler BS, Hetzler TM, Christian ME: Missouri State University, Springfield, MO

Context: Functional movement is necessary to perform activities of daily living and sports-related skills. Asymmetry is seen as a limitation to functional movement, however, there is limited research on the prevalence of asymmetry in the healthy population. The objective of this study is to utilize the Shapes of Movement (SoM) profile to observe the prevalence of asymmetry amongst healthy individuals. **Methods:** This study utilized a cross-sectional design and was performed in a research laboratory. The convenience sample of 17 individuals participated in this study (male=5; female=12; age=22.47±1.18yrs; weight=167.71±32.72lbs; height=67.56±3.67in) on a Midwest university campus. Participants had no current musculoskeletal, neurological, or medical injury or illness that was a contraindication to performing the position, and were between the ages of 18 and 64. Participants reported for a single session to perform the Crouching Cheng shape (Figure 1) through verbal instructions from the investigator and 2 other shapes not analyzed for this study. To perform the shape, participants were instructed to maintain an asymmetrical

single-leg stance in a half squat. Participants held the position while criteria were assessed to determine if they passed or failed the shape. To have symmetry, the participant must pass or fail the Crouching Cheng criteria on both the right and left sides. Asymmetry is prevalent when the participant passes the Crouching Cheng criteria on one side and fails on the other side. Data were analyzed using descriptive statistics and correlations. Data collection is continuing and will be completed with approximately 100 participants by the time of the presentation. **Results:** Preliminary data analysis found of the 17 participants, the majority failed the Crouching Cheng shape criteria on the right (fail=11 [64.7%], pass=6 [35.3%]) and the left (fail=13 [76.5%], pass=4 [23.5%]). There was a positive, significant relationship between the right Crouching Cheng and the left Crouching Cheng ($r=.751$, $p<.001$). There was a statistically significant association between the right and left Crouching Cheng shapes, $\chi^2(1) = 9.59$, $p = .002$. The association between the right and left Crouching Cheng shapes was strong ($\phi_c=.751$). Out of 17 participants, 15 presented with symmetry, while 2 presented with asymmetry. **Conclusions:** Using the SoM profile criterion, healthy individuals show symmetry in the Crouching Cheng shape. Despite the general assumption that humans are side-dominant, healthy individuals are capable of showing symmetry in asymmetrical functional movements.

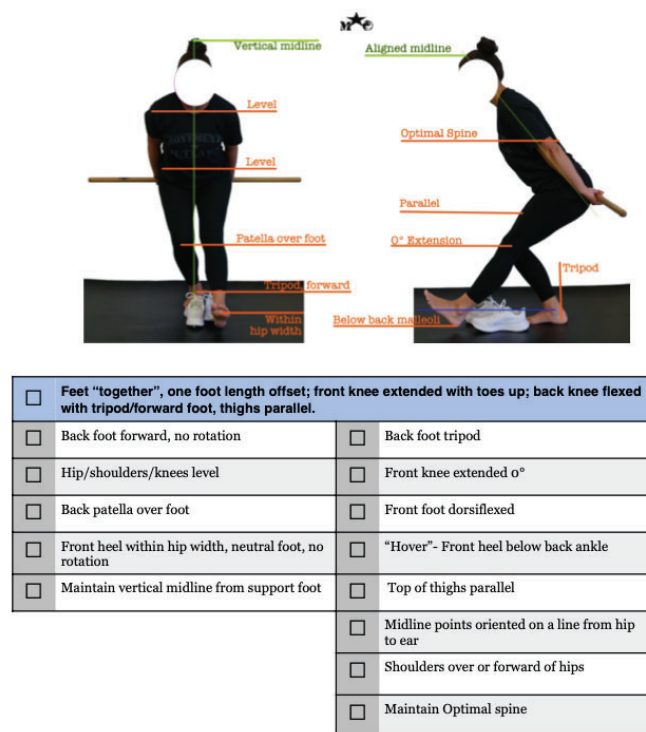


Figure 1. Crouching Cheng shape and criteria.

Workload of Collegiate Marching Artists During a Division I Football Game Day

Brancalone MP, Edwards NA, Greve K, Caccese JB, Onate JA: The Ohio State University, Columbus, OH

Context: Workload monitoring can provide athletic trainers, coaches, and athletes with objective measures of performance to reduce fatigue or injury risks. Marching artists practice and perform with a high physical activity volume while marching with their instrument. Minimal evidence is available regarding the physical demands experienced by marching artists throughout a game day. Therefore, the purpose of this study was to examine accelerometry-derived workloads of collegiate marching artists throughout a college football game day. **Methods:** Fifteen marching artists completed this cross-sectional study (12 males, 3 females; 21.23±1.23 yrs; 1.77±0.12 m; 74.78±11.17 kg). Data were collected throughout game day during the 2022 college football season with a single inertial measurement unit (IMU) (Opal, APDM, Portland, OR, USA) attached to the participant's right shank with athletic wrap. All ambulatory physical activity throughout the day was recorded, including the rehearsal period prior to the game and the performance period during the game. Data were collected at 200Hz, and manually recorded timestamps were used to identify the beginning and end of the rehearsal and performance periods. Data processing was performed in MATLAB (MathWorks, Natick, MA, USA). Consistent with prior work, data were band-pass filtered between 0.2Hz and 8.0Hz with high-pass and low-pass fourth-order Butterworth filters, respectively. A stride was identified as a vertical acceleration surpassing 0.5g's no closer than 300 milliseconds from another stride. Data were also visually inspected to confirm their step-detection accuracy while marching. Outcome measures

of interest included total step count, average steps per minute, and vertical acceleration magnitudes (measured as gravitational forces equivalents; g's). We reported total workload throughout the day and compared workload between rehearsal and performance periods using a paired-samples t-test and calculated Cohen's d effect sizes. **Results:** Throughout the game day (10 hours and 28 minutes), marching artists performed 23020.40±2650.33 steps (37.23±8.40 steps/minute) with mean vertical accelerations of 1.16±0.44g and peak vertical accelerations of 4.35±0.92g. Marching artists had a higher step count during the rehearsal period (2104.53±410.63 steps) than during the performance period (1232.46±149.87 steps) ($p<0.001$; $d=6.05$). However, the step rate was lower during the rehearsal period (77.27 steps/minute) compared to the performance period (96.17 steps/minute) ($p<0.001$; $d=5.40$). Vertical accelerations were also lower during rehearsal (mean=1.34±0.10g, peak=3.38±0.88g) than performance period (mean=1.45±0.10g, peak=3.49±0.73g) ($p<0.001$; $d=1.48$). **Conclusions:** This research highlights the workload of marching artists during a collegiate football game day. Findings suggest that the vast majority of steps taken throughout the day are outside of rehearsal and performance periods. However, instrument load was not considered during these critical periods, which may place greater stress on the body. Ultimately, healthcare professionals should consider the physical demands that marching artists experience throughout a college game day to reduce fatigue or injury risks for this unique population.

Onate, James (PI); Caccese, Jaclyn. Defense University Research Instrumentation Program (N00014-21-1-2943). Office of Naval Research. \$506,326 (September 2021 – September 2022). TEAM-UPS: Tactical Exposure Assessment Metrics – Utilizing Physiologic Signatures.

Injury and Treatment Characteristics of Patients With Low Back Pain Receiving Care From Athletic Trainers: A Report From the Athletic Training Practice-Based Research Network

Pierce JL, Lam KC: Boston University, Boston, MA, and AT Still University, Mesa, AZ

Context: Low back pain is common in populations that receive care from athletic trainers. While epidemiological studies provide insight into injury characteristics of patients with low back pain, little is known about how these patients are managed by athletic trainers at the point-of-care. The purpose of this study was to describe injury and treatment characteristics of patients with low back pain receiving care from athletic trainers. **Methods:** We conducted a retrospective analysis of de-identified patient data from the Athletic Training Practice-Based Research Network. Data were recorded between 2009-2021 by 171 athletic trainers (female=88, 51.5%) practicing in 68 clinical sites (secondary school=46, college=16, clinic=4, military=1, and industrial=1) across 21 states. Athletic trainers were, on average, certified for 6.1 ± 7.6 years and employed at their clinical site for 3.0 ± 5.3 years. Patients were diagnosed with low back pain by an athletic trainer and identified using the International Classification of Disease-10 diagnosis code for low back pain (M54.5). Descriptive statistics (frequency counts, percentage, mean, median, standard deviation, range, interquartile range [IQR]) were used to summarize injury (sport, time of injury, mechanism of injury) and treatment (amount, duration, and type of care) characteristics.

Results: A total of 460 patient cases (male=234, 50.9%) were included in this study. Low back pain was most frequently diagnosed in patients participating in football ($n=79$, 17.7%), volleyball ($n=68$, 14.8%), basketball ($n=55$, 11.9%), and soccer ($n=45$, 9.8%) (Table 1). Low back pain most often occurred during in-season practice ($n=206$, 44.8%), non-sport related activity ($n=67$, 14.6%), and in-season competition ($n=46$, 10.0%). The most common mechanisms of injury were insidious onset ($n=246$, 53.5%), non-contact ($n=134$, 29.1%), and contact ($n=40$, 8.7%). Athletic trainers provided 3,817 treatment services to patients with low back pain across a median of 3 visits per patient case (IQR=1-5, range=1-40) in which patients were provided a median of 2 services per visit (IQR=1-3, range=1-20). The median duration of care was 8 days (IQR=0-29, range=0-80). The most common services provided were hot or cold packs ($n=745$, 19.5%), manual therapy techniques ($n=442$, 11.6%), therapeutic exercise (procedure) ($n=436$, 11.4%), and electrical stimulation ($n=391$, 10.2%). **Conclusions:** To our knowledge, this is the first study to describe treatment characteristics of patients with low back pain receiving care from athletic trainers. Our findings suggest that athletic trainers are managing patients with low back pain using current best practices. Our findings related to injury characteristics also concur with previous epidemiological studies. Athletic trainers play an important role in the management of low back pain, and future research should investigate direct cost of care and patient outcomes related to athletic trainers' management of low back pain.

Low Back Pain Diagnosis (Sport or Occupation)			
Sport	Male (n,%)	Female (n,%)	Total (n,%)
Football	79 (33.8)	0 (0.0)	79 (17.17)
Volleyball	7 (3.0)	61 (27.0)	68 (14.78)
Basketball	28 (12.0)	27 (11.9)	55 (11.96)
Soccer	19 (8.1)	26 (11.5)	45 (9.78)
Track	18 (7.7)	11 (4.9)	29 (6.3)
Other	10 (4.3)	19 (8.4)	29 (6.3)
Industrial Worker	23 (9.8)	4 (1.8)	27 (5.87)
Military	10 (4.3)	9 (4.0)	19 (4.13)
Softball	0 (0.0)	15 (6.6)	15 (3.26)
Baseball	14 (6.0)	0 (0.0)	14 (3.05)
Cross Country	5 (2.1)	7 (3.1)	12 (2.61)
Swimming	3 (1.3)	9 (4.0)	12 (2.61)
Recreational Athlete	4 (1.7)	4 (1.8)	8 (1.74)
Tennis	1 (0.4)	7 (3.1)	8 (1.74)
Lacrosse	2 (0.9)	5 (2.2)	7 (1.52)
Field Hockey	0 (0.0)	7 (3.1)	7 (1.52)
Cheerleading	0 (0.0)	6 (2.7)	6 (1.3)
Gymnastics	0 (0.0)	6 (2.7)	6 (1.3)
Wrestling	6 (2.6)	0 (0.0)	6 (1.3)
Hockey	4 (1.7)	0 (0.0)	4 (0.87)
Golf	1 (0.4)	2 (0.9)	3 (0.65)
Badminton	0 (0.0)	1 (0.4)	1 (0.22)
Total	234 (100.0)	226 (100.0)	460 (100.0)

Epidemiology of Bone Stress Injuries and Healthcare Utilization in PAC-12 Cross-Country Runners

Wayner RA, Crowell CB, Soucy M, Choe S, Simon JE: Ohio University, Athens, OH, and Oregon State University, Corvallis, OR

Context: Bone stress injuries are a common injury in collegiate athletics. Injury rate and healthcare utilization of bone stress injuries is not well documented in running athletes. The purpose of this study was to describe the rate, classification and healthcare utilization in collegiate cross-country runners with a diagnosed bone stress injury. **Methods:** This is a descriptive epidemiology study. Data were collected in PAC-12 collegiate cross-country programs as part of the PAC-12 Student-Athlete Health and Well-Being Initiative, which oversees the PAC-12 Health Analytics Program injury registry. Injury occurrence for PAC-12 collegiate cross-country runners were collected during the 2018-2019, 2019-2020, and 2020-2021 athletic seasons. Eleven institutions provided data over the first two collection years (July 2018-June 2019 and July 2019-June 2020) and 12 institutions participated in the third year (July 2020-June 2021). Injuries were diagnosed by body part involved and classified by mechanism of injury as acute or overuse, as well as time-loss (TL) or non-time loss (NTL). Associated healthcare utilization, including athletic training services (AT services), physician-level encounters, prescription medication, tests, procedures and surgery were reported for each occurrence. For analysis, injury rates were reported as per athlete season and frequencies of healthcare

utilization were stratified by mechanism of injury and time-loss status. **Results:** A total of 136 bone stress injuries were reported over three seasons from 59 team seasons (M: 25, F: 34) and 894 athlete seasons, resulting in 1,499 AT services and 95 physician encounters. Overall, bone stress injuries represented 21% of all injuries reported by cross-country athletes. The average bone stress injury rate was 0.15 per athlete season. Injury rates were higher in female athletes (0.18) compared to males (0.11) and rates were higher in the 2019-2020 season (0.20) compared to the 2020-21(0.14) and 2018-2019 (0.12) seasons. A majority of the bone stress occurred in the lower leg (25%) and the foot (24.3%). Most injuries were classified as overuse and time-loss (75%) and accounted for the majority of AT services (76%) and physician encounters (77%). Overuse-NTL injuries represented 10 % of the injuries and accounted for 11% of AT services and 8% of physician encounters. Very few bone stress injuries were classified as acute-TL (5.2%), and no acute-NTL injuries were reported. On average, there were 11.22 AT services per overuse-TL injury and 13.08 AT services per overuse-NTL injury. Mean occurrence was lower for physician encounters (0.70), prescription medications (0.05), tests (0.75), procedures (0.007), and surgery (0.02). **Conclusions:** Bone stress injuries are a common overuse-TL injury in collegiate cross-country runners and require considerable athletic training resources. These findings indicate a considerable healthcare burden in this population. Athletic trainers should be appropriately staffed and trained in best-practices for the management and prevention of bone stress injury in collegiate runners.

Epidemiology of Low Back Injuries in NCAA Sports: 2009/10 to 2018/19

Rao N, Boltz AJ, Collins CL, Chandran A: Datalys Center for Sports Injury Research and Prevention, Indianapolis, IN, and Michigan Concussion Center, School of Kinesiology, University of Michigan, Ann Arbor, MI

Context: Low back injuries (LBIs) are of concern due to negative short-term outcomes and potential long-term consequences following injury. Athletes participating at the National Collegiate Athletic Association (NCAA) level are particularly at risk for LBI, given the dynamic nature of biomechanics associated with various sports, and rely on athletic trainers as the first point of contact regarding LBI-related care. Despite the risk of LBIs among NCAA athletes, few studies have explored the burden of these injuries across collegiate sports. Therefore, we aimed to describe the epidemiology of LBIs in men's and women's NCAA sports. **Methods:** LBI exposure and injury data reported to the NCAA Injury Surveillance Program (ISP) from the 2009 / 10 to 2018 / 19 academic years were examined. ATs at participating institutions contributed data via their Electronic Medical Record systems. Injury incidence (examined as rates per 10,000 athlete exposures [AEs]) was examined overall, by competition level (Division I, Division II, Division III), and event type (practice, competition). Distributions of injuries were examined by mechanism (player contact, surface contact, apparatus contact, overuse / non-contact), chronicity (chronic, non-chronic), injury history (new, recurrent), and diagnosis as frequencies (%). Differential rates of injuries across explanatory variables of interest were assessed using Injury Rate Ratios (IRRs) and Injury Proportional Ratios (IPRs); effect estimates with 95% Confidence Intervals (CIs) excluding 1.00 were deemed statistically significant. **Results:** During the study period, 2,629 LBIs from 12,213,285 AEs (Rate=2.15 / 10,000 AEs) were reported in 23 sports;

injury rates were highest in Division III overall (Rate=2.50), and in Division I competition (Rate=3.33). Injury rates between men's and women's sports were comparable (IRR=0.98, 95% CI=0.91, 1.06); highest rates were in women's gymnastics (Rate=5.39) and men's tennis (Rate=3.39). Men's competition LBI rates were higher than practice (IRR=2.15, 95% CI=1.94, 2.39); rates did not vary by event type in women's sports. Notably high competition rates were observed in men's football (Rate=7.38) and women's gymnastics (Rate=7.11). LBIs were most attributed to overuse / non-contact mechanisms (women's=69.99%, men's=55.92%); these LBIs were more prevalent in practices than competitions (IPR=3.03, 95% CI=2.54, 3.60). Most injuries were new (79.81%) and diagnosed as lower back spasms (30.51%). The prevalence of chronic LBIs (19.6% of all LBIs) was higher in practice than competition (IPR=1.85, 95% CI=1.53, 2.25), and in women's sports compared with men's sports (IPR=1.75, 95% CI=1.52, 2.02). **Conclusions:** LBI incidence density was highest in women's gymnastics, and overall, was most attributed to overuse / non-contact mechanisms. Although player contact remains a factor in athletic injuries, a majority of LBIs presented were resultant of non-contact-based mechanisms. Based on these findings, prevention efforts focused on player overuse during practice, post-play recovery, and targeted musculoskeletal training / rehabilitation could play a role in reducing the burden of LBIs in this population.

The NCAA Injury Surveillance Program was funded by the NCAA. The Datalys Center is an independent nonprofit organization that manages the operations of the NCAA ISP. The content of this report is solely the responsibility of the authors and does not necessarily represent the official views of the funding organization. We thank the many ATs who have volunteered their time and efforts to submit data to the NCAA ISP. Their efforts are greatly appreciated and have had a tremendously positive effect on the safety of collegiate student-athletes.

Can Hamstring Flexibility Accurately Identify Risk Of Hamstring Injury: A Critically Appraised Topic

Patton S, Mansell JL, Tierney RT, Russ AC: Temple University, Philadelphia, PA

Context: Hamstring strain injuries (HSI) are frequently occurring injuries that require explosive movements, cutting, and rapid changes in direction. In the athletic population, can hamstring flexibility measures assessments identify those at increased risk of HSI? **Methods:** A search of PubMed electronic database using a PIO strategy was conducted in June of 2022 using (patient group, intervention, outcome) to generate a Boolean phrase. The following Boolean Phrases were used: (Sensitivity AND Specificity) and (Hamstring AND Injury) NOT ACL. Inclusion criteria were examined measures of hamstring flexibility as a risk factor for injury, reported sensitivity, specificity, and/or receiver operator curves (ROC) or area under the curve (AUC), published within the past seven years and in English. Exclusion criteria include studies that are Level 3 or higher and do not include a cohort of subjects. The Critical Appraisal Skills Programme (CASP) tool was used to evaluate the selected research studies. Sensitivity, specificity, ROC, and AUC were compared across studies. **Results:** The search returned 31 articles and 3 met all inclusion criteria. In the study by Van Dyk et al., the Passive Knee Extension (PKE) test failed to be a risk

factor in predicting HSI (AUC=0.52). O'Connor noted poor flexibility in the Active Knee Extension (AKE) test during preseason screening and previous injury were unable to predict those at risk of sustaining a hamstring strain (AUC =0.62). Molina-Cárdenas examined predicting hamstring strains based on ROM in an analysis from a gender perspective. Combining a Straight Leg Raise (SLR) with the Thomas Test in females had a sensitivity of 77.8% and specificity of 100% when for identifying those at risk of HSI. In males, the SLR and hip external rotation had a sensitivity of 88.2% and specificity of 97.4%. With the CASP grading, the van Dyk article and the O'Connor articles both scored a 9/9. The Molina-Cardenas article scored a 7/9 with concerns about the small sample size not meeting numbers needed to treat. **Conclusions:** Hamstring flexibility measures are unable to accurately predict HSI. Van Dyk and O'Connor both presented AUC's that were insufficient in supporting PKE and AKE to identify those at risk of HSI. Molina-Cárdenas presented research with a high sensitivity and specificity when the SLR was used in combination with other hip mobility assessments. Stand-alone flexibility measures presented poor predictive scores, whereas hamstring flexibility measures in combination with other flexibility measures resulted in increased accuracy in HSI risk predictability. Clinicians should assess more than hamstring flexibility to accurately identify those at increased risk of HSI. SORT B

Lateral Ankle Sprain Recurrence and Healthcare Utilization by Gender, Race/Ethnicity, and Sport in Division I Collegiate Athletes

Brown CN, Bovbjerg VE, Johnson ST, Norcross MF: Oregon State University, Corvallis, OR

Context: Lateral ankle sprain (LAS) is a common injury with a high recurrence rate. Potential inequities in care provided may contribute to recurrence. Our purpose was to describe LAS classified as 'recurrent' in NCAA Division I athletes across select gender comparable sports, assessing for potential differences in occurrence and healthcare utilization by gender, race/ethnicity, and recurrence type. **Methods:** This descriptive epidemiology design used de-identified medical records from 14,030 student athletes from a single conference who provided authorization for research. Participating member institutions reported injuries from August 2016-November 2021. Sport-related LAS were identified by Orchard Sports Injury Classification System code, then stratified by recurrence type (i.e. new sprain, first recurrence, multiple recurrence). Frequencies by gender, race/ethnicity, and gender comparable sport (i.e. baseball/softball, basketball, and cross country/

track) were calculated. Athletic training services (ATS) provided and whether or not a physician level encounter (PE) occurred were noted for each LAS. Chi-square and Kruskal-Wallis tests were applied ($\alpha < 0.05$) to assess for differences by gender, race/ethnicity, and recurrence type.

Results: Of 38,084 sport-related injuries, 2,862 (7.5%) were ankle sprains, of which 2,168 (75.8%) were LAS. Of those, 334 occurred in gender comparable sports and reported race/ethnicity, and were retained for analysis. Because only 57 student-athletes with LAS and race/ethnicity other than Black or White were included, those individuals were combined into a Non-Black/Non-White category. Of the 334 LAS analyzed, 72.2% were new sprains ($n=241$), 13.5% ($n=45$) were first recurrence, and 14.4% ($n=48$) were multiple recurrence (Table 1). Within gender comparable sports, there were no significant associations between recurrence type and gender ($X^2=0.04$, $P=0.98$) or race/ethnicity ($X^2=5.52$, $P=0.24$). When assessing the intersection of gender and race/ethnicity, recurrence type was not associated with race/ethnicity when assessing men or women separately ($X^2=8.80$, $P=0.07$, $X^2=1.75$, $P=0.78$). ATS were most frequent for new sprains ($n=2,013/2,735$, 73.6%, Table 1). There were no significant differences in ATS provided for recurrence type between genders (Kruskal-Wallis $H=5.0$, $P=0.42$). There

were no differences in number of ATS provided for each recurrence type between race/ethnicity groups in men or women, nor when genders were combined ($P>0.05$). PE were most frequent for new sprains ($n=67/86$, 77.9%, Table 1). There was no association between gender and PE ($X^2=0.24$, $P=0.89$). Due to low cell counts, only the intersection of race and recurrence type was assessed, and no significant association was identified ($X^2=3.7$, $P=0.44$). **Conclusions:** Approximately 28% of LAS were classified as recurrent in gender comparable sports. There were no significant associations in frequency of recurrence type among genders, nor in the intersection of gender and race/ethnicity for any measure. Though LAS recurrence rate was relatively high, we did not find evidence of inequities in healthcare utilization or access in these collegiate student-athletes.

This project was supported by the Pac-12 Conference's Student-Athlete Health and Well-Being Initiative. The content of this abstract is solely the responsibility of the authors and does not necessarily represent the official views of the Pac-12 Conference, or its members.

Table 1. Frequencies of Lateral Ankle Sprain Occurrence, Athletic Training Services and Physician Encounters by Gender and Race/Ethnicity

Frequencies		New Sprain				First Recurrence				Multiple Recurrence			
		n	% of All LAS	95% CI LL	95% CI UL	n	% of All LAS	95% CI LL	95% CI UL	n	% of All LAS	95% CI LL	95% CI UL
Men	Black	61	18.3%	14.3%	22.8%	11	3.3%	1.7%	5.8%	19	5.7%	3.5%	22.8%
	White	53	15.9%	12.1%	20.2%	7	2.1%	0.8%	4.3%	6	1.8%	0.7%	20.2%
	Non-B/W	13	3.9%	2.1%	6.6%	5	1.5%	0.5%	3.5%	0	0.0%	N/A	N/A
	Total Men	127	38.0%	32.8%	43.5%	23	6.9%	4.4%	10.2%	25	7.5%	4.9%	43.5%
Women	Black	33	9.9%	6.9%	13.6%	8	2.4%	1.0%	4.7%	8	2.4%	1.0%	13.6%
	White	53	15.9%	12.1%	20.2%	10	3.0%	1.4%	5.4%	8	2.4%	1.0%	20.2%
	Non-B/W	28	8.4%	5.6%	11.9%	4	1.2%	0.3%	3.0%	7	2.1%	0.8%	11.9%
	Total Women	114	34.1%	29.1%	39.5%	22	6.6%	4.2%	9.8%	23	6.9%	4.4%	39.5%
Overall Total		241	72.2%	67.0%	76.9%	45	13.5%	10.0%	17.6%	48	14.4%	10.8%	76.9%
Athletic Training Services (ATS)		n	% of All ATS	95% CI LL	95% CI UL	n	% of All ATS	95% CI LL	95% CI UL	n	% of All ATS	95% CI LL	95% CI UL
Men	Black	347	12.7%	11.5%	14.0%	51	1.9%	1.4%	2.4%	84	3.1%	2.5%	14.0%
	White	317	11.6%	10.4%	12.8%	62	2.3%	1.7%	2.9%	45	1.6%	1.2%	12.8%
	Non-B/W	237	8.7%	7.6%	9.8%	20	0.7%	0.4%	1.1%	0	0.0%	N/A	N/A
	Total Men	901	32.9%	31.2%	34.7%	133	4.9%	4.1%	5.7%	129	4.7%	4.0%	34.7%
Women	Black	438	16.0%	14.7%	17.4%	183	6.7%	5.8%	7.7%	38	1.4%	1.0%	17.4%
	White	455	16.6%	15.3%	18.1%	34	1.2%	0.9%	1.7%	18	0.7%	0.4%	18.1%
	Non-B/W	219	8.0%	7.0%	9.1%	85	3.1%	2.5%	3.8%	102	3.7%	3.1%	9.1%
	Total Women	1112	40.7%	38.8%	42.5%	302	11.0%	9.9%	12.3%	158	5.8%	4.9%	42.5%
Overall Total		2013	73.6%	71.9%	75.2%	435	15.9%	14.6%	17.3%	287	10.5%	9.4%	75.2%
Physician Encounters (PE)		n	% of All PE	95% CI LL	95% CI UL	n	% of All PE	95% CI LL	95% CI UL	n	% of All PE	95% CI LL	95% CI UL
Men	Black	39	45.3%	34.6%	56.5%	6	7.0%	2.6%	14.6%	6	7.0%	2.6%	56.5%
	White	28	32.6%	22.8%	43.5%	4	4.7%	1.3%	11.5%	3	3.5%	0.7%	43.5%
Overall Total		67	77.9%	67.7%	86.1%	10	11.6%	5.7%	20.3%	9	10.5%	4.9%	86.1%

LAS Lateral Ankle Sprain; CI Confidence Interval; LL Lower Limit; UL Upper Limit; Non-B/W Non-Black/Non-White.

The Incidence of Injuries in Elite Fencers During National Competitions: An Epidemiological Inquiry

Freedman AD, Brumitt J, Dompier TP, Martin M: Rocky Mountain University of Health Professions, Provo, UT, and University of Illinois Springfield, Springfield, IL

Context: Fencing is an open-skilled combat sport that uses blunt-ended swords. Two fencers fight indirectly through their weapons. The sport is practiced with 3 different weapons (foil, epee, and sabre), with each discipline having slightly different rules, skills, actions, and objectives. Since 1999, the popularity of fencing has increased exponentially. According to the United States Fencing Association (USFA), membership has grown from 23,000 in 2013 to more than 40,000 in 2022. There are a limited number of studies that focus on fencing injuries. One reason for this gap centers around the limited number of health care professionals who specialize in providing care to fencers. This study will report rates of injury per age, sex, and weapon to help clearly identify the risks of injury when participating in fencing. **Methods:** This study utilized a descriptive epidemiological design. Data was collected during 8 tournaments conducted over one competitive season. A customized Sport Event Medical Encounter System (SEMES) injury surveillance system developed by CueTree, Incorporated (New York,

NY) was used to collate injury and exposure data. Injuries and conditions were evaluated and reported by a member of the US Fencing Sports Medicine team consisting of athletic trainers (AT), chiropractors (DC), and physical therapists (PT). Four health care providers attended each of the monthly competitions held in large-scale venues (e.g., convention centers) lasting 4 days. **Results:** Over the course of the season, 70,404 competitive bouts resulted in 140,808 athlete-exposures (AEs). Data were stratified by age and sex. Over the course of the season, 667 injuries occurred (men = 375, women = 292). Injury rates for men were 4.58/10,000 AEs (95% CI = 4.12, 5.04) and injury rates for women were 4.95/10,000 AEs (95% CI = 4.39, 5.52). There was no difference in injury rates between sexes (IRR = 1.08; 95% CI: 0.93, 1.26). **Conclusions:** This study demonstrated injury rates between men and women were similar across most age groups and weapons. Male competitors in the 16 and under group had a significantly higher rate of injury than 16 and under females. Female competitors who participated in the 40 and older group, or who used a foil, had significantly higher rates of injury than their male counterparts. Fencing is a sport that has seen a large growth in participation. With this growth, there is an increased need to identify common injuries, consistently report those injuries so comparisons can be made between sports and begin to identify trends and risks associated with those injuries.

GameReady® 2.0 Reduces Intramuscular Temperature More Than the Hyperice X

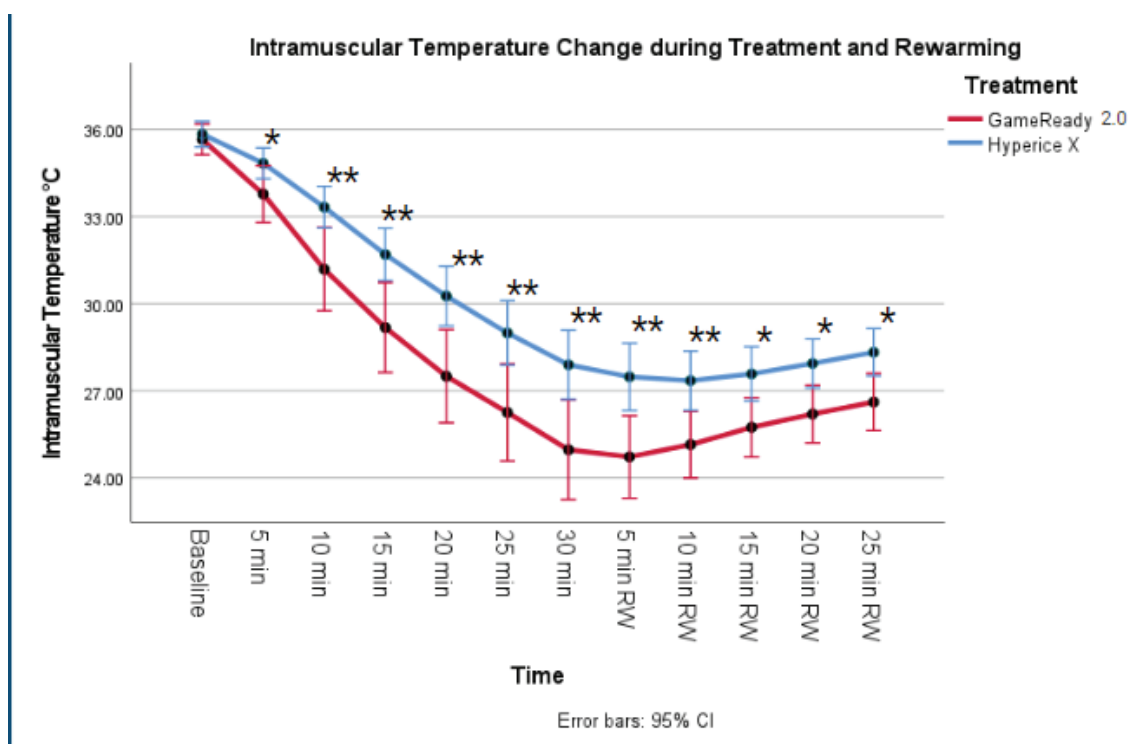
Rupe T, Bland M, Watkins B, Herzog V: Weber State University, Ogden, UT

Context: Previous research has shown the effectiveness of various devices in cooling intramuscular tissue. The new Hyperice X may be a more affordable option than other commercially available cold compression units. The purpose was to compare the intramuscular temperature changes of the GameReady® 2.0 (~\$3,000) or the Hyperice X (~\$400). We hypothesized that the GameReady® 2.0 would reduce intramuscular temperatures more than the Hyperice X. **Methods:** This was a randomized crossover study in a controlled research laboratory. Twenty individuals (10 males, 10 females, age=24±2.25years, ht=173.86±7.99cm, wt=78.22±12.45kg, SQ fat=0.86±0.24 cm) volunteered to participate. Each received both treatments, with at least 48 hours between bouts. Participants were randomly assigned to

the treatment order, counterbalanced by sex and treatment order. The total treatment time was 30 minutes with a 25-minute rewarming period. The low leg was cooled and compressed (35-45mmHg- measured with the PicoPress) with the Hyperice X or the GameReady® 2.0 on the high-pressure setting (cycled 5-75mmHg). Data were collected using an Isothermix™ thermocouple to record intramuscular temperature every 30 seconds. The dependent variable was intramuscular temperature at 1 cm+subcutaneous fat. Data were analyzed using a two-way repeated measures ANOVA, 0.05 alpha level. **Results:** There was no statistical difference in baseline intramuscular temperature (P=0.541) between the GameReady® (35.66±1.14°C) and Hyperice X (35.84±0.95°C). The GameReady® 2.0 lowered IM temp significantly more than the Hyperice X (F(1, 11)=9.08, p<.001, n2=0.323, observed power=0.947) at all other time points (see Figure 1). The GameReady® 2.0 showed clinically significant (2.1°C) lower intramuscular temperatures than the Hyperice X from 10 minutes into the treatment through 10 minutes

of rewarming. The greatest difference was seen at the end of the 30 minute treatment (p<.001), with the GameReady® 2.0 at 24.97 ± 3.66°C and the Hyperice X at 27.90 ± 2.54°C. The coldest intramuscular temperature for the Hyperice X was achieved 10 minutes into rewarming (27.35±2.18°C) and for the GameReady® 2.0 at five minutes into rewarming (24.73±3.03°C). **Conclusions:** While both treatments reduced intramuscular temperatures, the GameReady® 2.0 was more effective at reducing intramuscular temperature than the Hyperice X although the Hyperice X is more affordable. Future research should measure intramuscular temperatures with other new devices such as the Rapid Reboot system or the Polarice. Future studies should also include injured patients, use a greater needle insertion depth, and measure temperature changes within joint spaces. A temperature threshold should be determined for therapeutic effects on edema prevention, pain reduction, and secondary injury reduction.

Figure 1- Intramuscular Temperature Change during Treatment and Rewarming



* = statistically significant but not clinically significant (>2.1°C difference)

** = statistically significant and clinically significant

The Effects of Exercise and Manual Manipulation for Reducing Pain and Disability Associated With Sacroiliac Joint Dysfunction: A Critically Appraised Topic

Joyce CJ, Nowell KB, Boling MC: University of North Florida, Jacksonville, FL

Context: Sacroiliac Joint Dysfunction(SIJD) is pain in the sacroiliac region that can be caused by factors like leg length discrepancy, arthritis, pregnancy, and trauma. Many interventions can be used to treat SIJD including thermotherapy, electrical stimulation, exercise intervention, and manual manipulation. In active individuals with SIJD, is an exercise intervention and/or manual manipulation effective in reducing pain and improving function? **Methods:** PubMed, Google Scholar, and Physiotherapy Evidence Database(PEDro) were searched in November 2021. Primary search terms included: (Sacroiliac Joint Pain OR Sacroiliac Joint Dysfunction) AND (Exercise Intervention OR Exercise Protocol) AND (Manipulation Techniques). Studies were included if participants were physically active and published within the last 5 years. Articles were excluded if other low back pain conditions existed, were < 18 or > 60, or if mechanical manipulation was an intervention. The primary outcomes assessed were pain via a 10cm Visual Analog Scale(VAS) and the Oswestry Low Back Pain Disability Index(ODI). Change scores from baseline mean values were calculated for VAS and ODI to determine if the interventions lead to changes that were clinically meaningful for VAS (MCID >

2cm) and ODI (MCID > 10). Validity was assessed using the PEDro scale. **Results:** Articles were screened by title, excluding 637 articles (review/case report:n=115; systematic review:n=18; meta-analysis:n=8; books:n=6). Fifteen articles were screened for inclusion/exclusion criteria, resulting in 3 articles. Means, standard deviations, and change scores are presented in Table 1. All clinically meaningful results were also statistically different from baseline values ($p < 0.05$). In the first RCT [interventions: manual manipulation(MT) and exercise intervention(E)], VAS and ODI change scores were clinically meaningful in the MT and E groups at 2 and 4 weeks, respectively. In the second RCT (interventions: MT, E, combined MT-E), VAS change scores were clinically meaningful in the MT and MT-E groups at week 6 and ODI change scores were clinically meaningful only in the MT group at week 6. MT-E and E groups demonstrated clinically meaningful changes for VAS at 12 and 24 weeks and ODI at 12 weeks but not 24 weeks. In the third RCT [interventions: SI joint exercise and MT(MT-SI), lumbar exercise and MT(MT-L), and lumbar exercise(LE)], VAS and ODI change scores were clinically meaningful in the MT-SI and MT-LE groups at 4 and 12 weeks. There were no clinically significant changes in VAS and ODI in the LE group at 4 and 12 weeks. The first and third RCTs scores were 5/10 and the second RCT score was 4/10. **Conclusions:** There is SORT level B evidence to support both manual manipulation and exercise can improve pain and disability in individuals with SIJD. Combined MT and E interventions led to clinically meaningful changes in pain and function from 2 to 24 weeks.

Table 1: Means, standard deviations and change scores (Δ) for VAS and ODI in individuals with SIJD.

Outcome Measure	RCT	Intervention	Baseline	1 week	2 weeks	4 weeks	6 weeks	12 weeks	24 weeks
VAS (cm)	Kamali et al.(2019)	MT	5.8 \pm 1.41		2.28 \pm 1.93 (Δ 3.5)*				
		E	4.73 \pm 2.02			1.77 \pm 1.44 (Δ 2.96)*			
	Nejati et al.(2019)	MT	4				0.64 (Δ 3.36)*	2.47 (Δ 1.53)	2.82 (Δ 1.18)
		E	5.52				3.64 (Δ 1.88)	0.35 (Δ 5.17)*	2.23 (Δ 3.29)*
		E-MT	4.7				2.35 (Δ 2.35)*	0.47 (Δ 4.23)*	2.64 (Δ 2.06)*
	Javadov et al.(2021)	M-SIE	4.1 \pm 1.2	2.5 \pm 1.2 (Δ 1.6)	1.6 \pm 1.0 (Δ 2.5)*	0.6 \pm 0.7 (Δ 3.5)*		0.1 \pm 0.3 (Δ 4.0)*	
		M-LE	4.8 \pm 1.0	3.4 \pm 1.3 (Δ 1.4)	2.6 \pm 1.5 (Δ 2.2)*	2.3 \pm 1.6 (Δ 2.5)*		1.3 \pm 1.4 (Δ 3.5)*	
		LE	4.8 \pm 1.1	3.8 \pm 1.2 (Δ 1.0)	3.3 \pm 1.2 (Δ 1.5)	3.4 \pm 1.4 (Δ 1.4)		3.1 \pm 1.7 (Δ 1.7)	
ODI	Kamali et al.(2019)	MT	32.9 \pm 16		19.7 \pm 14.4 (Δ 13.2)*				
		E	25.9 \pm 8.2			14.4 \pm 7.9 (Δ 11.5)*			
	Nejati et al.(2019)	MT	23.6				11.9 (Δ 11.7)*	20.2 (Δ 3.4)	22.2 (Δ 1.4)
		E	28.5				23.5 (Δ 5)	11.2 (Δ 17.3)*	19.6 (Δ 8.9)
		E-MT	28.5				18.5 (Δ 10)	12.2 (Δ 16.3)*	22.1 (Δ 6.4)
	Javadov et al.(2021)	M-SI	31.6 \pm 14.2			14.2 \pm 9.7 (Δ 17.4)*		7.1 \pm 5.3 (Δ 24.5)*	
		M-L	45.1 \pm 15.4			27.7 \pm 13.4 (Δ 17.4)*		19.7 \pm 13.9 (Δ 25.5)*	
		LE	35.1 \pm 13.2			27.5.4 \pm 15.0 (Δ 7.6)		26.4 \pm 15.3 (Δ 8.7)	

Note. MT=manual manipulation, E=exercise intervention, E-MT=combined manual manipulation and exercise intervention, M-SI=manual manipulation and sacroiliac exercises, M-L=manual manipulation and lumbar exercises, LE=lumbar exercises. *Indicates a clinically meaningful change. (VAS MCID > 2cm, ODI MCID > 10) and statistically different from baseline ($p < 0.05$). Standard deviations are not presented for Nejati et al.(2019) as they were not presented in the manuscript.

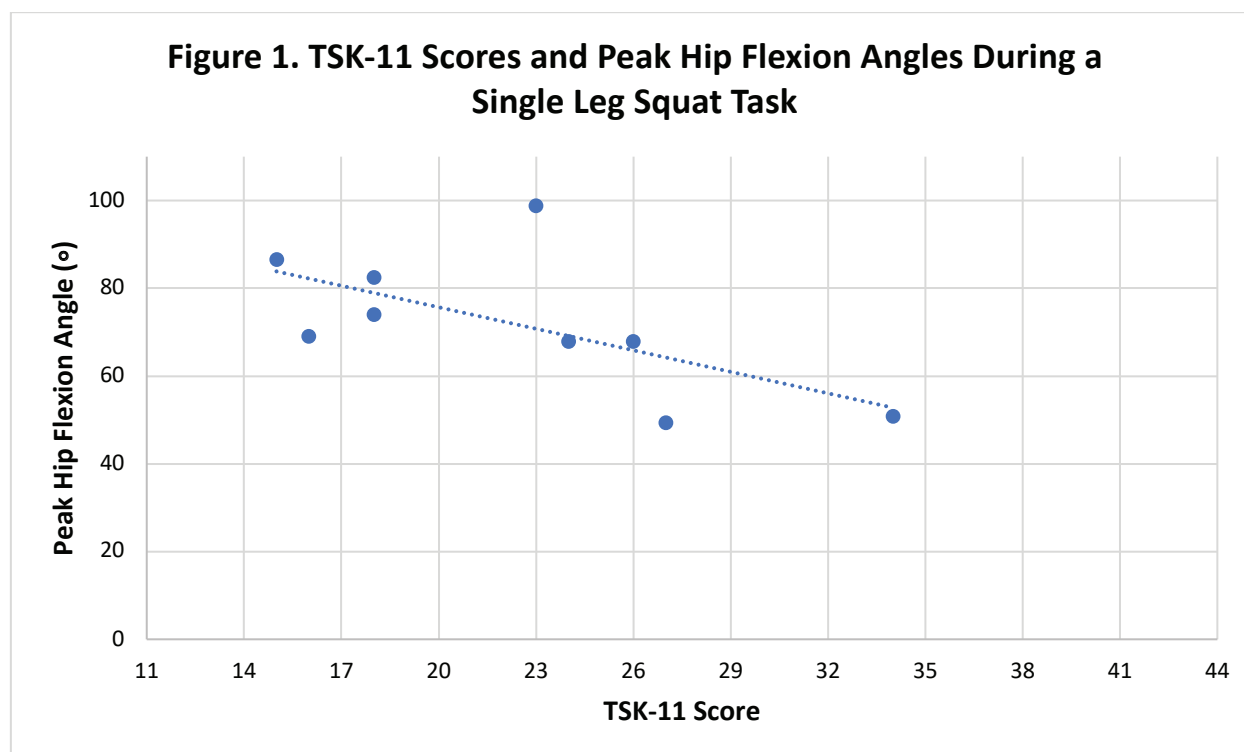
Sagittal Plane Single Leg Squat Kinematics and Kinesiophobia Before and After a Strength and Neuromuscular Training Intervention in Individuals With Hip-Related Pain

Kramer EM, Murro M, Samaan MA, Dewig D, Nguyen A, Mancinelli CA, Jochimsen KN: West Virginia University, Morgantown, WV; University of Delaware, Newark, DE; University of Kentucky, Lexington, KY

Context: Kinesiophobia is related to patient-reported pain and function in individuals with hip-related pain (HRP) (non-arthritis, intra-articular hip pathologies). However, its relationship to biomechanics and response to non-operative exercise-based interventions in individuals with HRP is unknown. Understanding these relationships, specifically during highly-demanding single-leg tasks, may help guide rehabilitation interventions to address biomechanical impairments. Therefore, we aimed to 1) determine the influence of a 12-session strength and neuromuscular training intervention on kinesiophobia and involved limb sagittal plane ankle, knee, and hip kinematics during a single leg squat and 2) determine the relationship between kinesiophobia and sagittal plane ankle, knee, and hip kinematics before and after the intervention. We hypothesized that kinesiophobia would be

negatively related with sagittal plane hip kinematics, and kinesiophobia would decrease and sagittal plane kinematics would increase following the intervention. **Methods:** Participants with chronic HRP completed the 11-item Tampa Scale for Kinesiophobia (TSK-11). A 10-camera three-dimensional (3D) motion analysis system was used to capture kinematics (200Hz) of the involved-side lower extremity during three single leg squats. Peak sagittal plane hip, knee, and ankle angles were calculated for each trial and averaged for analysis. Pre- to post-intervention TSK-11 scores and sagittal plane kinematics were compared using paired t-tests and the relationships between TSK-11 scores and sagittal plane kinematics were examined using Pearson's product-moment correlations ($\alpha = 0.05$). **Results:** Of 10 participants with HRP (2M/8F, 25.5 ± 3.0 years, 25.6 ± 4.4 kg/m²), one did not complete the intervention due to a non-study related injury. TSK-11 scores (PRE: 22.2 ± 7.4 , POST: 22.3 ± 6.2 , $P=0.95$) and peak sagittal plane ankle (PRE: $17.7^\circ \pm 3.1^\circ$, POST: $15.6^\circ \pm 8.0^\circ$, $P=0.42$) and hip (PRE: $60.0^\circ \pm 23.4^\circ$, POST: $71.9^\circ \pm 16.0^\circ$, $P=0.11$) angles did not change from pre- to post-intervention. Peak knee flexion angle increased from pre- to post-intervention (PRE: $74.0^\circ \pm 14.1^\circ$, POST: $85.6^\circ \pm 12.9^\circ$, $P=0.004$). TSK-11 scores were not significantly related to any kinematic variables at either timepoint ($P=0.07$ to 0.90); however, a moderate relationship between

post-intervention TSK scores and peak hip flexion angle was observed ($r=-0.63$, $P=0.07$), such that higher levels of fear were related with lower hip flexion angles. (Figure 1) **Conclusions:** The results of this study demonstrated an increase in peak knee flexion angle following a 12-session strength and neuromuscular training intervention, suggesting the intervention successfully improved neuromuscular control in individuals with HRP. Further work is necessary to understand if improvements in pain and function are associated with this modified movement pattern. Additionally, a moderate, non-significant relationship was identified between higher levels of kinesiophobia and lower peak hip flexion angles. Future studies should evaluate this relationship in a larger sample and explore if interventions aimed at reducing kinesiophobia may also improve hip motion during functional tasks.



Effects of an 8-Week Lumbopelvic-Hip Complex Training Program on Stability and Single-Leg Landing Mechanics: A Preliminary Report

Zambarano EK, Glaviano NR, Norte GE, Bazett-Jones DM, Mangum LC, Murray AM: University of Toledo, Toledo, OH; University of Connecticut, Storrs, CT; University of Central Florida, Orlando, FL

Context: The high prevalence of lower extremity injuries in athletics creates a need for injury prevention programs. Lumbopelvic-hip complex (LPHC) instability relates to movement patterns associated with increased injury risk, contributing to the recommendations that include LPHC exercises in injury prevention programs. While LPHC training can improve LPHC stability, the effect of isolated LPHC training on single-leg landings remain unclear. Our purpose was to determine the effects of isolated LPHC training on measures of LPHC stability and single-leg landing biomechanics in physically active individuals. **Methods:** This randomized controlled trial included 11 uninjured male and female athletes actively participating in club lacrosse (n=9) and volleyball (n=2). Independent variables were group (training [n=7], control [n=4]) and time (baseline, 8 weeks). The training group completed supervised LPHC exercises twice weekly for 8 weeks. The control group completed weekly

physical activity surveys. LPHC stability measures included performance on the Sahrman 5 level stability test, seated trunk control test, unilateral hip bridge, side plank endurance time, and sports-specific endurance plank test (SSEPT). Landing biomechanics were assessed during single-leg drop (SLD) and single-leg cross drop (SLCD) tasks using three-dimensional motion analysis synchronized with embedded force plates. Peak knee flexion angle (°), internal knee extension moment (Nm/kg*m), and vertical ground reaction force (vGRF; N/kg) were extracted during the first 100 ms of landing. Paired t-tests, or Wilcoxon signed-rank tests, evaluated within-group differences between time points. Independent t-tests, or Mann-Whitney U tests, evaluated between-group differences in change scores for each variable ($\alpha=.05$). **Results:** At 8 weeks, the training group improved on three LPHC stability measures while the control group exhibited no changes (Table 1). Peak knee flexion increased in both groups during the SLD (training: pre=46.6+7.6°, post=53.2+9.0°, p=.012; control: pre=51.7+4.3°, post=55.9+3.1°, p=.048), but only in the control group during the SLCD (training: pre=43.7+11.8°, post=49.7+10.2°, p=.099; control: pre=51.4+4.7°, post=54.8+3.6°, p=.046). Peak knee extension moment increased in the training group during the SLD (training: pre=1.6+0.2 Nm/kg*m, post=1.9+0.3 Nm/kg*m, p=.008; control: pre=1.9+0.4 Nm/kg*m, post=1.9+0.3 Nm/kg*m, p=.975) and SLCD (training: pre=1.4+0.2 Nm/kg*m, post=1.6+0.3

Nm/kg*m, p=.004; control: pre=1.7+0.2 Nm/kg*m, post=1.7+0.1 Nm/kg*m, p=.997). vGRF increased in the control group during the SLD (training: pre=4.0+0.2 N/kg, post=4.0+0.5 N/kg, p=.816; control: pre=3.8+0.7 N/kg, post=3.9+0.6 N/kg, p=.038), and did not change in the SLCD for either group (training: pre=3.6+0.5 N/kg, post=3.5+0.5 N/kg, p=.582; control: pre=3.2+0.7 N/kg, post=3.4+1.1 N/kg, p=.368). Change scores did not statistically differ between groups. **Conclusions:** An 8-week intervention focused on LPHC stability training improved clinical measures of LPHC stability and altered single-leg landing mechanics in uninjured club sport athletes, but with limited evidence of benefit greater than the control group. The increased knee flexion angles and knee extension moments observed likely contribute to more controlled landings.

This study was supported by the Great Lakes Athletic Trainers' Association Robert Behnke Research Assistance Award.

Table 1. Lumbopelvic-hip complex stability outcomes for training and control groups

	Training Group			Control Group		
	Pre Mean+SD	Post Mean+SD	p	Pre Mean+SD	Post Mean+SD	p
Sahrman 5-level stability test (0-5)	2.4+1.4	4.4+0.8	.026	4.0+1.4	4.25+1.0	.655
Seated trunk control test (number of errors)	1.0+1.3	1.2+1.8	.822	1.1+1.0	1.9+1.3	.547
Unilateral hip bridge (0-3)	1.4+1.1	2.7+0.8	.024*	1.8+1.3	1.3+1.3	.157
Side plank endurance (seconds)	58.4+28.7	109.9+31.1	<.001*	55.7+47.0	61.4+50.8	.147
Sport specific endurance plank test (0-8)	5.0+3.7	6.7+1.8	.109	3.5+3.3	3.75+3.3	.317

*Change scores significantly different compared to control group

Impact of Blood Flow Restriction Training and High Intensity Training to Improve Hamstring Muscle Cross Sectional Area

Colapietro M, Thompson Murray S, Miller SJ, Cortes D, Sebastianelli W, Vairo G: Department of Kinesiology, Department of Mechanical Engineering, and Department of Orthopaedics and Rehabilitation, The Pennsylvania State University, University Park, PA

Context: Limited evidence exists describing musculotendinous performance, morphological, and biomechanical responses to blood flow restriction training (BFRT), especially in the hamstrings. Thus, conclusive clinical utility of BFRT is lacking. The objectives of this study was (1) to compare the effect of a 4-week targeted knee flexor intervention between BFR training and HIT on knee flexor strength and morphological outcome measures in healthy, physically active young adults and (2) compare the effect of different therapeutic exercises with and without BFR training. It was hypothesized that knee flexor strength would improve regardless of intervention assignment, while muscle size and tendon stiffness was hypothesized to not change for all groups. **Methods:** We employed a randomized control trial design that compared differences among two BFRT interventions and one control condition. Twenty-one participants (age: 23.19 ± 4.4 y, Tegner: 6.0 ± 0.89) free of recent lower extremity injury were randomly allocated to a group via concealed assignment: open kinetic chain (OKC, $n=8$), closed kinetic chain (CKC, $n=5$), control ($n=8$). OKC and CKC participants completed a month of progressive BFRT (three sessions per week) in a supervised clinical research setting.

Limbs in the OKC and CKC groups were randomly assigned to either BFRT at 20-30% one repetition max (1RM) with 80% limb occlusion pressure or high-intensity training (HIT) at 70-85% 1RM. Controls were restricted to activities of daily living. Eccentric knee flexor peak force and moment, normalized to body mass, were measured with a NordBord (VALD performance, NC, USA). Muscle cross sectional area (CSA) was assessed via panoramic ultrasound and shear wave elastography (SWE) calculated semitendinosus tendon stiffness. A two-way analysis of variance between time (pre and post) and group (OKC, CKC, control) compared differences between means. Tukey's post hoc testing analyzed pairwise comparisons. $P < 0.05$ denoted statistical significance.

Results: A group by time effect was identified for biceps femoris CSA in the limbs assigned to BFRT ($F=3.717$, $P=0.045$, $\eta^2=0.292$) and HIT ($F=10.287$, $P=0.001$, $\eta^2=0.533$). Biceps femoris CSA increased following BFRT [OKC: pre $11.9 \pm 1.97\text{cm}^2$ (10.26-13.55), post $13.0 \pm 2.46\text{cm}^2$ (10.91-15.03); CKC: pre $11.8 \pm 1.04\text{cm}^2$ (10.48-13.07), post $12.5 \pm 1.45\text{cm}^2$ (10.68-14.29)] and HIT [OKC: pre $11.8 \pm 1.92\text{cm}^2$ (10.24-13.45), post $13.0 \pm 2.04\text{cm}^2$ (11.28-14.68); CKC: pre $12.6 \pm 2.17\text{cm}^2$ (9.88-15.28), post $13.5 \pm 2.09\text{cm}^2$ (10.94-16.14)]. Post hoc testing did not identify pairwise differences. No other differences were observed.

Conclusions: Similar improvements in biceps femoris CSA with the absence of eccentric peak torque increases were identified for both intervention groups regardless of BFRT or HIT assignment. BFRT may serve as an alternative to HIT to improve hamstring outcome measures. Future analysis should analyze the potential impact of BFRT on clinical populations suffering from knee flexor atrophy.

A Comparison of Instrument Assisted Soft Tissue Mobilization and Static Stretching for Hamstring Flexibility
Nieves MJ, Gildard M, Powers ME:
ProClinix Sports Physical Therapy & Chiropractic, Armonk, NY, and Marist College, Poughkeepsie, NY

Context: Increasing flexibility is beneficial for both athletic performance and activities of daily living and must consistently be maintained to prevent chronic shortening of tissues. The consistent and chronic shortening of muscles occurs daily and involves natural microtrauma within the tissues with consistent use. Thus, various therapeutic techniques have been found to aid in tissue repair, the healing processes, clearance of muscular damage and recovery optimization. Instrument assisted soft tissue mobilization (IASTM) is commonly used post injury or surgery for scar tissue remodeling. Its efficacy for improving flexibility has not been fully understood and comparisons between IASTM and static stretching (SS) are limited with inconclusive results. Thus, the purpose of this investigation was to examine and compare the effects of SS and IASTM on flexibility within a recreationally active population. **Methods:** A randomized single blind cross over design. Twenty-seven healthy recreationally active males and females (age=20 \pm 0.8 y, height=156.2 \pm 18.9 cm, mass=70.9 \pm 12.6 kg), who did not suffer from any contraindications to SS or IASTM or any lower extremity injuries within the previous

6 months volunteered. Each participant reported to the research facility for 3 sessions separated by a period of at least one week. At each session, the participants were assessed for hamstring flexibility using a passive straight leg raise (SLR) test immediately before (PRE), immediately following (IP) and 5 min following (5P) one of 3 treatment conditions. The SLR test was assessed with the participants supine and relaxed with the dominant leg strapped to the table. The non-dominant hip was then passively flexed with the knee extended until end range was achieved and a Saunders digital inclinometer placed on the anterior shin was used to determine the angle. Three measures were taken and the average used in the analyses. The 3 treatment conditions were randomly assigned using a single blind crossover design and consisted of 5 min of hamstring SS, IASTM applied to the hamstrings or control (CON). **Results:** A significant main effect for Test was observed ($F_{2,52}=22.59$, $p=.001$), as the IP ($87.28 \pm 15.78^\circ$) and the 5P ($86.96 \pm 16.27^\circ$) ROM were significantly greater than the PRE ROM ($84.85 \pm 15.45^\circ$). No difference was observed when comparing IP to 5P. The condition however had no effect on ROM as a significant Condition x Test interaction ($F_{4,104}=.457$, $p=.767$) was not observed. **Conclusions:** Neither SS or IASTM appear to be effective for improving acute hamstring flexibility, however a longer duration of treatment or variations within other parameters might provide different result. Future research should focus on these parameters.

ACL-R Patients

Friday, June 23, 2023; authors present 11:45 AM-12:40 PM; Poster Hall

Relationship of ACL Volume to Clinical Knee Arthrometer and Imaging-Derived Laxity Measures

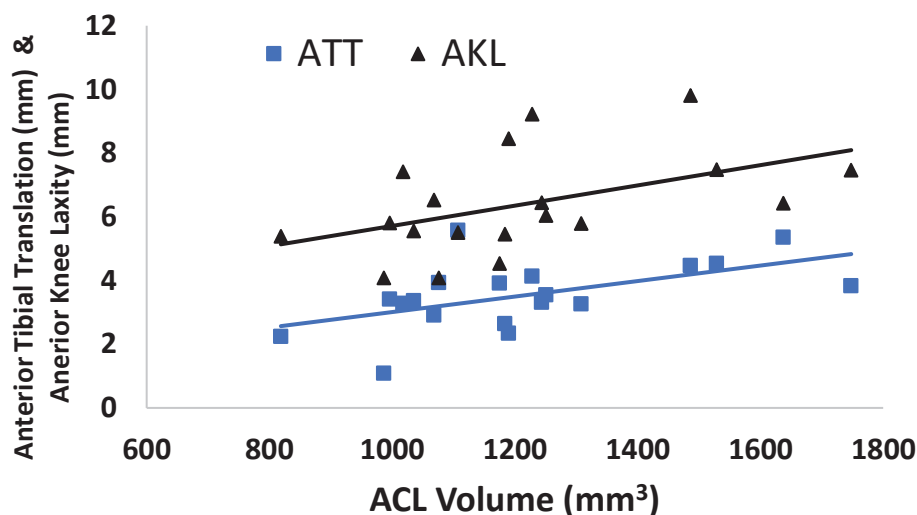
Schmitz RS, Bacon BR, Park-Braswell K, Shultz SJ: University of North Carolina Greensboro, Greensboro, NC, and Indiana Wesleyan University, Marion, IN

Context: Smaller ACL volume may be less capable of resisting external forces, leading to lower failure loads. Anterior knee laxity (AKL) is a strong predictor of ACL injury risk. An inverse relationship between AKL (measured by clinical knee arthrometer) and ACL size (measured by MRI) has been established. However, clinical measures of AKL are limited in that true tibia to femur motion is not being assessed. The purpose was to compare laxity measures obtained via clinical arthrometry with measures of tibiofemoral motion assessed in-vivo with MRI as predictors of ACL volume. We hypothesized that both measures would be related to ACL volume, but that MRI obtained tibiofemoral motion would have a stronger relationship with ACL volume. **Methods:** Nineteen physically-active females (24.1 ± 4.5 yr; 65.1 ± 8.1 kg) with no previous knee injury participated. AKL was measured using a KT-2000 knee arthrometer over three cycles. AKL (mm) was calculated

as average displacement from 0-133N over the last two cycles. For in-vivo anterior tibial translation relative to the femur (ATT), participants were positioned inside the scanner with their leg in an MRI compatible joint loading device. A 16-channel coil was placed about the knee to obtain dynamic MR knee images while anteriorly directed tibial loading was performed from 0 to 133N for a total of five load-relaxation cycles over a duration of 36s. ATT (mm) was measured from knee images obtained at 0 and peak loading phases, and average over the first three loading cycles for analysis. T2-weighted scans imaged ACL volume. Each slice with ACL tissue was manually segmented to create a 3d ACL volume (mm^3). Stepwise linear regression determined relative predictivity of AKL and ATT to ACL volume. Pearson correlations were used to determine the zero-order relationship between AKL, ATT, and ACL volume. **Results:** ATT (3.5 ± 1.1 mm; range = 1.1-5.6mm) entered the regression first to predict ACL volume ($1215.0 \pm 239.1 \text{ mm}^3$) ($R^2 = 0.30$; $P = .016$); with AKL (6.4 ± 1.6 mm; range = 4.1-9.8mm) entering on the second step (R^2 overall = 0.42; $R^2\Delta = 0.12$; $P = .091$). Significant zero-order Pearson correlations were noted between ACL volume and ATT ($r = 0.55$, $P = .016$) and AKL ($r = 0.48$, $P = .038$). (Figure 1) Part correlations were also reported for ACL volume and ATT ($r = 0.49$) and AKL ($r = 0.41$). **Conclusions:** While

ATT entered model first, both AKL and ATT were relatively similar in ability to be independent predictors of ACL volume. Thus, measures of AKL obtained with a clinical arthrometer are reasonably representative of true tibiofemoral motion in the sagittal plane. Additionally with a smaller range of ATT than AKL, which generally makes prediction more statistically difficult, this suggested that ACL volume is critical in understanding true bony restraint biomechanics.

Figure 1 – Scatterplots and corresponding regression lines of Anterior Tibial Translation and Anterior Knee Laxity relative to ACL Volume



Simple Reaction Time is Associated With Self-Reported Knee Function in Individuals After Anterior Cruciate Ligament Reconstruction

Baez SE, Reiche E, Genoese FM:
University of North Carolina at Chapel Hill, Chapel Hill, NC, and Michigan State University, East Lansing, MI

Context: Slower reaction time (RT) has been associated with ACL injury risk and with elevated injury-related fear after ACL reconstruction (ACLR). However, we do not know whether simple RT (SRT), which is the minimal time needed to respond to a stimulus, is associated with other clinically meaningful outcomes post-ACLR, including decreases in self-reported knee function. Characterizing this relationship could provide another treatment target after ACLR to reduce ACL injury risk and improve long-term knee joint health after ACLR. Therefore, the purpose of this study was to examine the relationship between SRT and self-reported knee function in individuals with a history of ACLR. We hypothesized that individuals post-ACLR with slower SRT would exhibit

worse self-reported knee function. **Methods:** Sixteen participants (14 females; age=21.7±5.3 years; time since surgery=26.9±13.8 months) were recruited from a local sports medicine clinic. Participants were included if they were 14-35 years old and between 4 months and 5-years post primary, unilateral ACLR. A computerized sensorimotor assessment (i.e., Senaptec Sensory Station) was used to assess average SRT (ms). Participants were instructed to maintain pressure with both index fingers on a tablet in two individual circles. When a circle turned red, the participant removed their finger from the circle as quickly as possible. Increased time to remove their finger represents slower SRT. Participants also completed the Knee Injury and Osteoarthritis Outcome Score (KOOS) to evaluate self-reported knee function. The KOOS has 5 subscales, including symptoms (KOOS-Sx), pain (KOOS-P), activities of daily living (KOOS-ADL), sport and recreation function (KOOS-Sport), and quality of life (KOOS-QOL). Higher scores on the KOOS subscales indicate better self-reported knee function. Descriptive statistics were calculated for SRT and the KOOS subscales. Pearson product moment correlations were used

to examine the relationships between SRT and the KOOS subscales. R-values were interpreted as weak (0.00 to 0.39), moderate (0.40 to 0.69), and strong (> 0.70). Significance was set a priori to $p \leq 0.05$. **Results:** Descriptive statistics for SRT and KOOS subscales are presented in Table 1. A significant, moderate, negative association was observed between SRT and the KOOS-P, KOOS-ADL, and KOOS-Sport subscales (Table 1). As self-reported knee function decreased (i.e., scores were lower), SRT was slower (i.e., times were higher). No associations were observed between SRT and KOOS-Sx or KOOS-QOL. **Conclusions:** Individuals with a history of ACLR with worse self-reported knee function exhibited slower SRT. In concert with our results, elevated pain has been associated with deficits in RT in other musculoskeletal populations. Unresolved pain can lead to reduced activity and increased injury-related fear, which could further slow RT. This is concerning as deficits in RT have been associated with lower extremity injury risk. Future research should identify targeted interventions to improve self-reported knee function and SRT after ACLR.

Table 1. Correlation Matrix between Simple Reaction Time and KOOS subscales

	RT (ms)	KOOS-Symptoms	KOOS-Pain	KOOS-ADL	KOOS-Sport	KOOS-QOL
RT	1.0					
KOOS-Symptoms	0.29 (0.26)	1.0				
KOOS-Pain	-0.57* (0.02)	-0.45* (0.06)	1.0			
KOOS-ADL	-0.52* (0.03)	0.12 (0.64)	0.40 (0.10)	1.0		
KOOS-Sport	-0.57* (0.02)	-0.29 (0.24)	0.80* (0.00)	0.53* (0.02)	1.0	
KOOS-QOL	-0.05 (0.84)	0.55* (0.02)	0.19 (0.44)	0.44* (0.07)	0.30 (0.22)	1.0
Mean	329.48	88.23	82.64	98.27	76.61	80.25
SD	29.81	9.44	11.24	2.24	15.67	13.72

*denotes statistical significance; Abbreviations: RT = Reaction Time, KOOS = Knee Injury and Osteoarthritis Outcome Score, KOOS-ADL = KOOS Activities of Daily Living Subscale, KOOS-Sport = KOOS Sport and Recreation Function Subscale, KOOS-QOL = KOOS Quality of Life Subscale

Changes in Single Leg Squat Knee and Hip Kinematics and Kinetics Following ACL Reconstruction

Adler SN, Renner MN, Srygler EC, Trigtsted SM, Biese KM, Bell DR: University of Wisconsin-Madison, Madison, WI, and University of Wisconsin-Oshkosh, Oshkosh, WI

Context: After ACL reconstructive (ACLR) surgery, neuromuscular deficits are commonly observed in the lower extremity and can persist for up to two years post-operatively. The single leg squat (SLS) is used by clinicians during rehabilitation because it is a common, yet demanding activity associated with activities of daily living. Previous literature has investigated knee and hip kinematics and kinetics during the later phases (7-9 months) of rehabilitation but is limited for the mid-phase (4-6 months). The purpose of this study was to determine if SLS knee and hip kinematics and kinetics change throughout the mid-phase of rehabilitation (post-operative months 4, 5, and 6). We hypothesized hip and knee kinematics and kinetics will improve in the reconstructed limb over time. **Methods:** A cohort of 20 participants (Height: 173.5±9.7cm; Mass: 72.6±19.1kg; Age: 18.2±3.1yrs) who underwent ACLR surgery following a primary, unilateral ACL injury were included. Participants were instructed to perform 5 consecutive SLS, as deep as they felt comfortable, on the healthy and reconstructed limbs at 4, 5, and 6 months post-ACLR. Subjects reported International Knee Documentation Committee (IKDC) scores monthly to assess subjective knee function and symptoms. Higher scores indicate perceived improvement in knee function. Kinematics and kinetics were collected via an integrated electromagnetic tracking and force platforms system. Repeated measures ANOVAs

(time (3-levels: months 4, 5, and 6) by limb (2-levels, healthy versus reconstructed)) were used to determine changes in the knee and hip sagittal plane kinematics and kinetics during the SLS ($\alpha<0.05$). Post hoc testing was performed using Fisher's LSD. **Results:** Average IKDC scores throughout the mid-phase increased monthly within participants: (m4: 70.32±12.3, m5: 72.34±11.8, m6: 76.04±13.4; $P=0.01$). There was a significant time by limb interaction for knee extension moment (Healthy: m4: -1.49±0.3nm/Kg, m5: -1.25±0.3nm/Kg, m6: -1.39±0.4nm/Kg; Reconstructed: m4: -1.24±0.3nm/Kg, m5: -1.25±0.3nm/Kg, m6: -1.30±0.3nm/Kg; $F=4.7$; $P=0.014$). Post hoc testing revealed that knee extension moment in the injured limb did not change significantly from months 4 and 5 but worsened at month 6. There was a significant main effect between limbs for hip (Healthy: m4: -80.0±18.2°, m5: -83.0±18.5°, m6: -80.47±17.7°; Reconstructed: m4: -79.15±21.9°, m5: -76.86±21.1°, m6: -76.53±18.2°; $P=0.04$) and knee (Healthy: m4: 74.73±12.9°, m5: 78.34±12.0°, m6: 75.01±11.7°; Reconstructed: m4: 67.28±12.3°, m5: 67.89±11.1°, m6: 67.93±11.4°; $P=0.03$) flexion angles, with the healthy limb achieving greater peak flexion compared to the reconstructed limb. There were no other significant observations ($P>0.05$). **Conclusions:** We reject our hypothesis as knee and hip kinematics and kinetics did not significantly improve over three months of rehabilitation, despite positive changes in IKDC scores from months 4-6. Following ACLR, patients should continue progressive loading activities to improve knee kinematics and kinetics throughout the late phases of rehabilitation to reduce risk of re-injury.

This project was supported by a grant from the NATA Foundation.

Continuous Analysis of Dynamic Knee Extension and Flexion Torque Magnitude and Control in Individuals With ACL Reconstruction

Schwartz AS, Sherman DA, Rush JL, Norte GE: University of Toledo, Toledo, OH; Live4 Physical Therapy and Wellness, Acton, MA; Boston University, Boston, MA; Harvard University, Cambridge, MA

Context: Individuals with ACL reconstruction (ACLR) exhibit deficits in the magnitude (peak torque) and control (coefficient of variation [CoV]) of knee flexor-extensor force production during isometric contractions, which may be detrimental to joint health and increase risk of re-injury. However, prolonged isometric contractions do not reflect in vivo muscle behavior during athletic movements, suggesting a need for continuous assessment through a full ROM during dynamic contractions. Therefore, our aims were to compare thigh torque magnitude and control between limbs throughout the ROM of an isokinetic contraction. We hypothesized the involved limb would demonstrate lower peak torque and higher CoV, with differences being greatest at shorter muscle lengths.

Methods: In this cross-sectional investigation, 22 individuals with primary, unilateral ACLR via hamstrings tendon autograft (time from surgery = 46.9 ± 26.3 months) completed a single trial of 5 concentric-concentric knee extension-flexion repetitions at 60°/s with maximal effort. Repetitions were separated into 5 flexion and extension torque-angle (T-A) curves and averaged per participant, then across participants for each limb. Torque CoV-angle (CoV-A) curves were generated by dividing the standard deviation by the mean at each joint angle of the resultant T-A curves—higher CoV indicated more trial-to-trial variability in torque production at a given joint angle. To maximize useable data, participants unable to achieve a 30-85° ROM were removed from analysis. Statistical parametric mapping was used to compare T-A and CoV-A curve between limbs across the ROM. Results below are reported as mean differences. Paired t-tests and Cohen's d effect sizes were used to compare peak torque (Nm/kg), angle of peak torque (°), and area under the T-A and CoV-A curves between limbs. **Results:** Lower knee flexion torque was generated by the involved limb at 60° (-0.083 Nm/kg, $p=.050$, $d=-0.46$), and from 64-84° (-0.10 Nm/kg, $p<.001$, $d=-0.5$) (Figure 1A) than the uninvolved limb. The involved limb also demonstrated

lower peak knee flexion torque (-0.76 Nm/kg, $p=.015$, $d=-0.4$) and area under the T-A curve (-4.47 , $p=.008$, $d=-0.44$). Higher knee extension torque CoV was generated by the involved limb from 77-78° (0.044 , $p=.020$, $d=0.71$) (Figure 1D) than the uninvolved limb. The involved limb also demonstrated lower peak knee extension torque (-0.138 Nm/kg, $p=.04$, $d=-0.39$) and area under the T-A curve (-6.20 , $p=.02$, $d=-0.38$). **Conclusions:** Deficits in knee flexor torque magnitude in positions of deep knee flexion may reflect over-reliance on, or diminished ability to effectively utilize, the medial hamstrings, which are reportedly weakened due graft harvesting. Deficits in knee extensor torque control suggest neural alterations, potentially related to decreased rate coding and inhibited motor unit recruitment. Deficits in flexor torque magnitude and knee extensor torque control occur at angles away from optimal fiber length, highlighting a need to consider the full ROM in rehabilitation and when assessing muscular recovery.

Data from this abstract were partially supported by funding from the American College of Sports Medicine.

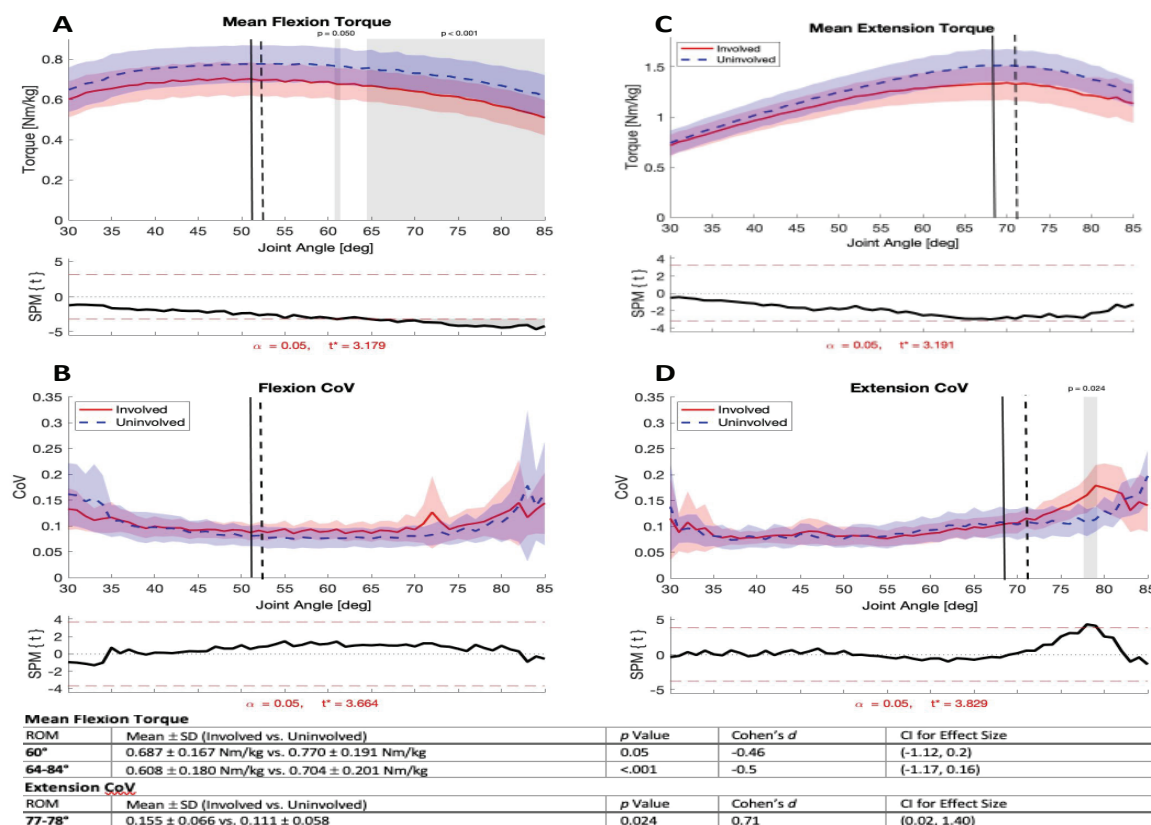


Figure 1. Continuous, Dynamic Assessment of Knee Flexor/Extensor Torque Magnitude and Control. Upper panels show mean flexion torque (A) and CoV (B) and mean extension torque (C) and CoV (D) from 30-85° of knee flexion for involved (red) and uninvolved (blue) limbs. Lower panels show the t-statistic of SPM analysis comparing each outcome between limbs ($\alpha = 0.05$, $t = 3.259$). Shaded regions indicate areas of statistically significant difference between limbs. Solid and dashed black lines indicate the angle of peak torque for the involved and uninvolved limb, respectively.

Changes in Y-Balance Scores During Rehabilitation After ACL Reconstruction

Srygler EC, Renner MN, Adler SN, Powell AJ, Trigsted SM, Biese KM, Bell DR: University of Wisconsin – Madison, Madison, WI, and University of Wisconsin – Oshkosh, Oshkosh, WI

Context: Injuries to the ACL in the knee typically result in lengthy recoveries and long rehabilitation periods. Although a plethora of literature exists regarding the early stages of rehab following ACL reconstruction (ACLR) surgery, less is known about the mid- to late-phases of rehabilitation and potential differences between healthy and reconstructed limb performance during functional testing. The purpose of this study is to determine if y-balance test (YBT) scores obtained during the mid-phase of ACLR rehabilitation changed over months 4, 5, and 6. We hypothesized that YBT performance for the injured limb would improve over time.

Methods: A total of 29 participants (18 females; 18.8 ± 3 years (range 15-24); 174 ± 10 cm; 72 ± 17 kg) were enrolled in the study. For inclusion, patients sustained a primary, unilateral ACL injury and had no episodes of instability or knee giving away. Participants were not excluded based on graft type. Participants were tested at months 4, 5, and 6 post-ACLR. For YBT scores, participants completed three trials in three directions (anterior, posterolateral (PL), and posteromedial (PM)) on both their reconstructed and healthy limbs. The maximum distance reached in centimeters was recorded for each trial. Repeated measures ANOVAs (3 (Time: months 4, 5, and 6) by 2 (Limb: healthy versus reconstructed)) were used to determine changes in the YBT scores. Post hoc testing

(Fischer's LSD) was used when necessary. Effect sizes were calculated using Cohen's d. Alpha level > 0.05 . **Results:** A main effect for limb was observed for the anterior (Healthy: m4: $78.8\text{cm} \pm 5.8$, m5: $79.5\text{cm} \pm 5.2$, m6: $79.4\text{cm} \pm 5.8$; Reconstructed: m4: $75.1\text{cm} \pm 13.8$, m5: $78.5\text{cm} \pm 5.1$, m6: $78.1\text{cm} \pm 6.4$, $p=0.023$) and PM (Healthy: m4: $80.0\text{cm} \pm 8.7$, m5: $81.0\text{cm} \pm 9.1$, m6: $82.9\text{cm} \pm 8.9$; Reconstructed: m4: $79.3\text{cm} \pm 6.8$, m5: $79.4\text{cm} \pm 8.2$, m6: $81.1\text{cm} \pm 8.5$, $p=0.013$) directions indicating that the reconstructed limb performed worse than the healthy limb. However, these differences were associated with small effect sizes (Anterior: $d=0.22$; PM: $d=0.02$). A main effect for time was observed for the PL (Healthy: m4: $74.5\text{cm} \pm 8.1$, m5: $75.8\text{cm} \pm 7.4$, m6: $77.6\text{cm} \pm 8.2$; Reconstructed: m4: $74.1\text{cm} \pm 8.6$, m5: $74.6\text{cm} \pm 7.7$, m6: $76.8\text{cm} \pm 9.8$; $p=0.027$) direction. Descriptive statistics, p-values, and effect sizes can be seen in Table 1. Post-hoc testing revealed that patients improved at each time point (month 6 $>$ month 5 $>$ month 4). However, these differences were also associated with small effect sizes ($d=0.08$). No other significant observations were found. **Conclusions:** Generally, our hypothesis was not supported. While we did observe a main effect for time in the PL direction, that was associated with a small effect size indicating that the observed differences may not be clinically meaningful. Functional tests such as the YBT may not be sensitive enough to detect changes during mid-phase rehabilitation following ACLR. Alternatively, it's possible that patients are not improving during this period and more focus needs to be rehabilitation and improving outcomes.

This project was supported by a grant from the NATA Foundation.

Table 1. Repeated Measures ANOVA Comparing Healthy and Reconstructed Limbs in Different YBT Reach Directions Across Months 4, 5, and 6 of ACL Reconstruction Rehabilitation

Reach Direction	Month	Limb	Mean (cm)	Standard Deviation	p-value
Anterior	4	Healthy	78.8	5.8	ME Limb = 0.023 ME Time = 0.274 Limb*Time = 0.294
		Reconstructed	75.1	13.8	
Anterior	5	Healthy	79.5	5.2	
		Reconstructed	78.5	5.1	
Anterior	6	Healthy	79.4	5.8	
		Reconstructed	78.1	6.4	
PL	4	Healthy	74.5	8.1	ME Limb = 0.196 ME Time = 0.027 Limb*Time = 0.883
		Reconstructed	74.1	8.6	
PL	5	Healthy	75.8	7.4	
		Reconstructed	74.6	7.7	
PL	6	Healthy	77.6	8.2	
		Reconstructed	76.8	9.8	
PM	4	Healthy	80.0	8.7	ME Limb = 0.013 ME Time = 0.109 Limb*Time = 0.772
		Reconstructed	79.3	6.8	
PM	5	Healthy	81.0	9.1	
		Reconstructed	79.4	8.2	
PM	6	Healthy	82.9	8.9	
		Reconstructed	81.1	8.5	

PM = posteromedial, PL = posterolateral, ME = Main Effect

Symmetries in Functional Hop Tests Do Not Relate to At-Risk Landing Biomechanics Following ACL Reconstruction

Heckert TE, McCrory JL, Dewig DR, Mancinelli CA, McDonough EB, Nguyen A: West Virginia University, Morgantown, WV

Context: Limb symmetry of functional hop tests are commonly used to evaluate return to sport (RTS) testing following ACL reconstruction (ACLR). Despite passing RTS testing criteria, reinjury rates are high following ACLR. Functional hop symmetry may not be a good indicator of an athlete's readiness to RTS as it does not consider asymmetries in landing biomechanics. Empirical evidence relating symmetries in hop tests and at-risk landing biomechanics is limited. Therefore, the purpose of this study was to examine the relationship between functional hop tests and landing biomechanics limb symmetries in athletes following ACLR. Understanding this relationship may help clinicians determine appropriate test batteries to include in RTS testing. **Methods:** Retrospective analyses were performed on 15

comprehensive ACL RTS testing sessions, extracted from 8 athletes (1M, 7F: 18.0±2.3yrs, 68.1±22.1kg, 168.8±6.2cm) who had undergone ACLR (9.2±2.5 months post-op) and displayed symmetry across all functional hop tests [limb symmetry index (LSI) < 15%]. Athletes completed the single-leg forward hop (FH), crossover hop (CH), and triple hop (TH) tests. Three-dimensional kinematics and kinetics were evaluated separately following a single-leg hop (SLH) over a hurdle (height= 7.6cm) set to 40cm from the middle of the force plates and a drop vertical jump (DVJ) from a box (height= 20cm). Maximum distance for FH, CH, and TH across 2 trials, and the average peak external knee abduction moment (KAM), peak vertical ground reaction force (vGRF), and knee valgus ROM [peak angle – angle at initial contact (IC=vGRF > 10N)] during the deceleration phase (IC to peak knee flexion) of the DVJ and SLH, across three trials, were calculated. LSI and normalized symmetry index (NSI) were calculated between the involved and uninvolved limbs for each functional hop test and landing biomechanics, respectively. Pearson Product-Moment correlations were used to evaluate the relationship between symmetry indices during functional hop tests and landing biomechanics

(alpha=0.05). **Results:** The calculated symmetry indices returned values between 0% (full symmetry) and ±100% (full asymmetry). All correlations between the functional hop tests and at-risk landing biomechanics are summarized in Table 1. Greater limb symmetry in the FH test was positively correlated with greater symmetry in DVJ knee valgus ROM (P=0.001) and SLH KAM (P=0.03). No other significant correlations were observed between symmetry indices (P > 0.05). **Conclusions:** Functional hop tests do not reflect asymmetries in lower extremity landing biomechanics in athletes who displayed an acceptable level of limb symmetry during RTS testing. Athletes who meet the criteria to RTS, based on functional hop tests, could have asymmetrical landing patterns that increase risk of reinjury. Evaluation of symmetry in landing biomechanics should be included in RTS testing. Future work should include the development of efficient and accessible methods to quantify landing biomechanics for practicing clinicians.

Table 1. Correlations Between Functional Hop Tests and Landing Symmetry Indices

	Single-Leg Hop LSI (3.5±3.9%)		Crossover Hop LSI (2.8±5.3%)		Crossover Hop LSI (-0.04±3.8%)	
	Pearson <i>r</i>	<i>P</i> Value	Pearson <i>r</i>	<i>P</i> Value	Pearson <i>r</i>	<i>P</i> Value
DVJ Knee Valgus ROM NSI (-4.9±28.7%)	0.747*	.001	0.384	0.157	-0.408	0.131
DVJ Knee Abduction Moment NSI (16.9±36.2%)	0.324	.239	0.206	0.462	-0.362	0.185
DVJ vGRF NSI (1.8±9.1%)	0.088	.755	0.353	0.197	-0.027	0.924
SLH Knee Valgus ROM NSI (5.9±35.5%)	-0.079	0.779	-0.051	0.856	-0.191	0.495
SLH Knee Abduction Moment NSI (-4.3±41.7%)	0.566*	0.028	0.004	0.990	-0.189	0.499
SLH vGRF NSI (-1.3±8.0%)	0.376	0.167	0.107	0.704	0.032	0.909

Abbreviations: DVJ, drop vertical jump; SLH, single leg hop; LSI, Limb Symmetry Index; NSI, Normalized Symmetry Index

Sagittal Plane Landing Biomechanics Differ Between Limbs in ACL Reconstructed Athletes With Symmetrical Functional Hop Distances
Nguyen A, Heckert TE, McCrory JL, Mancinelli CA, McDonough EB, Dewig DR: West Virginia University, Morgantown, WV

Context: Symmetry in distance between involved (INV) and uninvolved (UNI) limbs during functional hop tests are commonly used to determine readiness to return to sport (RTS) following ACL reconstruction (ACLR). However, evidence suggests that symmetrical hop distance is not related to symmetrical lower extremity landing biomechanics, which may in part, explain the high reinjury rates following ACLR. It is plausible that athletes adopt different neuromuscular strategies, masking biomechanical impairments, to achieve an acceptable level of symmetry during functional hop testing. Therefore, the purpose of this study was to examine differences between sagittal plane hip and knee kinetics and kinematics of the INV and UNI limbs during landing tasks in athletes following ACLR. **Methods:** As part of a comprehensive ACL RTS program, data from athletes who displayed limb symmetry across functional hop tests [limb symmetry index (LSI) < 15%] were retrospectively analyzed. Fifteen testing sessions, extracted from 8 athletes (1M, 7F: 18.0±2.3yrs, 68.1±22.1kg, 168.8±6.2cm) who had undergone ACLR (9.2±2.5 months post-op) were used for analyses. Three-dimensional kinematics and kinetics were collected during a single-leg hop (SLH) over a hurdle (height=7.6cm) 40cm from the

middle of the force plates and a drop vertical jump (DVJ) from a box (height=20cm). The average peak internal knee extension moment (KEM), knee flexion (KFLX) ROM [peak angle - initial contact angle (IC=vGRF > 10N)], peak internal hip extension moment (HEM), and hip flexion (HFLX) ROM during the deceleration phase (IC to peak KFLX), across three trials of the DVJ and SLH, were calculated and used for analyses. Paired t-tests determined differences in sagittal plane knee and hip kinetics and kinematics between the INV and UNI limbs during each landing task ($\alpha=0.05$). **Results:** Differences in sagittal plane hip and knee kinetics and kinematics between INV and UNI limbs during landing tasks are summarized in Table 1. During the DVJ, peak KEM ($P=0.001$) and KFLX ROM ($P=0.02$) were less in the INV compared to the UNI. During the SLH, peak KEM ($P=0.01$) and KFLX ROM ($P=0.01$) were less, while HEM ($P=0.04$) was greater, in the INV compared to the UNI. No other significant differences were observed between limbs ($P > 0.05$). **Conclusions:** Athletes following ACLR were observed to adopt a quadriceps avoidance strategy of the INV limb during the DVJ and SLH where KEM and KFLX ROM was less compared to the UNI limb. Additionally, a preferred hip strategy, greater HEM, was observed in the INV limb to successfully perform the SLH. This quadriceps avoidance strategy, combined with a preferred hip strategy, during the SLH may explain why at-risk knee biomechanics are observed in athletes that display symmetrical functional hop distances. Future work should confirm whether different sagittal plane hip and knee strategies observed during landings are consistent during functional hop testing.

Table 1. Comparison of Sagittal Plane Hip and Knee Kinetics and Kinematics during Landing Tasks

	Involved Limb (mean±SD)	Uninvolved Limb (mean±SD)	Mean Difference ±SD	<i>t</i> Value	<i>P</i> Value
DVJ Knee Extension Moment (Nm·kg ⁻¹ ·m ⁻¹)	0.46±0.58	1.49±0.53	1.02±0.99*	3.99	0.001
DVJ Hip Extension Moment (Nm·kg ⁻¹ ·m ⁻¹)	0.88±0.50	0.91±0.48	0.03±0.42	0.30	0.77
DVJ Knee Flexion ROM (°)	55.09±9.58	59.65±11.84	4.55±6.73*	2.62	0.02
DVJ Hip Flexion ROM (°)	47.22±15.66	49.64±17.43	2.42±4.94	1.90	0.08
SLH Knee Extension Moment (Nm·kg ⁻¹ ·m ⁻¹)	0.31±0.75	1.45±0.74	1.14±1.44*	3.06	0.01
SLH Hip Extension Moment (Nm·kg ⁻¹ ·m ⁻¹)	0.80±0.71	0.45±0.74	-0.35±0.60*	2.26	0.04
SLH Knee Flexion ROM (°)	31.07±6.60	35.47±9.56	4.40±5.96*	2.86	0.01
SLH Hip Flexion ROM (°)	16.66±6.76	17.40±9.63	0.75±5.55	0.52	0.61

Abbreviations: DVJ, drop vertical jump; SLH, single leg hop

Free Communications, Poster Presentations: Assessments to Improve Our Understanding of Concussion

Friday, June 23, 2023; authors present 11:45 AM-12:40 PM; Poster Hall

Correlation Between the Limits of Stability and Stability Evaluation Tests in Healthy Intercollegiate Athletes

Cripps AE, Toonstra JL, Stiltner S:
Bowling Green State University,
Bowling Green, OH

Context: Balance is known to be impaired following a concussion; as such, routine balance assessments are conducted during baseline testing and have been recommended to be included in the management of concussions. Most frequently, balance assessments include a measure of static balance, such as the Stability Evaluation Test (SET), where athletes are asked to maintain a steady center of gravity (COG) position throughout the test. While these methods have been shown to be reliable, they do not measure an athlete's functional abilities, including the ability to intentionally displace the COG to the stability limits (known as volitional control). The Limits of Stability Test (LOS) was designed to measure an individual's ability to volitionally displace their center of gravity (COG) without losing their balance. This ability is vitally important in athletics, as athletes are often required to adjust COG rapidly without losing control. However, it is not known if there is a relationship between static

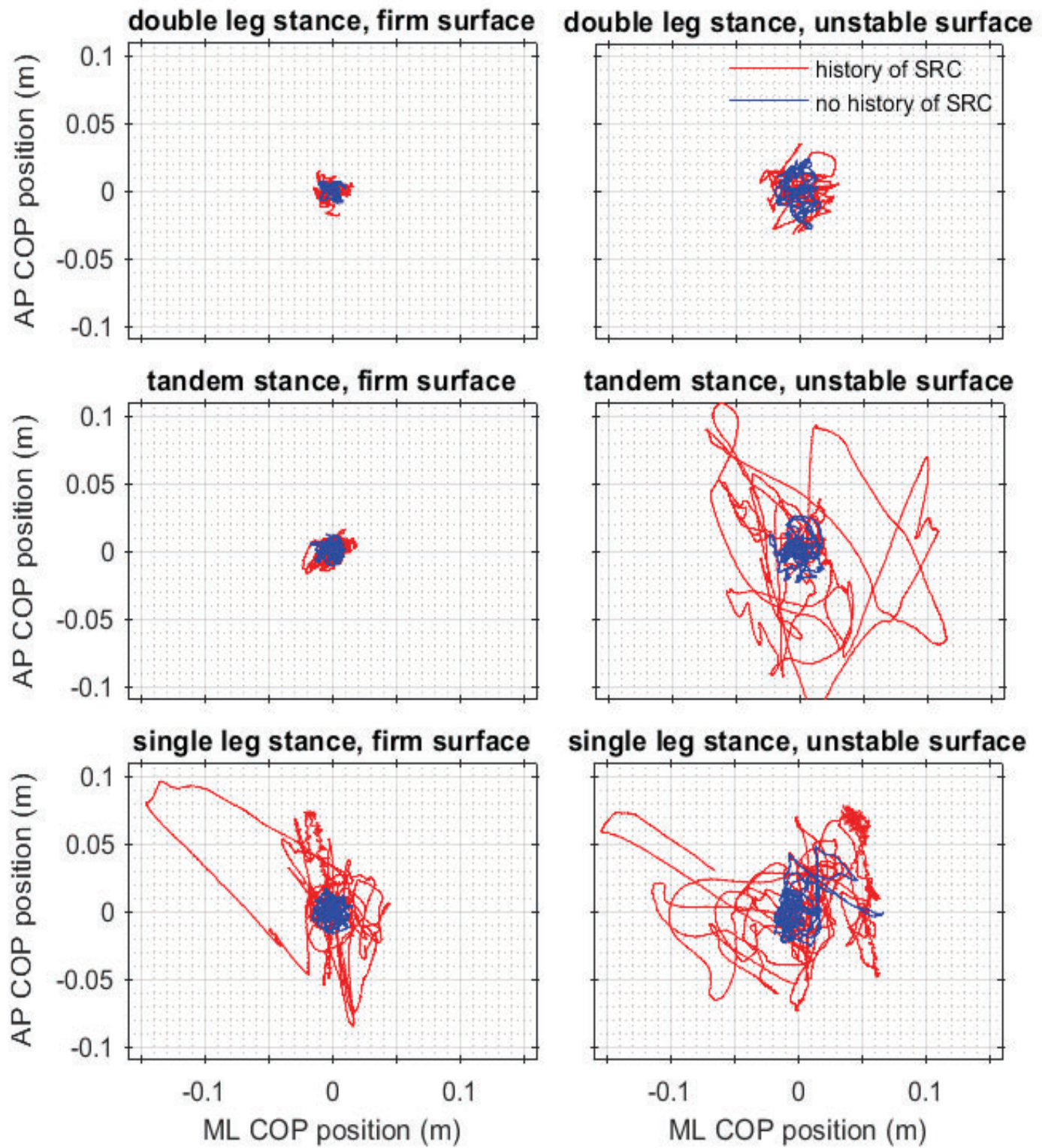
and volitional balance control. The purpose of this study is to determine if volitional control is correlated with static balance in a large sample size. **Methods:** 506 healthy intercollegiate athletes (age 19.60 \pm 1.47 years, height 177.31 \pm 11.58 cm, weight 77.57 \pm 20.245 kg) completed the SET and LOS testing protocol on the Natus NeuroCom® VSR Sport System as part of routine preseason baseline assessments. Outcome measurements include the LOS test outcomes (reaction time composite [RT], movement velocity composite [MVL], endpoint excursion composite [EPE], maximum excursion composite [MXE], and directional control composite [DC]) and the sway velocity composite score for the SET test. **Results:** A strong positive relationship was found between the LOS composite outcomes ($r=0.113-0.758$, $P<0.01$). There were no relationships between the SET sway velocity composite score and any of the LOS outcomes (RT $r=0.043$, MVL $r=0.043$, EPE $r=0.010$, MXE $r=0.015$, DCL $r=0.052$, $P<0.05$ for all outcomes). **Conclusions:** These results suggest that the LOS and the SET may measure different constructs of balance in healthy collegiate athletes. Health care practitioners who are utilizing static balance in their clinical setting should consider implementing the LOS into clinical practice to have a better understanding of impairments in volitional balance control.

Clinical and High-Resolution Balance Assessments in Division I Collegiate Gymnasts With and Without a History of Sport-Related Concussion

Robinson HM, Duque Urrego D, Pinnock Branford K, Aristizábal Pla G, Settle HA, Cain SM, Jochimsen KN: West Virginia University, Morgantown, WV

Context: Sport Related Concussions (SRC) are one of the most common injuries in collegiate gymnastics. Balance deficits commonly occur following SRCs, and balance is an essential aspect of gymnastics performance and safety. The Balance Error Scoring System (BESS) is a common test used to assess balance and inform RTP decisions post-SRC. While the BESS is a reliable clinical test for balance assessment, it may not be sensitive enough to detect deficits for athletes highly skilled in balance tasks. We aimed to compare BESS performance (# of errors and force plate derived steadiness measures) between gymnasts with and without a history of SRC. We hypothesized there would be no differences in the number of BESS errors; however, gymnasts with a history of SRC would be more unsteady. **Methods:** A total of 17(F) Division I collegiate gymnasts completed the BESS on a force plate (1000 Hz) at preseason. The BESS was scored traditionally (# of errors) by a trained clinician and six measures of steadiness were calculated from force plate data (MDIST: average distance from the mean center of pressure (COP), MDISTAP: average

anterior-posterior (AP) distance from the mean COP, TOTEX: total length of the COP path, TOTEXAP: total length of the AP COP path, MVELO: average velocity of the COP, and AREA-SW: sway area/area enclosed by the COP path per unit of time). Following tests for normality, variables of interest were compared between groups using Mann-Whitney U or independent t-tests, as appropriate. **Results:** Ten gymnasts (58.8%) reported a history of SRC. Gymnasts with (INJ) and without (NON) a history of SRC did not differ in the number of errors on the BESS (INJ: 6.4 ± 2.3 , NON: 8 ± 3 , $P=0.26$), steadiness variables for double leg, single leg, or tandem stance on a firm surface ($P \geq 0.14$), or double leg or tandem stance on an unstable surface ($P \geq 0.10$). They did differ in terms of TOTEX (INJ: $7.3\text{m} \pm 1.5\text{m}$, NON: $6.0\text{m} \pm 0.6\text{m}$, $P=0.04$), MVELO (INJ: $0.4\text{m/s} \pm 0.07\text{m/s}$, NON: $0.3\text{m/s} \pm 0.03\text{m/s}$, $P=0.04$), and AREA-SW (INJ: $0.004\text{m}^2 \pm 0.002\text{m}^2$, NON: $0.003\text{m}^2 \pm 0.0008\text{m}^2$, $P=0.03$) during the single-leg stance task on the unstable surface, such that gymnasts with a history of SRC had a higher TOTEX, MVELO, and AREA-SW. (Figure 1) **Conclusions:** While the BESS is a good clinical balance assessment, these data suggest it may not be sensitive enough to detect persistent post-SRC balance deficits for athletes who are highly skilled in balance tasks, such as gymnasts. Considering that the BESS is often an aspect of SRC RTP protocols, clinicians may consider integrating higher resolution measures of balance, such as those enabled by a force platform, which are sensitive enough to detect persistent balance deficits.



Differences in Voluntary Motor Control Between Intercollegiate Athletes of Different Sports

Toonstra JL, Stiltner S, Cripps AE:
Bowling Green State University,
Bowling Green, OH

Context: Measures of balance have been recommended to be included in the baseline assessment of a concussion protocol. Traditionally, these assessments are static in nature, where the athlete is asked to move as little as possible. These assessments do not properly reflect the functional tasks that athletes encounter during sporting activities and may not fully ascertain the complexities of balance. A limits of stability (LOS) test quantifies impairments in an athlete's ability to intentionally displace the center of gravity (COG) to their stability limit without losing balance. However, it is currently not known, how athletes of different sporting events fare on the LOS and if there is a need to produce normative data for each sport. The purpose of this study was to determine if there are differences on LOS outcomes between athletes participating in different sporting events. **Methods:** 499 healthy intercollegiate athletes (age 19.60 +/- 1.47 years, height 177.31 +/- 11.58 cm, weight 77.57 +/- 20.245 kg) completed the LOS testing protocol on the Natus NeuroCom ® VSR

Sport System as part of routine preseason baseline assessments. Athletes from 15 sports participated. Outcome measurements are the LOS test outcomes (reaction time composite [RT], movement velocity composite [MVL], endpoint excursion composite [EPE], maximum excursion composite [MXE], and directional control composite [DC]). A one-way ANOVA with post-hoc testing was executed to analyze differences between athletes competing in distinctive sports.

Results: Significant between group differences were noted in RT ($F_{14,484}=4.171$, $p<0.05$), MVL ($F_{14,484}=3.515$, $p<0.05$), and DCL ($F_{14,484}=2.181$, $p<0.05$). No significant differences were found on the EPE ($F_{14,484}=1.182$, $p=0.285$), and MXE ($F_{14,484}=0.585$, $p=0.877$) outcomes. Post hoc testing revealed multiple significant difference between sports. Table 1 shows the average time to movement (named RT) for each of the sports tested. All sports demonstrated a significantly different RT compared to at least one other sport, and most showed multiple differences. **Conclusions:** Athletes participating in different sports demonstrate significant variations when assessed on a limits of stability test. Healthcare professionals should consider the adoption of a limits of stability test as part of the routine baseline concussion assessment, allowing them to establish a metric for comparison following a concussive episode.

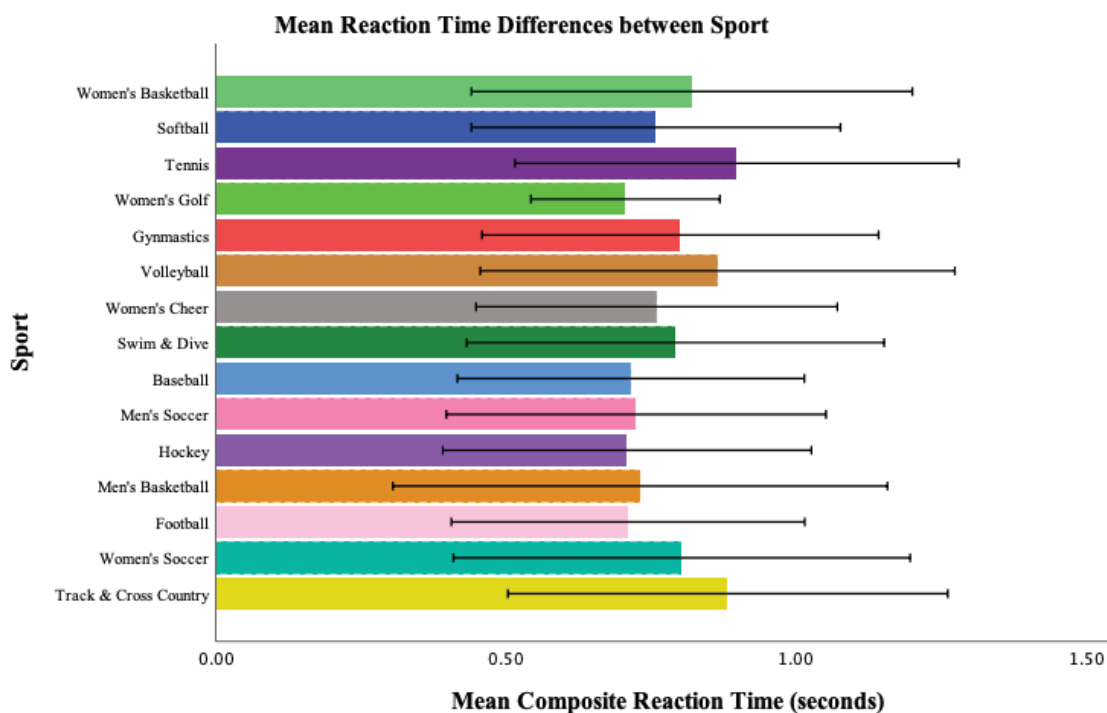


Figure 1. Time to Movement. All sports displayed a statistically significant difference with at least one other team ($p<0.05$)

Examining the Relationship Between Concussion History and Dynamic Balance in Police Officers

Williams RM, Hill C, liams A, Laska T, Matija M, Rogers S, Gnacinski SL: Drake University, Des Moines, IA

Context: Concussions are multifaceted and may include balance impairments throughout recovery. Some research has suggested that lingering balance deficits and delayed reaction time may occur months to years following a concussion. Occupations such as law enforcement involve tasks that require muscular strength, coordination, and dynamic balance. Thus, it is imperative to explore connections between concussion history and indicators of lower extremity injury risk among officers. Specifically, for those officers who have sustained previous concussions through athletics or recreation, it is unclear how their concussion history may impact dynamic balance and add risk to lower extremity injury. Therefore, this study aimed to examine the effect of concussion history on dynamic balance among active-duty police officers. **Methods:** Thirty-six officers (concussion history: n=17; no concussion history: n=19; Age: 33.38±9.37; Height: 177.37±8.04 cm; weight: 88.44 ± 15.25 kg; BMI: 28.12 ± 4.72) completed an online demographic survey including concussion history

and a y-balance test (YBT) for dynamic balance. YBT measures directional reach per limb, including the right (R) and left (L) anterior, posteromedial, and posterolateral. Practice trials were incorporated to account for learning effects. L and R reach distances were normalized to limb length. L and R composite scores were computed by averaging YBT scores. Data were analyzed using an independent-samples t-test by group (concussion history, no concussion history), for normative YBT, FMS overall score, and health history questions ($\alpha = 0.05$). No differences in age were present between groups; therefore, the authors did not include age as a covariate. **Results:** Seventeen officers reported a recreational concussion history with an average of 3.88 ±6.15 concussions. Significant group differences were found in YBT normative scores between L anterior (P=0.012), L posteromedial (P =0.005), R anterior (P =0.028), R posteromedial (P=0.008), L composite score (P =.009), and R composite score (P =0.08), respectively. No significant group differences were found for, YBT L posterolateral, YBT R posterolateral, and LQYBT percent (Table 1). **Conclusions:** The findings from this study highlight that individuals with a concussion history demonstrated greater YBT reach in all directions, except posterolateral, compared to officers without a concussion history. While it was expected that officers with a concussion history

would demonstrate poor dynamic balance because of residual balance deficits, previous literature has demonstrated no differences between participants with and without concussion history in dynamic balance when assessed with the YBT. It is possible that concussions may not involve long term effects on the type of neuromuscular activation required for YBT performance. Clinicians should be aware of concussion history when assessing balance performance in sworn officers. Future research should involve a variety of neuromuscular control and activation assessments (e.g., reaction time, time to stabilization, etc.) to holistically characterize possible long-term concussion deficits in this population.

This project is funded by Drake University Faculty Research Grant.

Table: Variables means, standard deviations, 95% Confidence interval, and cohen's d.

Variable	Concussion History Mean (SD)	No Concussion History Mean (SD)	T	P value	95% CI	Cohen's d
Norm YBT L ANT	.73 (.07)	.67 (.06)	2.65	.012*	.01 to .11	.89
Norm YBT L PM	1.20 (.10)	1.10 (.09)	3.03	.005*	.03 to .16	1.0
Norm YBT L PL	1.13 (.13)	1.10 (.09)	1.95	.059	-.00 to .17	.66
Norm YBT R ANT	.73 (.08)	.68 (.07)	2.30	.028*	.01 to .11	.78
Norm YBT R PM	1.19(.11)	1.10 (.09)	2.82	.008*	.03 to .17	.96
Norm YBT R PL	1.12 (.16)	1.04 (.12)	1.66	.106	-.02 to .18	.56
YBT Comp L	1.02 (.09)	.94 (.08)	2.78	.009*	.02 to .13	.94
YBY Comp R	1.01 (.1)	.94 (.08)	2.49	.018*	.01 to .14	.84
LQ YBT Percent	97.40 (2.42)	96.68 (2.42)	.88	.382	-.94 to 2.39	.30
Age	33.53 (8.62)	33.26 (10.24)	.08	.93	-6.19 to 6.72	.03

Virtual Reality Motor Response Variability and Self-Rated Well-Being Associate With Remote Concussion History

Wilkerson GB, Colston MA, Acocello SN, Hogg JA, Carlson LM: University of Tennessee at Chattanooga, Chattanooga, TN

Context: A lack of long-term sport-related concussion effects on standard clinical measures of performance capabilities does not preclude the possible existence of subtle neural processing impairments that may elevate risk for subsequent concussion occurrence, and which may be associated with greater susceptibility to neurodegenerative processes. The purpose of this study was to assess the potential value of metrics derived from a virtual reality (VR) test for detection of a subtle and persistent impairment in perceptual-motor function among college students with a history of sport-related concussion (HxSRC), which may concurrently exist with persistent post-concussion symptoms documented by survey responses. **Methods:** A prospective exploratory cohort study included 75 college students (20.7 ± 2.1 years): 39 Reserve Officer Training Corp cadets (10 female), 16 football players, and 20 wrestlers; HxSRC was self-reported by 20 (29.2 ± 27.1 months prior, range: 3-96). A VR test involving 40 lunging-reaching response times to horizontally moving dots (filled-congruent: same direction response; open-incongruent: opposite direction response) was administered, along with an electronic version of the Sport Fitness and Wellness Index (SFWI). Dispersion (standard deviation of 12 T-scores for neck, upper extremity, and whole-body response times for congruent and incongruent visual stimuli originating from central and peripheral locations) and SFWI responses were the primary outcomes of interest. Previous research involving college students has

demonstrated good internal consistency for both the Sport Fitness and Overall Wellness components of the SFWI (Chronbach's $\alpha = 0.89$ and 0.82 , respectively). The latter component has also demonstrated good discriminatory power for identification of HxSRC ($AUC = 0.71$). No reliability data currently exist for the VR metrics. Backward stepwise logistic regression modeling included multiple VR metrics, SFWI, and interaction between each VR metric and SFWI, which included assessment of the possible influences of covariates on the final model. **Results:** Logistic regression modeling of Dispersion (range: 1.5-21.8) and the interaction of Dispersion with SFWI (range: 44-100) provided 81% HxC classification accuracy (Model $\chi^2[2]=26.03$, $p<.001$; Hosmer & Lemeshow $\chi^2[8]=1.86$, $p=.967$; Nagelkerke $R^2=.427$). Figure depicts Area Under Curve=.84 (95% CI: .73, .95). Binary modeling that included VR Dispersion ≥ 3.2 and SFWI ≤ 86 demonstrated 75% sensitivity and 86% specificity with both factors positive (Odds Ratio=17.6, 95% CI: 5.0, 62.1). **Conclusions:** Detection of subtle indicators of altered brain processes that might otherwise remain unrecognized is clearly important for both short-term and long-term clinical management of concussion. Although test-retest reliability has not yet been established for measurements derived from the VR system that we used, performance inconsistency may be an important factor that characterizes suboptimal integration of perceptual-motor processes by the brain. Motor responses to different types of moving visual stimuli, along with survey responses suggesting suboptimal well-being, merit further investigation as possible clinical indicators of persisting effects of concussion that might be modifiable.

Presenter serves as a consultant to REACT Neuro (Cambridge, MA), which provided virtual reality equipment for data collection.

Altered Postural Stability With Virtual Reality Immersion After Recent Concussion

Farraye BT, Nguyen A, McFeely M, Haas M, Grooms DR, Simon JE: Ohio University, Athens, OH; University of South Florida, Tampa, FL; State College Area School District, State College, PA; OhioHealth, Columbus, OH

Context: The BESS is widely used to identify post-concussion recovery, but has a ceiling effect limiting clinical utility. Virtual reality (VR) is an emerging tool to induce visual perturbations that can further challenge balance and reduce the ceiling effect in athletes. Therefore, the aim of this study was to evaluate if a VR single-leg balance task can challenge postural stability after a recent concussion compared to the standard eyes-closed (EC) condition. **Methods:** A case-control study was conducted in high school ATFs. Thirteen participants were enrolled post-concussion after physician clearance who followed the current consensus statement on concussion management (5 females, 15.85±1.14 years, 1.73±0.13m, 68.63±11.53kg, 10.5±1.43 days since cleared). Thirteen healthy controls matched on sex, age, height, weight, and sport (5 females, 16.15±1.14 years, 1.74±0.11m, 67.68±9.72kg) with no concussion history and no lower extremity injury in the past year were enrolled; no significant differences between

group demographics ($p > 0.05$). Participants completed a non-dominant single-leg balance test for 20 seconds under EC and VR conditions on a force plate (Bertec; Columbus, OH) with firm and foam (Airex; Sins, Switzerland) surfaces. An Oculus VR headset played a 360° rollercoaster video for the VR condition following an acclimation session. Athletic trainers administered the tests and scored the number of errors using BESS errors. Three practice trials were given for each condition and surface and 2 trials of each condition and surface were averaged for analyses with 1 minute rest between trials. A repeated measures ANOVA was conducted for the dependent variables CoP medial-lateral velocity, CoP anterior-posterior velocity, and number of errors. Each repeated measures ANOVA had two within-subjects factors surface (firm and foam) and condition (EC and VR) and one between-subjects factor group (healthy and recent concussion). The primary comparison of interest was the three-way interaction (surface x condition x group). Post-hoc testing was conducted as appropriate, with $\alpha = 0.05$. **Results:** The three-way interaction of surface x condition x group was significant for CoP medial-lateral velocity, CoP anterior-posterior velocity, and number of errors ($p = 0.014$, $p < 0.001$, $p = 0.002$, respectively; Table 1). CoP medial-lateral and anterior-posterior velocities were significantly increased under the VR condition compared to EC for both surfaces only in the recently concussed group (medial-lateral: mean difference 1.69±0.33cm/s firm and 2.78±0.22cm/s

foam; anterior-posterior: mean difference 1.54±0.16cm/s firm and 2.48±0.29cm/s foam). There was a significant increase in errors for the VR condition compared to EC for both surfaces only in the recently concussed group (mean difference 3.89±0.32 errors firm and 4.27±0.29 errors foam). **Conclusions:** Individuals with a recent concussion demonstrated altered postural control during a single-leg balance task with VR immersion compared to healthy individuals and the EC condition. This may indicate that visual-vestibular deficits linger past concussion recovery and may not be exposed with the traditional EC BESS.

This project was supported by the Great Lakes Athletic Trainer's Association. The content of this abstract is solely the responsibility of the authors and does not necessarily represent the official views of the Great Lakes Athletic Trainer's Association, or its members.

Table 1. CoP Velocity and Number of Errors Descriptive Statistics Across All Conditions in Both Groups

Data presented Mean±SD		Firm		Foam	
		Eyes-Closed	Virtual Reality	Eyes-Closed	Virtual Reality
CoP Medial-Lateral Velocity (cm/s)	Healthy	1.56±0.27	1.86±0.30	2.01±0.46	1.81±0.55
	Recent Concussion	3.68±1.08*	5.37±0.91*†	3.47±0.85*	6.25±0.60*†
CoP Anterior-Posterior Velocity (cm/s)	Healthy	1.44±0.29	1.89±0.36	1.81±0.32	1.99±0.64
	Recent Concussion	3.91±0.68*	5.44±0.45*†	3.57±0.76*	6.05±0.81*†
Number of Errors	Healthy	2.54±1.07	3.03±0.22	4.62±0.55	4.92±0.53
	Recent Concussion	3.15±0.88	7.03±1.13*†	4.65±0.55	8.92±0.91*†

* significant difference between groups ($p < 0.05$)

† significant difference between conditions within a group ($p < 0.05$)

Comparison of Head Impact Kinematics for Head Impacts Initiated By Helmets and Shoulder Pads Among High School American Football Athletes

Sinnott AM, Collins CL, Boltz AJ, Robison HJ, Pinapaka H, Mihalik JP: Matthew Gfeller Center, University of North Carolina at Chapel Hill, Chapel Hill, NC, and Datalys Center for Sports Injury Research and Prevention, Indianapolis, IN

Context: Helmets and shoulder pads are required equipment intended to protect American football athletes by attenuating collision forces during regular participation (e.g., blocking, tackling). Despite helmets requiring rigorous industry-wide certification standards, no standards exist for shoulder pads. Given their hard plastic design, shoulder pads—and not just helmets—may have the potential to cause injurious head impacts. Surprisingly, research differentiating head impact kinematics initiated by helmets from those initiated by shoulder pads has not been completed. The current study's purpose was to determine the effects of equipment (i.e., helmet, shoulder pads) on head

impact kinematics among adolescent football athletes. **Methods:** We conducted a prospective cohort investigation comprised of sixty-nine male American football athletes from three high schools who were equipped with Head Impact Telemetry (HIT) System (Riddell Inc.; Rosemont, IL) instrumentation. The HIT System quantifies peak linear (g) and rotational (rad/s²) accelerations using six single-axis accelerometers embedded inside select Riddell football helmets. These real-time data are transmitted to a sideline data collection system and post-processed using a proprietary algorithm. Data were extracted for video-confirmed impacts during two competitions (Team 1 vs. 2, and Team 1 vs. 3). Separate ordinary least squares regressions were used to evaluate if equipment contact (helmet, shoulder pad) predicted linear and rotation accelerations, respectively. Linear and rotational accelerations underwent natural logarithmic transformations because they followed an expected non-normal distribution since head impact kinematics are heavily skewed toward low-magnitude impacts. **Results:** We examined 1,150 video-confirmed impacts involving helmet or shoulder pad contact. Shoulder pad-initiated head impacts were observed in 16.5% (N=190) of all impacts (Table 1). Equipment

contact did not predict linear ($p = 0.809$) or rotational ($p = 0.351$) acceleration. **Conclusions:** Overall, our findings revealed head impact kinematics were similar across impacts initiated by helmets and shoulder pads. This suggests shoulder pads can deliver comparable forces to helmets during regular football participation. Industry standards should be explored for shoulder pads. Clinicians, equipment manufacturers, and injury prevention scientists may need to factor in the unintended role shoulder pads may play in elevating head injury risk. Future epidemiological studies should explore injury rates and other sport-related factors that may inform injury prevention interventions including player position, play type, and closing distance.

This study was funded by the National Operating Committee on Standards for Athletic Equipment (NOCSAE).

Table 1. Frequency (Percentage) of Head Impacts Initiated by Helmet (N=960) or Shoulder Pads (N=190) Across Gameplay Characteristics.

Variable	Helmet (N=960)			Shoulder Pad (N=190)			Total (N=1,150)	
	Count	Percentage of Helmet Impacts	Percentage Within Category	Count	Percentage of Shoulder Pads Impacts	Percentage Within Category	Count	Percentage of Total Impacts
Quarter								
1	278	29.0%	87.1%	41	21.6%	12.9%	319	27.7%
2	246	25.6%	82.3%	53	27.9%	17.7%	299	26.0%
3	229	23.9%	79.2%	60	31.6%	20.8%	289	25.1%
4	207	21.6%	85.2%	36	18.9%	14.8%	243	21.1%
Play Type ^a								
Pass	253	26.4%	86.6%	39	20.5%	13.4%	292	25.4%
Rush	574	59.8%	83.2%	116	61.1%	16.8%	690	60.0%
Screen	13	1.4%	86.7%	2	1.1%	13.3%	15	1.3%
PAT/Field Goal	43	4.5%	87.8%	6	3.2%	12.2%	49	4.3%
Kickoff, returned	25	2.6%	67.6%	12	6.3%	32.4%	37	3.2%
Punt, returned	13	1.4%	61.9%	8	4.2%	38.1%	21	1.8%
Punt, not returned	25	2.6%	86.2%	4	2.1%	13.8%	29	2.5%
Transition/Celebratory	3	0.3%	75.0%	1	0.5%	25.0%	4	0.3%
Unknown	11	1.1%	84.6%	2	1.1%	15.4%	13	1.1%
Play Type-GROUP								
Rush	574	59.8%	83.2%	116	61.1%	16.8%	690	60.0%
Pass and Screen Plays	266	27.7%	86.6%	41	21.6%	13.4%	307	26.7%
Special Teams and Transition	120	12.5%	78.4%	33	17.4%	21.6%	153	13.3%
Striking								
Delivered contact (striking)	655	83.1%	83.1%	133	70.0%	16.9%	788	68.5%
Received contact (player struck)	305	16.9%	84.3%	57	30.0%	15.7%	362	31.5%
Preparedness ^b								
Anticipated, good body position	813	84.7%	84.8%	146	76.8%	15.2%	959	83.4%
Anticipated, poor body position	131	13.6%	77.1%	39	20.5%	22.9%	170	14.8%
Unanticipated	16	1.7%	76.2%	5	2.6%	23.8%	21	1.8%
Closing Distance ^c								
Less than 5 Yards	788	82.1%	86.6%	122	64.2%	13.4%	910	79.1%
5-10 yards	134	14.0%	75.3%	44	23.2%	24.7%	178	15.5%
More than 10 yards	38	4.0%	61.3%	24	12.6%	38.7%	62	5.4%

^a $\chi^2(8) = 17.18, p = 0.028$ ^b $\chi^2(2) = 7.06, p = 0.029$ ^c $\chi^2(2) = 37.21, p < 0.001$

The Reliability and Validity of Smartphone Balance Measures: Implications for Clinical Use
 Prato TA, Lynall RC, Howell DR, Lugade V: UGA Concussion Research Laboratory, Department of Kinesiology, University of Georgia, Athens, GA; University of Colorado School of Medicine, Children's Hospital Colorado, Aurora, CO; Division of Physical Therapy, Binghamton University, Binghamton, NY

Context: Clinical balance assessments require interpretation that often results in varying assessment reliability(1). With the technological advancements and accessibility of smartphones, new methods to objectively measure balance at little to no cost could provide clinicians with superior assessment tools. Our objective was to assess the reliability and validity of standing balance outcomes within the Improve smartphone application. We hypothesized the app would be a reliable and valid standing balance measure. **Methods:** A repeated-measures study was conducted in a laboratory with a convenience sample of healthy participants who completed four 30-second standing trials of four balance conditions (tandem-stance eyes open, tandem-stance eyes closed, single-leg eyes open, single-leg eyes closed,) at two time points separated by ~7 days. The nondominant leg was used for single leg balance conditions and was the rearmost foot in the heel-to-toe tandem-stance. Participants were fitted with a

belt that held an Android (Samsung Galaxy S7) and iOS (iPhone X) smartphone vertically over their lower back. The Improve application was pre-installed on each phone, which collected tri-axial accelerations at 200Hz. Attached to the belt were three coplanar retroreflective markers, which were tracked by an 8-camera Qualisys motion capture system at 200 Hz. Dependent variables from each phone and the motion capture system were range, 95% elliptical area, and path. To assess between-session reliability, we applied an ICC (2,k). Values below 0.5 were considered poor, 0.50-0.75 moderate, 0.75-0.90 good, and above 0.90 excellent reliability(2). To assess validity, we utilized Pearson's r correlations between marker data and each smartphone at the first session. Values between 0.00-0.30 were considered negligible, 0.30-0.50 low, 0.50-0.70 moderate, 0.70-0.90 high, and 0.90-1.00 very high(3). **Results:** Twenty-three participants (22.9±3.0 years old, 65.2% female) completed both data collection sessions. Reliability and validity results, broken-down by condition, are in Table 1. Android, iOS and the marker system all demonstrated good to excellent reliability across all variables during the two eyes open conditions. Moderate to good reliability was demonstrated during the single-leg eyes closed condition for the iOS and marker system, but the Android demonstrated poor to good reliability. However, path remained good to excellent regardless of condition or system. Correlations assessing validity between the Android or iOS smartphone and the marker data demonstrated moderate to very high values. **Conclusions:** The standing balance outcomes within the Improve

smartphone application adequately measured standing balance performance with both operating systems proving to be equally reliable and valid. Higher difficulty tasks were associated with poorer outcomes, but this was to be expected due to the variability in performance caused by those tasks. With the growing accessibility of smartphones, clinicians can begin to implement the Improve application as a stable and valid objective standing balance assessment.

Dr. Vipul Lugade also serves as a developer creating the Improve smartphone application.

Table 1. Reliability and validity of the Improve balance outcomes during tandem-stance (Tandem) and single-leg stance (Single) with eyes-open (EO) and eyes-closed (EC).

		Reliability (ICC 2,k)				Validity (Pearson r)			
		Tandem -EO	Tandem -EC	Single -EO	Single -EC	Tandem -EO	Tandem -EC	Single -EO	Single -EC
Android	Range	0.90	0.50	0.94	0.71	0.92	0.83	0.93	0.88
	Path	0.89	0.87	0.94	0.78	0.83	0.93	0.85	0.85
	Elip	0.84	0.41	0.84	0.58	0.97	0.66	0.90	0.89
iOS	Range	0.86	0.51	0.94	0.76	0.82	0.77	0.93	0.88
	Path	0.88	0.86	0.82	0.79	0.88	0.87	0.84	0.87
	Elip	0.89	0.51	0.87	0.68	0.70	0.56	0.91	0.93
Marker	Range	0.95	0.73	0.94	0.63				
	Path	0.93	0.87	0.89	0.75				
	Elip	0.93	0.70	0.84	0.31				

Abbreviations: EO, Eyes Open; EC, Eyes Closed; Elip, 95% elliptical area.

Relationship Between Performance on the Sensory Organization Test and Vestibular-Ocular Motor Screen in Collegiate Athletes

Higgins HM, Rosenblum DJ, Donahue CC, Resch JE: University of Virginia, Charlottesville, VA

Context: The Sensory Organization Test (SOT) and the Vestibular-Ocular Motor Screen (VOMS) are clinical measures used to evaluate athletes before and after a suspected sport concussion (SC). Due to similarities in postural control mechanisms evaluated by each assessment, it is important to further understand the unique contribution of the SOT and VOMS in the clinical assessment of SC. The purpose of this study was to examine the relationship between SOT and VOMS performance in healthy collegiate athletes. We hypothesized that a significant negative correlation would be observed between the SOT and VOMS outcome scores in healthy collegiate athletes. **Methods:** This cross-sectional study consisted of 212 (81 females, 131 males) Division I collegiate athletes who were on average 18.8±1.4 years of age. All participants were administered the SOT and VOMS in alignment with the university Athletic Department's concussion management protocol. The SOT and VOMS were administered by trained examiners. Primary outcome

measures included were the SOT Equilibrium score (EQUIL), Somatosensory (SOM), Visual (VIS), and Vestibular (VEST) sensory ratios and the VOMS total symptom score. Chi-squared tests (χ^2) and independent t-tests were used to compare group composition by gender and sport. Due to non-normally distributed data, Spearman's rho (ρ) was used to calculate the correlations between each SOT outcome score and the VOMS total symptom score. All analyses were performed with $\alpha=0.05$. **Results:** A significant, but weak, negative correlation was observed between the SOT's EQUIL score and the VOMS total symptom score ($\rho=-0.15$, $p=0.03$). Additionally, a significant, but weak, positive correlation ($\rho=0.17$, $p=0.01$) was observed between the SOT's SOM sensory ratio and the VOMS total symptom score. No additional significant correlations were observed between any SOT outcome score and the VOMS total symptom score ($p > 0.05$). **Conclusions:** Our data suggests a weak, but significant, relationship between some, but not all, SOT outcome scores and the VOMS total symptom score. Future research should examine the relationship between each VOMS subtest and each SOT outcome scores in healthy collegiate athletes and those with SC. These findings support that the SOT and the VOMS are measuring two distinct constructs and that each test should be incorporated into a concussion management protocol.

Free Communications, Poster Presentations: Mental Well-Being

Friday, June 23, 2023; authors present 11:45 AM-12:40 PM; Poster Hall

The Relationship Between Fad Dieting Behaviors and Disordered Eating in Athletic Trainers

Madrak E, Volberding JL, Cole KL, Miller BM: The University of Virginia, Charlottesville, VA; Oklahoma State University, Center for Health Sciences, Stillwater, OK; Oklahoma State University, Stillwater, OK; The University of South Carolina, Columbia, SC

Context: Although athletic trainers (ATs) have a strong baseline of knowledge in what it takes for their patients to be physically healthy, they rarely practice the same principals, especially when it comes to weight control and nourishment. These poor nutritional behaviors often are a precursor to disordered eating and eating disorders, which have been observed in the general population. Because of this, we wanted to determine if there was a relationship between [weight-loss] dieting behavior and disordered eating behavior in ATs. We hypothesized that those who had or were currently following a fad diet would demonstrate a greater level of disordered eating behavior. **Methods:** A cross-sectional online survey was emailed to 2500 NATA members, with 265 completing the survey. Participants completed the 12-item Eating Disorder Questionnaire, Short-form (EDE-QS), with an internal reliability of 0.82. Scores were placed in categories, rather than in continuous form for

ease of reporting. In addition to the EDE-QS 5 researcher-created questions were used: “Are you currently following a diet?” “Have you ever followed a diet intended for weight-loss?” “On average, how long do you follow a diet?” “Did you lose weight?” “How long were you able to keep the weight off?” Chi square tests were used to determine significance between total score of the EDE-QS and diet questions. **Results:** A total of 3 chi-square tests demonstrated statistically significant results, satisfying all assumptions, “Are you currently following a diet” and total score, $\chi^2(3)=15.28$, $p<0.05$; “Have you ever followed a diet” and total score, $\chi^2(3)=51.57$, $p<0.05$; and “How long were you able to keep the weight off [from dieting]” and total score, $\chi^2(6)=47.76$, $p<0.05$. **Conclusions:** In comparison that those who have not utilized dieting, those that have dieted at least once have a greater likelihood of disordered eating behavior. This remains consistent with our hypothesis. These behaviors are likely a result of western societal beauty standards and pressures, experiences from dieting during childhood, the growing influence of social media and media in general, and the impact on the impressionable minds of young adults. These results suggests that ATs may not be taking proper health guidelines into consideration when it comes to weight-loss. This may have a huge impact on AT credibility toward patients, and therefore their compliance with our treatment/education.

The Association of Energy Drink and Alcohol Use With Coping Styles Among Acrobatics and Tumbling Athletes

Lee KL, Gallucci AR, Funderburk LK, Forsse JS, Cherpe de Souza L, Irvin LR, Boyer EJ, Fant KH: Baylor University, Waco, TX

Context: Collegiate student athletes face significant stressors related to academics and sport. Such stressors can be managed through a variety of coping strategies, one of which is substance use. This study examined two commonly consumed substances amongst college students – alcohol and energy drinks. Previous research on caffeine consumption in college students found multiple motivations including decreasing fatigue, improving concentration, and alleviating stress. Significant additional research has focused on collegiate student athletes' use of alcohol to cope with the stress of sport and life demands. The relationship between energy drink, alcohol use and coping style has not been previously examined in acrobatics and tumbling (A&T) athletes. The purpose of this study was to examine the coping styles of A&T athletes and assess the relationship with the use of energy drinks and alcohol. **Methods:** 42 female A&T student athletes (19.60 +/- 1.17 years) at a NCAA division I university participated in this cohort study. Participants completed online surveys at the beginning and end of the fall training period. The survey utilized the Brief COPE to assess coping style, as well as items assessing current alcohol and energy drink use. The validated Brief COPE consists of 28 questions utilized to assess the extent to which

individuals use approach and avoidance coping styles. T tests were used to determine if significant differences existed in alcohol and caffeine use at the beginning and end of fall training. Regressions determined the effect of energy drink consumption on coping scores. **Results:** Participants reported 6.48 +/- 12.10 energy drinks and 1.29 +/- 2.35 alcoholic beverages in the past 30 days at the beginning of fall training. Following fall training, they reported an increase in energy drink (7.60 +/- 10.69) and a decrease in alcohol intake (0.81 +/- 1.58). Only the decrease in alcohol consumption was significant ($p=0.038$). Approach coping scores were 30.34 +/- 8.65 at the beginning of fall training and 28.28 +/- 8.76 following. Avoidant coping scores averaged 19.74 +/- 4.65 initially and 18.44 +/- 4.85 following. A significant positive correlation ($r=0.37$, $p=0.018$) was found between energy drink and alcohol consumption prior to fall training. Avoidant coping scores were significantly higher at the beginning of the fall compared to following ($p=0.01$). Caffeine use was not a significant predictor of avoidant coping scores. **Conclusions:** During the fall training period, both alcohol consumption and avoidant coping scores decreased significantly. Energy drink consumption did not significantly increase. These patterns may reveal important coping strategies utilized by A&T student athletes. Specifically, increased caffeine and decreased alcohol consumption were used to address changing stress levels. Athletic trainers, coaches, and other support staff need to understand the coping styles utilized by athletes to aid them in support and development of appropriate strategies.

Incoming Student-Athlete Mental Health Scores Did Not Increase Due to the COVID-19 Pandemic: A Review of Pre-participation Exams

Pazik M, Diemer KJ, Tipper N, Prine BR, Roach RP, Moser MW, Smith MS, Horodyski MB: Department of Orthopaedic Surgery and Sports Medicine, University of Florida, Gainesville, FL, and College of Medicine, University of Florida, Gainesville, FL

Context: The rate of mental health illness in college students is rapidly increasing. Student-athletes are at an increased risk to experience mental health decline due to the additional pressures and demands placed on them. The COVID-19 pandemic only worsened the mental health of student-athletes as the world went into a lockdown and student-athletes were sent home with all sporting events suspended and educational activities moved online. The objective of the current study was to determine if there was a change in the General Anxiety Disorder 7 Scale (GAD-7) scores administered during Pre-Participation Exams (PPE) of incoming student-athletes at a two-year college due to the COVID-19 pandemic. Additionally, we evaluated 9 questions listed on the PPE to examine mental health history. **Methods:** We retrospectively reviewed our prospective database of collegiate athletes at a NJCAA institution. Subjects were enrolled during their initial PPE if they were between the ages of 17-30 and participated on 1 school-sponsored athletic team. All student-athletes complete the GAD-7 and a 9-item mental health history questionnaire as part of their PPE. Team physicians reviewed the PPE and made appropriate referrals if a

student-athlete's mental health question answers were concerning. To assess pre/post COVID-19 differences we grouped the athletes by year, with PPEs completed prior to August 2020 indicating pre-COVID-19. A One-Way Analysis of Variance (ANOVA) was used to calculate differences between groups for continuous variables. Chi-square tests were used to compare groups for categorical variables. **Results:** A total of 168 subjects met inclusion criteria. The cohort included 76 males and 92 females with a mean age of 19.0 (SD.79) years. Seven subjects were excluded from analysis due to incomplete answers of the GAD-7. GAD-7 scores (mean 1.08, SD 2.8, n=161) ranged from 0 (no anxiety) to 20 (severe anxiety). Female athletes (n=89) scored significantly poorer than males (n=72) on the GAD-7 scale (Females: mean 1.78, SD 3.6, Males: mean .22, SD .74, $P<.001$). On the mental health history questions, a significant difference in sex (females reporting a history) was noted for depression ($P=.002$), little interest or pleasure doing things ($P=.038$), and feeling down, depressed, or hopeless ($P=.014$). When assessing the impact of COVID-19 on GAD-7 scores we did not find a statistically significant difference ($P=.794$) between student-athletes that entered college pre-covid to student-athletes entering college post-covid. **Conclusions:** Though we found no difference in GAD-7 scores in our population, previous studies have found the COVID-19 pandemic increased student-athlete mental health symptoms. Our study demonstrated that female athletes scored poorer on anxiety and depression questionnaires than males and were more likely to have a history of mental health illness. With increasing concerns regarding mental health in collegiate student-athletes, mental health must be recognized and treated like any other illness or injury.

Collegiate Athletes Subjective Experiences Related to Care-Seeking Behavior

Beard MQ, Hartje DM, Smith MR:
Aurora University, Aurora, IL;
University of Wisconsin-Platteville,
Platteville, WI; Columbus Catholic
High School, Waterloo, IA

Context: Athletic trainers (ATs) play a critical role in post-injury care for collegiate athletes. However, approximately 45% of collegiate athletes choose not to report their injury to a licensed health care provider. Additionally, roughly 50% first seek injury advice from a non-healthcare provider. Several factors that could influence their care-seeking behavior are related to the subjective aspects of the athlete-athletic trainer relationship. These include such things as perceived pressure or tension, and choice in seeking care, as well as how they value and relate to the AT. The objective of this study was to examine the difference in subjective experiences in the athlete-athletic trainer relationship between athletes who did and did not seek care for a sports-related injury. **Methods:** Participants were Division III collegiate athletes under the care of an AT. Athletes completed the Qualtrics survey at the end of their sport season. The Intrinsic Motivation Inventory (IMI) measures the subjective experiences of an individual that may influence motivation. The IMI sub-categories included were Pressure/Tension (5 statements, score 7-to-35), Value/Usefulness (9 statements, score 7-to-63), Perceived Choice (6 statements, score 7-to-42), and Relatedness

(8 statements, score 7-to-56). Twenty-nine statements were responded to using a 7-point Likert scale (1=strongly disagree, 7=strongly agree). Total IMI scores ranged from 29-to-203. The survey also asked about sport-related injuries during the season, from whom the athlete sought care, and reasons for seeking care. A Mann-Whitney U test assessed differences between participants who did and did not seek care from their AT ($p < 0.05$). **Results:** One-hundred and eighty-nine collegiate athletes completed the survey in its entirety. About 58% ($n=109$) reported sustaining an injury during their sport season. Of these, only five athletes (4.6%) did not seek care from an AT. Athletes who did not seek care from an AT scored significantly lower for the IMI total ($p=0.002$), and Relatedness ($p=0.001$) and Value subcategories ($p=0.02$), and significantly higher in the Pressure/Tension subcategory when compared to athletes who did seek care (Table 1). The top three reasons for not seeking care from an AT included “fear of being pulled from participation”, “Did not think the athletic trainer could help me”, and “I did not feel comfortable being evaluated by the athletic trainer.” The number one person from whom these athletes sought care from was a family member ($n=3$). **Conclusions:** Collegiate athletes that did not seek care from an athletic trainer reported greater pressure, anxiety, tension and nervousness when seeking care. Additionally, these individuals felt less related or connected to the AT, and found little or no value in the AT and the services provided. Athletic trainers should recognize that these subjective experiences could influence whether collegiate athletes seek care for an injury.

Table 1. Comparison of athletes who did and did not seek care from an athletic trainer.

	Sought AT (N=104)		Did not Seek AT (N=5)		P-value	d (95% CI)
	M	SD	M	SD		
IMI Total	141.79	11.20	119.60	27.68	0.027*	0.80 (-0.10, 1.71)
Choice	30.62	4.81	25.40	6.84	0.63	0.76 (-0.14, 1.67)
Pressure/Tension	10.80	4.44	20.20	3.35	0.001*	-2.81 (-3.78, -1.83)
Relatedness	45.93	5.53	32.00	10.30	0.001*	1.35 (0.44, 2.27)
Value	54.44	6.42	42.00	12.35	0.02*	1.01 (0.10, 1.91)

*Statistically significant difference ($p<0.05$). Abbreviations: AT, athletic trainer; IMI, Intrinsic Motivation Inventory; M, Mean; SD, Standard Deviation; d, Cohen’s d Effect Sizes; CI, Confidence Interval.

In Clinically Practicing Healthcare Providers, Is Burnout Associated With Self-Reported Medical Errors: A Critically Appraised Topic

Myers M, Mansell JL, Tierney RT, Russ AC: Mount St. Mary's University, Emmitsburg, MD, and Temple University, Philadelphia, PA

Context: Burnout and medical errors both adversely affect the standard of patient care, the clinician, and the healthcare system. In clinically practicing healthcare professionals, are those experiencing burnout more likely to report medical errors? **Methods:** Search of PubMed electronic database was conducted during June of 2022 using a primary Boolean phrase “physicians” [MeSH Terms] OR “physician” [All Fields] AND “burnout” [All Fields] OR “burnout, psychological” [MeSH Terms] AND “Maslach” [All Fields] OR “Maslach’s” [All Fields] AND “medical errors” [MeSH Terms] OR “medical” [All Fields] AND “error” [All Fields]. A secondary search included “patient’s” [All Fields] OR “patients” [MeSH Terms] AND “outcome” [All Fields] OR “outcomes” [All Fields]. The inclusion criteria were: cross-sectional studies, examined physicians or athletic trainers (AT), Maslach Burnout Inventory (MBI) to measure burnout, self-reported medical errors (SRME), and published between 2017-2022. Articles were reviewed for relevance by title, abstract, and full text. Studies were included or excluded on relation to research aim and matching outcome measures. Validity was assessed using the STROBE checklist for cross-sectional studies. Odds ratio (OR) and 95% confidence intervals (CI) comparing self-reported medical errors in those with and without burnout.

MBI was used to determine levels of clinician burnout. Consisting of three domains, burnout is delineated by emotional exhaustion (EE), depersonalization (DO), and personal accomplishment (PA). Either a two or four item questionnaire denotes self-reported medical errors.

Results: The primary search resulted in 60 articles and the secondary search provided 53 articles. Inspection of the search determined 3 articles met inclusion criteria. Physicians (n=1354) reported the highest association between burnout and SRME (OR=1.48; 95% CI= 1.25, 1.71). Roughly (n=40) 27% of residents admitted to SRME in last 3 months. Overall burnout rates were not reported. Within surgical residents, burnout increased the risk of SPME (OR=1.35; 95% CI= .69, 2.61). Approximately 58% of surgical residents (n=146) met the criteria for burnout, with EE and DP most common. Athletic trainers experiencing PA burnout are more likely to admit SRME (OR=1.06; 95% CI= 1.02, 1.10). Approximately 18% of ATs (n=74) self-reported medical errors. Within the ATs (n=403), 75% experienced burnout. Each study scored 17/22 on the STROBE.

Conclusions: Burnout directly increased the odds of SRME. Physicians and surgeons with burnout had a higher risk of a SRME than athletic trainers with burnout. This disparity may reflect the different definitions, oversight, and opportunities to commit medical errors in the respected fields. Emotional exhaustion and personnel accomplishment appear to drive ME within clinically practicing athletic trainers, whereas EE and DP are indicative of ME within practicing physicians. Understanding the mechanism behind burnout within practice settings may provide insight into mitigation strategies to reduce medical errors and improve patient outcomes. SORT B

Adverse Childhood Experiences Impact Burnout in Athletic Trainers

Hedrick A, Russ AC. Temple University, Philadelphia, PA

Context: Burnout, a state of physical or emotional exhaustion, is a concern within athletic training, as between 17 and 40% of athletic trainers (ATs) report high levels of burnout. Adverse childhood experiences (ACES) are linked with higher levels of burnout in other health professions. The purpose of this study is to compare burnout to ACES in athletic trainers. **Methods:** 1000 certified athletic trainers were invited to complete a Qualtrics survey about burnout and ACES. The NATA Research Survey Services was used to recruit clinically-practicing ATs and 78 participants started the survey. The survey consisted of 3 sections: demographic information, the ACES Questionnaire, and the Copenhagen Burnout Inventory (CBI). At the close of the survey, participants were provided with a list of support resources. The ACES Questionnaire consists of 10 yes/no questions about the participant's experiences during their first 18 years of life. Questions address abuse, neglect, and household dysfunction. "Yes" responses are summed for a total score. The CBI consists of 19 5-point Likert Scale questions about personal, work, and patient-related exhaustion. Average scores range from 0-100 and are calculated for the total score and subscales. Higher scores are indicative of burnout. Both the ACES Questionnaire and CBI are established as valid and reliable. Multiple

ANOVAs were used to determine the association between ACE score and total, personal, work, and client-related burnout. Bonferroni post hoc corrections were used and the a priori alpha level was $p < .05$. The study protocol was approved by the IRB. **Results:** Seventy-five participants (51 females, 24 males) completed the study for a completion rate of 96.15%; 37 (49.33%) reported at least one ACE. Moderate burnout ($CBI > 50.00$) was reported in 27 (36%; total), 44 (58.67%, personal), 34 (45.3%), and 15 (20.00%, patient-related). Participants with 4 ACES (67.11 ± 19.89) had significantly higher total burnout (ANOVA $F_{6, 68} = 2.59$, $p = .03$) than those with 0 (40.53 ± 17.12 , $p = .04$), 1 (38.42 ± 20.99 , $p = .04$), and 7 (19.08 ± 12.09 , $p = .03$) ACES. The same pattern existed with personal burnout as participants with 4 ACES (76.67 ± 17.33) had significantly higher scores (ANOVA $F_{6, 68} = 3.40$, $p = .00$) than those with 0 (46.60 ± 17.49 , $p = .02$), 1 (42.78 ± 21.48 , $p = .01$), and 7 (27.08 ± 20.62 , $p = .03$) ACES. No other significant differences existed. **Conclusions:** Higher levels of total and personal burnout were found in those with 4 ACES. While it was expected to see lower levels of burnout in those with lower ACES, it was surprising to see that those with 7 reported some of the lowest CBI scores. Regardless of ACES, between 20.00% and 58.67% of ATs surveyed reported some form of burnout. Adverse experiences during childhood may predispose individuals to burnout. More research is needed to explore the relationship and to examine if directed interventions may be beneficial to reduce burnout.

Pitch Counts and Overuse in High School Softball Pitchers: A Pilot Study Encompassing Bullpen, Warm-Up and Game Pitches

Kamarajugadda S, Pazik M, Zeppieri G Jr, Bruner M, Farmer KW, Zaremski JL, Horodyski MB, Smith MS: Department of Orthopaedic Surgery and Sports Medicine, University of Florida, Gainesville, FL; College of Medicine, University of Florida, Gainesville, FL; Department of Rehabilitation, University of Florida Health, Gainesville, FL; Department of Physical Medicine and Rehabilitation, University of Florida, Gainesville, FL

Context: The American Orthopaedic Society for Sports Medicine (AOSSM) has published softball pitch counts, though very little research exists to validate these guidelines¹. Given the significant amount of recent literature showing an increase in injury rates of softball pitchers and the rising popularity of the sport, lack of standard pitch limit guidelines in softball is a growing concern. We hypothesized that the typical high school softball pitcher exceeds the recommended pitch counts described in the AOSSM guidelines. Our objective was to quantify the number of pitches thrown by high school softball pitchers during games experience, specifically measuring bullpen, warm-up, live-game and calculate total pitches. **Methods:** The current study was an observational study of pitch counts performed among high school softball pitchers in North Central Florida. Researchers attended varsity high school softball games each season from February 2019-May 2021. Researchers were instructed to count total number of pitches each softball pitcher threw per

game. To calculate the total pitch count: bullpen (prior to entering a game), warm-up (thrown in between innings), and live-game pitches were tallied. As this was a noninterventional, observational study no demographic variables related to the softball pitchers were collected. One sample t-tests were used to compare pitch counts to the AOSSM recommended guidelines of 100 pitches per game. **Results:** A total of 8,248 pitches were counted during 89 pitching encounters. Total pitch count ranged from 5-201 pitches (mean 92.7, SD 51.2). Bullpen pitch count ranged from 0-80 (mean 17.99, SD 16.7). Warm-up pitches ranged from 0-36 (mean 12.4, SD 9.0). Live-game pitches ranged from 3-172 (mean 71.2, SD 41.2). Of the 89 pitching encounters, 11 consisted of bullpen only and are excluded from pitch count statistical analyses (n=78). We found a significant difference between live-game pitches and the recommended guidelines of 100 pitches per game (mean 71.6, SD 41.2, $P < .001$). When considering total number of pitches, we did not find a significant difference (mean 102.7, SD 46.5, $P = .305$). For pitchers that threw a full game (7 innings) we found significant differences for total pitch count (mean 143.6, SD 16.1, $P < .001$) and live-game pitch count (mean 108.7, SD 17.5, $P = .025$) from the recommended guidelines. **Conclusions:** Pitchers that pitch a full game have significantly more total and live-game pitches than the recommended guidelines. When providing pitch volume restrictions all pitches thrown off the pitching mound should be considered, including bullpen, warm-up, and in-game pitches. Similar to results found in high school baseball, total volume of pitches may increase fatigue and be a contributing factor to overuse throwing injuries. Evidence-based guidelines need to be developed and enforced for high school softball pitchers to decrease the growing rate of injuries.

Knee Function, Pain and Activity Levels in Young-Adult Females With and Without a History of Sport-Related Knee Injury During Adolescence

Goetschius J, Allen KL, Straughn C: James Madison University, Harrisonburg, VA

Context: Knee injuries are common among female, adolescent athletes and may lead to chronic knee dysfunction and pain later in life. The long-term effects of adolescent knee injuries are not well understood in the > 90% of adolescent athletes who end their sports career after high school. The purpose of this study was to determine whether young-adult females with a history of sport-related knee injury during adolescence reported deficits in knee function, knee pain, and activity levels compared to those without a history of knee injury. **Methods:** We used a cross-sectional design, and all data was collected via an online survey. Our sample included N=349 young-adult (18-25 years), females (assigned sex) from a large university who were adolescent athletes, but did not continue sport participation at the collegiate level. Participants with a recent knee injury (< 3-months) were excluded. Participants were stratified into Knee Injury (n=167, age (yrs): 20 [19-21], mass (kg): 65.8 [59.0-75.3], height (m): 1.65 [1.60-1.70]) or No Knee Injury groups (n=182, age (yrs): 20 [19-21], mass (kg): 63.6 [57.2-72.3], height (m): 1.68 [1.63-1.70]) based on whether they self-reported a sport-related knee injury that required them to miss at least 1-week of sport activity during adolescence. Our primary outcomes included the International Knee Documentation

Committee (IKDC) knee evaluation form (0-100%), a numeric knee pain scale (0-10), and the Tegner activity scale (0-10). We used Mann-Whitney tests and effect sizes with 95% confidence intervals to compare outcomes between the Knee Injury and No Knee Injury groups. Effect sizes were interpreted as small=0.20-0.49, moderate=0.50-0.79, and large > 0.80. **Results:** See Table 1 for descriptive statistics (median [interquartile range]), p-values, and effects sizes for between group comparisons. The Knee Injury group reported significantly lower IKDC scores and greater knee pain than the No Knee Injury group, suggesting poorer knee health. Differences in IKDC scores and knee pain were supported by large (0.94) and moderate (0.70) effect sizes, respectively. The Knee Injury group also reported significantly lower Tegner activity scale scores than the No Knee Injury group; however, the between group effect size was small (0.23) and median scores were similar. **Conclusions:** Young-adult females with a history of sport-related knee injury during adolescence reported large and clinically important deficits in knee function and knee pain compared to those without a history of knee injury. Young-adult females with a history of knee injury also reported slightly lower activity levels compared to those without a history of knee injury; however, the clinical importance of that finding may be limited. While this was not a prospective design, these findings highlight the importance of athletic trainer's educating adolescent patients on the potential long-term implications of knee injuries and considering patient's long-term knee health in their post-knee injury plan of care.

Table 1. Comparisons of IKDC scores, Knee Pain, & Tegner Activity Scores in the Knee Injury and No Knee Injury Groups

	Knee Injury (n = 164)	No Knee Injury (n = 180)	P-value	Effect Size (95% CI)
IKDC (0-100%)	93.0 [85.0, 98.0]	79.0 [69, 90.0]	<0.001*	0.90 (0.68 - 1.12)
Knee Pain (0-10)	0.0 [0.0, 2.3]	3.0 [0.0, 4.0]	<0.001*	0.71 (0.50 - 0.93)
Tegner Activity Scale (0-10)	7.0 [6.0, 9.0]	7.0 [5.0, 9.0]	0.02*	0.24 (0.03 – 0.45)

Descriptive statistics presented as median [interquartile range]

* = Statistically significant difference between groups (P<0.05)

Why Do So Many Youth Sport Athletes Specialize In A Particular Sport?

Mensch JM, Hendrix MA: University of South Carolina, Columbia, SC

Context: In recent years there has been a big increase in the number of youth athletes specializing in one sport. Gaining the perspective of current highly specialized youth athletes will help parents, athletes, coaches, and league administrators better understand the potential risks as well as the thought process associated with single sport specialization at the youth level. The purpose of this research was to learn more about why youth athletes decide to quit playing a variety of sports to specialize in one sport. **Methods:** This study used a qualitative grounded theory design in the form of in-depth interviews to gather the shared experiences of highly specialized youth sport athletes. Participants (n=10) included 6 male and 4 female youth athletes (ages 13-18) participating in 6 different sports (basketball, football, soccer, lacrosse, baseball, and volleyball) from a purposeful sample of specialized athletes from the southeast United States. All 10 participants were categorized as highly specialized athletes based off the 3-point questionnaire tool developed by Jayanthi et al. The interview guide was created and formatted based on the purpose of the study, current research on youth sport specialization, as well as the input from sports physicians and faculty members with experience in qualitative research design. The final interview guide consisted of 7 main categories: general background, injury risk, academics, training, quality of life, financial implications, and future goals. Interviews were completed and transcribed via zoom. Upon completion of the 10th interview, data saturation was determined by the interviewer through constant comparison. Credibility was established by several mechanisms, including investigator triangulation

during research analyses, member checks, and peer review. **Results:** Three major themes emerged from the data pertaining to youth athletes' decision to specialize in a particular sport. These themes were 1) the goal to play Division 1 athletics or receive an athletic scholarship, 2) to improve at their sport at the quickest rate possible, and 3) not having enough time to play multiple sports at an elite level. All 10 participants described having the goal of playing their sport at the next level. Statements such as "the goal has always been to go D1 and get a scholarship" were common across all participants. Data also suggested that athletes needed 1 on 1 attention to help them reach their goals. Athletes described that since having private coaching, their "level of play has increased and not stopped". While athletes had a desire to still play other sports, they indicated they will not be able to do so and focus on the sport they wish to be "elite". The problem of time constraint was also very prevalent in the data. One athlete said it was "physically impossible to play two sports at the same time". The data also indicated that athlete motivations came directly from the athlete and that parents served only as a support mechanism for their decisions. **Conclusions:** Our data suggests youth athletes are motivated by their own goals of improving in their sport to achieve the highest level of competition. Youth athletes attempting to play multiple sports at an elite level is virtually impossible because of the demands of practices, games, and travel. Athletes are now forced to choose and focus on a particular sport to reach their goals. Using a qualitative research design allowed us to explore the thought process of current highly specialized youth athletes, providing a better understanding of the culture of youth sports today. This prospective study gives insight to how and why youth athletes are making the decision to specialize and the factors affecting that decision while they are currently playing their sport.

Do Behaviors and Perceptions About Running Injuries Align for Adolescent Runners?

Bachand R, Bazett-Jones DM, Esculier JF, Fox C, Norte GE, Garcia MC: The University of Toledo, Toledo, OH, and The University of British Columbia, Vancouver, BC, Canada

Context: Adolescent runners perceive that running on hard surfaces and consuming a low number of calories increase the risk of sustaining an injury while having strong muscles and stretching decrease the risk of sustaining an injury. Many perceptions are not supported by research, but it is unknown if the behaviors of adolescent runners align with their perceptions. The behaviors of adolescent runners may therefore not be influencing injury risk as expected. The purpose of our study was to investigate if the self-reported behaviors of adolescent runners were aligned with their perceptions regarding running-related injury risk factors. **Methods:** We recruited adolescents (ages 12-19) who participated in long-distance running to participate in our national, cross-sectional survey. Of the 488 adolescents who initiated the survey, 302 completed the entire survey (F=164, M=138, age=16.0±1.4 y, running experience=11.4±2.6 y, completion rate=61.9%). Participants self-reported their

running behaviors including typical surface they run on, strength training habits, stretching habits, and tracking caloric intake. Participants also self-reported whether these factors influence the risk of injury (increase, neither increase nor decrease, decrease, unsure). We calculated odds ratio (OR) for participants who participated in a behavior (yes, no) and perceived the factor to increase or decrease (yes, no) the risk of injury, respectively. We set significance at $P \leq .05$. **Results:** Adolescent runners who typically ran on trails, incorporated strength training for their legs, and stretched before or after running were more likely to perceive that these behaviors decrease the risk of injury ($P < .001-.02$, Table 1). Adolescent runners who typically ran on paved surfaces were more likely to perceive that running on hard surfaces does not increase the risk of injury ($P=.02$, Table 1). Adolescent runners who incorporated strength training for their core or tracked caloric intake were not more likely to perceive that these behaviors influence the risk of injury ($P=.08-1.00$, Table 1). **Conclusions:** Adolescent runners who incorporated behaviors related to running surface, strengthening, stretching, and caloric tracking were generally more likely to perceive that these factors influence injury risk. Most adolescents stretch (90.3%) and those who stretch were more likely to perceive stretching reduces injury risk. Current evidence does not support

that stretching reduces injury risk and is inconclusive/limited for many of the other perceived risk factors. However, there is evidence that consuming a low number of calories increases the risk of injury for endurance athletes. Most adolescents (78.5%) perceived that having a negative caloric intake increases the risk of injury, but very few (7.6%) tracked their caloric intake. Educational materials directed at runners, coaches, and/or parents may help make training programs more evidence based. Further research is needed to better understand if educational materials change perceptions and/or behaviors and who is best targeted with these materials.

Table 1. Likelihood of adolescent runners to incorporate behaviors that are perceived to influence the risk of sustaining an injury.

Perceived to Increase Injury Risk				
Behavior	Yes	No	OR [95% CI]	P
<i>Typically run on paved surfaces</i>				
Yes	59 [73.8%]	21 [26.3%]	0.43	.02*
No	130 [86.7%]	20 [13.3%]	[0.21 - 0.91]	
<i>Caloric intake tracking</i>				
Yes	17 [73.9%]	6 [26.1%]	0.93	1.00
No	210 [75.3%]	69 [24.7%]	[0.33 - 3.00]	
Perceived to Decrease Injury Risk				
Behavior	Yes	No	OR [LL, UL]	P
<i>Typically run on trails</i>				
Yes	110 [72.4%]	42 [27.6%]	2.00	.02*
No	51 [56.7%]	39 [43.3%]	[1.10 - 3.59]	
<i>Strength train legs</i>				
Yes	182 [85.0%]	32 [15.0%]	2.13	.01*
No	64 [72.7%]	24 [27.3%]	[1.11 - 4.05]	
<i>Strength train core</i>				
Yes	180 [81.8%]	40 [18.2%]	1.75	.08
No	59 [72.0%]	23 [28.0%]	[0.92 - 3.28]	
<i>Static stretch before running</i>				
Yes	157 [87.2%]	23 [12.8%]	16.56	<.001
No	35 [28.9%]	86 [71.1%]	[8.97 - 31.63]	
<i>Dynamic stretch before running</i>				
Yes	230 [92.4%]	19 [7.6%]	2.87	.02
No	42 [80.8%]	10 [19.2%]	[1.11 - 7.04]	
<i>Static stretch after running</i>				
Yes	215 [90.0%]	24 [10.0%]	4.56	<.001
No	41 [66.1%]	21 [33.9%]	[2.19 - 9.47]	
<i>Dynamic stretch after running</i>				
Yes	43 [78.2%]	12 [21.8%]	5.08	<.001
No	101 [41.2%]	144 [58.8%]	[2.48 - 11.14]	

*Statistical significance ($P \leq .05$)

Abbreviations: OR = odds ratio, CI = confidence interval

Comparison of Running Injury Risk Perceptions Among Adolescents, Parents, and Coaches

Bazett-Jones DM, Bachand R, Esculier JF, Fox C, Norte GE, Garcia MC: The University of Toledo, Toledo, OH, and The University of British Columbia, Vancouver, BC, Canada

Context: Adult runners and healthcare professionals perceive that training habits, footwear, strength, and stretching influence the risk of sustaining a running-related injury. Little is known about adolescent runner perceptions or how they compare to adults and coaches. Adolescent athletes have different perceptions than parents for sport specialization and injury but it is unknown if this holds true for running-related training and injury. The purpose of our study was to compare perceived running-related injury risk among adolescent runners, parents of adolescent runners, and running coaches. We hypothesized that adolescent runners would have different perceptions from parents and coaches. **Methods:** We conducted a national, cross-sectional online survey for adolescent runners (ages 12-19), parents of adolescent runners, and running coaches. Of the 787 individuals who initiated the survey 523 completed the survey (completion rate=66.5%, 302 adolescents [F=164, M=138, age=16.0±1.4 y, running experience=11.4±2.6

y], 35 parents [F=21, M=14, age=45.1±5.4 y, running experience=20.9±11.0 y], and 186 coaches [F=80, M=106, age=43.9±11.0 y, running experience=15.9±8.2 y]). Parents who were also coaches were only counted as coaches. Participants self-reported whether training habits, footwear, strength, and stretching factors influence the risk of injury (increase, neither increase nor decrease, decrease, unsure). We performed Fisher's exact test to compare the proportions of perceptions among adolescents, parents, and coaches. We set significance at $P \leq .05$. **Results:** Compared to coaches, a lesser proportion of adolescents perceived that cross-training (12.6% difference), pre-season training (14.2% difference), and a strong core (15.5% difference) decrease injury risk; a greater proportion of adolescents perceived that shoe cushioning (15.7% difference) and pre-run static stretching (33.5% difference) decrease injury risk ($P < .001$, Table 1). Compared to parents, a greater proportion of adolescents perceived that shoe cushioning (30.8% difference) and pre-run static stretching (26.5% difference) decrease injury risk ($P < .001$, Table 1). A greater proportion of adolescents perceived that running in shoes with less cushion increase injury risk compared to coaches (20.5% difference) and parents (30.3% difference, $P < .001$, Table 1). Compared to parents, a great proportion of coaches perceived that pre-season training (16.0% difference) decreased injury risk ($P < .001$, Table 1).

Conclusions: We observed differences in running-related injury risk factor perceptions primarily between adolescents and coaches, with the greatest differences related to the perceived benefits of pre-run static stretching and more shoe cushioning. Adolescent perceptions differ from evidence-based injury risk recommendations. It is unknown if where adolescents receive their information from coaches, parents, or another source. Better understanding the interactions of perception, information source, and behavior may help to improve runner the development and dissemination of running-related injury education materials.

Table 1. Proportions of adolescents, parents, and coaches that perceive a factor to increase or decrease injury risk.

Factor	Adolescents	Parents	Coaches	P
<i>Increase Injury Risk</i>				
High Mileage	71.2%	85.7%	67.2%	.31
Running on Hard Surfaces	76.8%	77.1%	70.4%	.58
Shoes with less Cushion	73.2%	42.9%	52.7%	<.001*†
<i>Decrease Injury Risk</i>				
Running on Soft Surfaces	66.2%	45.7%	69.4%	.08
Incorporating Off Days	81.5%	88.5%	90.3%	.15
Cross-training	77.2%	91.4%	89.8%	<.001†
Summer/Pre-season Training	67.5%	65.7%	81.7%	<.001†‡
Strong Legs	81.5%	94.3%	89.8%	.07
Strong Core	79.1%	88.6%	94.6%	<.001†
Shoes with more Cushion	76.5%	45.7%	60.8%	<.001*†
Static Stretch Pre-run	63.6%	37.1%	30.1%	<.001*†
Dynamic Stretch Pre-run	90.1%	82.9%	91.9%	.14
Static Stretch Post-run	84.8%	68.6%	80.6%	.01

*Statistically significant difference adolescents vs parents ($P < .05$)

†Statistically significant difference adolescents vs coaches ($P < .05$)

‡Statistically significant difference parents vs coaches ($P < .05$)

Association Between Sport Motivation and Sport Specialization in Middle School-Aged Athletes

Biese KM, Winans M, McGuine TA, Kliethermes SA, Cadmus-Bertram LA, Andreae SJ, Brooks MA, Bell DR: University of Wisconsin-Oshkosh, Oshkosh, WI, and University of Wisconsin-Madison, Madison, WI

Context: Experts have cautioned that youth sport specialization may lead to burnout and dropout in youth athletes through a lack of sport enjoyment. Intrinsic motivation is participating in an activity for the enjoyment one finds in that activity. It has been linked with continued sport participation and wellbeing, whereas its antitheses, amotivation and controlled motivation, have been associated with sport dropout. Sport motivation has not been assessed in the context of sport specialization in middle school athletes. This study aimed to determine the association of sport specialization with autonomous motivation, controlled motivation, and amotivation in middle school-aged athletes. We hypothesized that highly specialized athletes would have less autonomous motivation compared to low or moderately specialized athletes. **Methods:** This was a cross-sectional study, in which middle school-aged athletes completed an anonymous, questionnaire assessing sport specialization level and types of motivation (autonomous, controlled, and amotivation). Questionnaires were distributed via schools, social media, and sport clubs in the Midwest. The survey contained demographics, sport participation (single-sport or multisport athlete), sport specialization, and the Youth Behavioral Regulation in Sport Questionnaire, which is a valid and reliable measure of motivation. Sport specialization was operationalized using a modified 3-point scale into categories of low, moderate, and

high. Kruskal-Wallis tests were used to analyze differences between the motivational scores (amotivation, controlled, and autonomous) by level of specialization. Mann-Whitney U tests were used to compare motivational scores between multisport versus single sport athletes ($\alpha < 0.05$). **Results:** A total of 178 athletes (Male=59%, private school=51%, grade: 6th=20%, 7th=32%, 8th=48%) completed the survey. Percentages of athletes by level of specialization were similar between groups (Low: 34%, Moderate: 33%, High: 33%) Eighty-three percent of participants were multisport athletes. No associations between sport specialization levels and autonomous motivation, controlled motivation, or amotivation were identified. Similarly, no differences were observed between multisport or single sport athletes and any type of motivation (Amotivation: $p=0.15$, Controlled: $p=0.39$, Autonomous: $p=0.11$). An exploratory analysis revealed multisport athletes had higher scores for intrinsic motivation, a subscale of autonomous motivation, compared to single sport athletes (single sport: median=5.00 25th-75th quartile=4.50-5.00; multisport: median=5.00 25th-75th quartile=5.00-5.00; $p=0.04$). **Conclusions:** Sport motivation did not differ between sport specialization groups in middle school athletes. It is possible that differences in sport motivation between sport specialization groups do not occur until athletes are older. Conversely, it is possible that non-motivated children younger than middle school have already dropped out of sports and were not assessed in this study. Our exploratory findings suggest that intrinsic motivation may differ between single and multisport middle school-aged athletes. Future studies are needed to confirm these findings, but clinicians may consider having an open dialogue with single-sport athletes, their parents/guardians, and their coaches to ensure athletes continue to enjoy their sport.

Influence of Sport Specialization on Quality of Life, Physical Literacy, and Injury History in Youth Hockey Players

Marshall KA, Chimera NJ, Valovich McLeod TC: A.T. Still University, Mesa, AZ; Excelsior Orthopaedics, Amherst, NY; Brock University, St. Catharines, ON, Canada

Context: Ice hockey is a time and resource intensive sport, with athletes often participating on multiple teams throughout the year. Specialization is known to increase the risk for sustaining overuse injuries and increase the risk of burnout and negative beliefs in physical activity later in life. Little is known about the specific effects of specialization in ice hockey on outcomes such as physical literacy, quality of life, and risk of injury. This study sought to examine the influence of sport specialization on quality of life, physical literacy, and injury history in adolescent ice hockey players. **Methods:** This study utilized a cross-sectional design, aimed at ice hockey players between the ages of 13 and 18. An anonymous, web-based survey was collated from existing validated surveys and patient-reported outcome measures. The survey included the Jayanthi 3-point specialization scale, which classifies the degree of specialization as low, moderate, or high, questions about participation in ice hockey, injury history, and 2 patient-reported outcome measures: the Physical Literacy Assessment for Youth (PLAY) self-assessment and Pediatric Global Health-7 (PGH-7) instruments. Pilot testing included face validity assessments by clinicians and athletes to assess for word clarity and understanding of

items. The survey link was distributed via social media and a network of athletic trainers and strength and conditioning coaches. Independent variables were level of specialization and gender. Dependent variables were average participation hours per week, scores on PLAYself, PGH-7, and number of injuries sustained. Main effects were evaluated using Kruskal-Wallis tests, with means (\pm SD) reported for demographic and score data. **Results:** Five athletes demonstrated low specialization (mean age = 15.6 ± 1.8), 24 had moderate specialization (mean age = $15.8, \pm 1.5$), and 34 noted high specialization (mean age = 16.2 ± 1.3). Significant differences were found between groups for average number of hours participated weekly ($p=.038$), with highly specialized players participating in a greater number of hours than low specialized players ($p = .027$), and hours spent in strength and conditioning sessions ($p=.025$) with highly specialized players spending more time in strength and conditioning sessions compared to moderately specialized players ($p = .010$, 6.09 ± 3.81 vs. 4.45 ± 4.69). No significant differences were observed between groups for PLAYself or PGH-7 scores (Table). Highly specialized players sustained a greater number of injuries than moderate and low specialized players ($p = .028$). **Conclusions:** Both specialization and over-participation were highly prevalent in our sample; however, the high level of specialization does not seem to contribute to poor physical literacy or quality of life. Results of this study may refute the use of current recommendations for participation in adolescent athletes including the use of age to limit weekly hours and avoidance of playing on multiple teams per season.

Table 1. Outcome Variables for Specialized Players

Column1	Low Specialization	Moderate Specialization	High Specialization
Males	2	17	19
Females	2	7	15
Non-Binary	1	0	0
PLAYself Total Score	74.3 (\pm 12.5)	77.4 (\pm 9.05)	75.0 (\pm 8.17)
PGH-7 Total Score	29.0 (\pm 2.55)	28.63 (\pm 4.56)	28.1 (\pm 3.48)
# Injuries (Past 12 Months)	3	7	22
Total Hours/ Week	11.0 (\pm 4.243)	18.6 (\pm 13.7)	21.4 (\pm 21.4)

A Preliminary Examination of Reactive Strength Index in Youth Athletes That Participate in Different Number of Sports

Her Many Horses K, Liu K: University of Colorado Colorado Springs, Colorado Springs, CO

Context: The reactive strength index (RSI) is a strength assessment that is calculated using a jumping protocol that has the individual quickly transition from an eccentric landing from an elevated surface to a quick concentric take off to a jump. Higher RSI numbers show better neuromuscular control and correlation to maximum strength. With sport specialization in the youth population becoming more popular, there is discourse around the pros and cons of participating in multiple sports versus a single sport year round. The purpose of this study is to examine differences in RSI between youth athletes that participate in single or multiple sports. **Methods:** In an ongoing study using a cross-sectional study design, 12 youth participants were recruited for this study (7 males, 5 females, mass=50.8±4.7kg, height=161.4±3.7cm, age=13.8±0.6 years.). Participants were excluded from the study if they have had a previous history of ankle or knee injuries. Number and type of sport(s) that the participants were involved in were recorded. In a laboratory setting, participants were instructed to drop from a 60cm dropbox, land on a force plate, then

jump back into the air as quickly as possible. Three trials were taken, recording the highest score and mean. RSI was calculated by dividing flight time by ground contact time. Ground contact time was characterized as the time in contact with the force plate after landing from the dropbox to the take-off phase, while flight time was defined as the time between the last contact of the take-off phase to the next contact onto the force plate. A t-test was used to analyze the difference of RSI scores between those who participate in a single sport and those that participate in multiple sports. **Results:** Seven participants in the study were involved in one sport, while five participants were involved in two or more sports. The mean RSI for single sport athletes was 0.69±0.11mm/ms, while the mean RSI for multi-sport athletes was 0.77±0.12mm/ms. The peak RSI for single sport athletes was 0.78±0.12mm/ms, while the peak RSI for multi-sport athletes was 0.88±0.09mm/ms. While multi-sport athletes recorded higher RSIs than single sport athletes, no statistical significance was found with mean RSI (P=0.53) and peak RSI (P=0.29). **Conclusions:** The small sample of participants in this study was due to an ongoing data collection effort. While no statistical significance of RSI scores were found between single or multi-sport youth athletes, further research should be encouraged in this subject. A better understanding of RSI values in sport specialized youth may have an impact on strength, neuromuscular control, and injury incidence.

A Description of Pain in High School Softball Pitchers and Its Relationship to Fatigue and Pitching Volume

Jochum JE, Jones ER, Neff JT, Vire BL, Brutchon AP, Jacob TJ, San Giacomo NP: University of Indianapolis, Indianapolis, IN

Context: Pain in softball pitchers is common and an understudied research area. Little is known about the effect of the high volume of activity commonly associated with this position. Recent research suggests that pitchers' perceived pain, exertion, and fatigue are greater near the end of their season when compared to the beginning. Further research into fatigue and pitching volume's effects on pitchers' reported pain can help inform prevention and intervention efforts. This study aims to describe the frequency and location of pain and determine if there is a relationship between pitching volume and fatigue among adolescent female softball pitchers during an entire high school season. **Methods:** Data was collected from 27 separate high school softball pitchers aged 14-19 years old across 9 schools from pre-season to end of the high school season, a total of 19 weeks. Vertical jump height data was measured using the VERT system and collected weekly by their relative ATs to gain an objective measure of full-body fatigue. Self-reported fatigue was collected using the Hecimovic Peiffere Harbough Exercise

Exhaustion Scale (HPHEES), pain using Numeric Pain Rating Scale (NPRS), perceived recovery using Perceived Recovery Status Scale (PRS), and pitch volume was collected weekly through a Google form survey. Spearman Rho statistics were used to investigate relationships between softball pitching volume, fatigue, perceived recovery, and pain throughout two complete regular seasons with statistical significance set at $p < 0.05$. **Results:** Frequency of pain, as well as pain intensity both, increased as the season progressed in this study. Pain was reported most frequently in the shoulder (26.8%), low back (26.1%), and non-specific or "other" location (23.4%). Pain was significantly correlated with decreased perceived recovery in 13 of the 19 weeks and correlated with increased fatigue in 11 of the 19 weeks of the season. Pain was not consistently correlated with increased pitch volume or whole-body fatigue as measured by vertical jump height throughout the course of a season in this study. **Conclusions:** This study describes the frequency and location of pain in high school softball pitchers. Pain is closely associated with fatigue and lowered perceived recovery but not with pitching volume. Close attention should be paid to these athletes' reported fatigue and recovery status to avoid pain and potential injury. Further investigation should seek to more accurately or objectively quantify pitching volume to determine if increased pitch volume is associated with pain and fatigue.

Free Communications, Poster Presentations: Heat & Hydration

Friday, June 23, 2023; authors present 11:45 AM-12:40 PM; Poster Hall

Visibility of the “Roundtable on Preseason Heat Safety in Secondary School Athletics” Publications Among High School Athletic Trainers

Kerr ZY, Adams WM, Register-Mihalik JK, Nedimyer AK: University of North Carolina at Chapel Hill, Chapel Hill, NC; Division of Sports Medicine, United States Olympic & Paralympic Committee, Colorado Springs, CO; United States Coalition for the Prevention of Illness and Injury in Sport, Colorado Springs, CO

Context: The April 2021 issue of *Journal of Athletic Training* (JAT) published updated recommendations on preseason heat safety in high school (HS) athletics to provide up-to-date and easy-to-access information related to best practices for preventing and managing exertional heat illnesses. The three “Roundtable...” publications focused on: “Environmental Monitoring During Activities in the Heat,” “Heat Acclimatization,” and “Prehospital Care of Patients with Exertional Heat Stroke.” The extent to which HS athletic trainers (ATs) have seen these publications, hereon forth known as the “2021 recommendations,” is unknown. This study explored the visibility of the 2021 recommendations, including the reasons HS ATs have not seen them, and their perceived level of confidence in implementing them. **Methods:** A cross-sectional, online questionnaire was distributed to a sample of HS ATs randomly selected from the Board of Certification listserv in November-December 2021. Additional ATs were recruited via social media in January 2022. Responding ATs noted whether they had seen the 2021 recommendations. If yes, ATs detailed which of the specific publications they reviewed and their perceived level of confidence in having to implement them (5-point-ordinal scale from “not at all confident” to “very confident”); if

no, ATs disclosed (open-ended) why they have not yet seen them. Measures were pilot-tested with a sample of ATs and revised accordingly. Descriptive statistics were calculated for quantitative variables; template analysis was used for qualitative analyses to identify themes related to reasons why 2021 recommendations were not seen. **Results:** Most of the 116 HS ATs (~2.6% recruitment rate) were male (56.9%) and white/non-Hispanic (87.9%); this differs from 2018 NATA membership data (male=44.1%; white/non-Hispanic=79.9%). The average years of age and AT practice were 46±11 and 23±11, respectively. Overall, 53 ATs (45.7%) reported having seen the 2021 recommendations, with 26 ATs (22.4%) having reviewed all three publications. The most reviewed publication was “Prehospital care...” (n=43), followed by “Heat Acclimatization” (n=37), and “Environmental Monitoring...” (n=36). Also, 67.9% of ATs who had seen the 2021 recommendations believed they would be very (n=17) or fairly (n=19) confident in implementing the recommendations at their HS. Of the 63 (54.3%) that had not seen the 2021 recommendations, common themes identified for not seeing them included: not aware they were published (n=18), have yet to read the April 2021 JAT issue (n=12), and no access to JAT (n=12). **Conclusions:** This exploratory study observed over half of surveyed HS ATs have not seen the 2021 recommendations. The reasons noted for not seeing them highlight the need to continue improving messaging about access to updated best-practice recommendations, particularly emphasizing that JAT is open-access online. Further, one-third of those ATs who had seen the 2021 recommendations did not feel confident in being able to implement them; continued efforts should identify strategies to aid proper implementation.

This study was part of a larger project funded by a 2021 NATA-REF Doctoral Grant (PI: Nedimyer).

Survey-Based Exploration of Information Seeking in Athletic Trainers Related to Exertional Heat Illness

Nedimyer AK, Chandran A, Adams WM, Kucera KL, Shea CM, Register-Mihalik JK, Kerr ZY: The University of North Carolina at Chapel Hill, Chapel Hill, NC; Datalys Center for Sports Injury Research and Prevention, Indianapolis, IN; Division of Sports Medicine, United States Olympic & Paralympic Committee, Colorado Springs, CO; United States Coalition for the Prevention of Illness and Injury in Sport, Colorado Springs, CO

Context: Current evidence suggests not all athletic trainers (ATs) utilize best practices for managing exertional heat illnesses (EHIs), a constellation of medical conditions that can occur during sport participation. Access to EHI-specific evidence-based research may play a role in low utilization of best practices as the translation of this evidence is necessary for implementation in one's clinical practice. This quantitative, survey-based study investigated the sources and mechanisms through which ATs access EHI-related evidence-based information

to inform their clinical practice. **Methods:** A cross-sectional, online questionnaire was distributed to a sample of ATs practicing in the high school and collegiate settings from the Board of Certification listserv, with additional ATs recruited via social media. Prior to deployment the questionnaire was reviewed by content experts and pilot tested by 5 ATs. Responding ATs reported demographic information, information about their educational and clinical experiences, and identified the information sources they access to inform their clinical practice related to EHI. ATs also reported barriers they faced in accessing such sources. χ^2 and Fisher's exact tests were used to explore associations between access and explanatory variables of interest. **Results:** A total of 175 ATs (n=154 through listserv recruitment [2.1% response ratio], n=21 via social media recruitment) practicing in the high school and collegiate settings from throughout the United States participated in the survey, with 164 (93.7%) ATs completing all measures of interest (Table 1). Responding ATs reported accessing a wide variety of information sources to inform their clinical practice related to EHI, with very few ATs reporting facing barriers to accessing information (4.9%). Position statements (91.5%) were most accessed, followed by structured continuing education opportunities (87.8%) and peer reviewed journal articles

(78.0%). Social media (29.9%) and news media/print journalism (29.9%) were least accessed, yet were often noted as having been used as a springboard to access other information sources. A higher proportion of collegiate ATs reported accessing unstructured experiences (i.e., conversations with colleagues, 63.6% vs. 44.2%, $p=0.027$) and policy (i.e., state or university policy, 84.1% vs 63.3%, $p=0.010$) compared to high school ATs, and a higher proportion of ATs who had been certified for < 20 years (51.6%) accessed social media (i.e., Twitter) to obtain EHI-related information compared to those ATs who had been certified for ≥ 20 years (30.3%, $p < 0.001$). **Conclusions:** With ATs accessing a wide variety of information sources and mostly prioritizing evidence-based sources coupled with few ATs reporting barriers to accessing information sources needed to inform their clinical practice related to EHIs, access may not be the primary factor contributing to the gap in translation between knowledge and implementation of best practices into clinical practice within this population. Exploring other factors responsible for this gap is warranted to ensure comprehensive patient-centered care.

This study was funded by a 2021 NATA-REF Doctoral Grant (2021DGP04).

Table 1. Demographics of Surveyed ATs Compared to BOC

AT Characteristics	Study No. (%) (n = 164)	BOC ^a %
Gender		
Female	76 (46.3)	57.2
Male	87 (53.1)	42.3
Prefer not to say	1 (0.6)	0.5
Ethnicity		
Hispanic/Latino	2 (1.2)	
Non-Hispanic/Latino	159 (98.8)	
Missing	3	
Age		
<30	12 (7.4)	33.9
30-39	37 (22.7)	34.2
40-49	53 (32.5)	18.8
50-59	46 (28.2)	10.1
≥ 60	15 (9.2)	3.0
Missing	1	
Years of Certification as AT		
<20	64 (39.5)	78.3
≥ 20	98 (60.5)	21.7
Missing	2	
Current Practice Setting		
College	44 (26.8)	16.3
High School	120 (73.2)	24.7

^aBOC statistics were utilized as found on the BOC website (<https://7f6907b2.flowpaper.com/BOCCertifiedATDemographics/#page=1>). Numbers don't add up to 100% in all categories as the BOC utilizes categories that the current study did not. Additionally, they do not report all categories utilized in the current study.

Exertional Heat Stroke in a 17-Year Old Male Runner During an 11.3km Summer Road Race: Type 3 CASE Study

Nolan JK, Butler BM, Lopez RM, Jardine JF, Troyanos C, Adams WM, Stearns RL, Casa DJ: Sacred Heart University, Fairfield, CT; University of South Florida, Tampa, FL; Korey Stringer Institute, Storrs, CT; International Institute for Race Medicine, Plymouth, MA; United States Olympic & Paralympic Committee, Colorado Springs, CO; United States Coalition for the Prevention of Illness and Injury in Sport, Colorado Springs, CO; University of Connecticut, Storrs, CT

Background: Exertional heat stroke (EHS) remains the second leading cause of sudden death during sport, despite evidence exhibiting a 100% survival rate when this medical emergency is properly recognized and treated. Incidence rates are highest during warm environmental conditions coupled with high exercise intensity. This Type 3 CASE study describes a healthy, young runner who presented with the highest rectal temperature (Tre) reported in the literature, while subsequently exhibiting a superior cooling rate. **Patient:** A male runner (age, 17y) was triaged to the medical tent immediately following an 11.3km(7mi) road race in hot conditions (27.0°C-29.2°C(80.6°F-84.6°C)). Past medical history revealed no previous heat-illness and self-reporting of proper training and hydration practices both prior to and during the race. The patient had no known allergies and was not taking any medications. The patient reported a history of SARS-CoV-2 diagnosis approximately 1-year prior to the race which did not require hospitalization. He completed the race as a top-10 finisher in his age group with

an average pace of 5:00min/km(8:02min/mi). Immediately upon arrival to the medical tent, the patient was unresponsive and presented with pale and wet skin. Rectal temperature was taken revealing an initial core body temperature of 44.9°C(112.8°F). **Intervention & Treatment:** The patient was immersed in a 50-gallon ice water immersion tub (~10°C(50°F)). The water was continuously circulated, and additional ice water doused towels were regularly rotated over his head and neck and any other skin surface that was unable to be immersed. The treatment protocol aligns with other successfully managed cases of EHS reported in the literature and supports best practice recommendations. The patient exhibited significant central nervous system (CNS) dysfunction that ranged from unresponsiveness to disorientation coupled with combative behavior (i.e. punching and thrashing upper extremities) and unintelligible speech. When Tre reached approximately 41.1°C(106°F) (~10 min after treatment began), the patient's CNS dysfunction improved, and he became calm, alert, and responsive to questions. The patient reported not being able to remember anything after the 6.4km(4 mi) mark of the 11.3km(7 mi) race. He was removed from the cooling tub when Tre reached 38.9°C(102°F), and Tre, mental status, and other vital signs continued to be monitored until the patient was discharged from care. **Outcomes or Other Comparisons:** Total treatment time (active CWI) was 18 minutes resulting in a cooling rate of 0.3°C/min.(0.6°F/min.). Once removed from the immersion tub, the patient's Tre continued to drop, with a minimal Tre of 35.3°C(95.5°F) (~1 hour and 40 minutes after initial triage, and 1 hour and 20 minutes after being removed from the immersion tub). The patient's Tre began to normalize, and he was medically cleared by a physician and discharged from the medical tent to the custody of his mother with a rectal temperature of 35.6°C(96.1°F), ~1 hour and

50 minutes after initial triage. **Conclusions:** This EHS case involved the highest recorded Tre for this race since 2002 when medical data began being collected and is believed to be the highest documented Tre reported in the literature. Despite the extremely elevated initial Tre, best-practice recommendations were followed in which the EHS was quickly recognized, and the patient was effectively treated onsite by Athletic Trainers and other medical personnel and medically discharged by a physician without the need of further intervention or transport to an advanced healthcare facility. **Clinical Bottom Line:** While EHS is a leading cause of sudden death in sport, there is a 100% survival rate when immediately recognized and properly treated. Even when initial Tre is extreme, rapid recognition and immediate CWI is effective at quickly treating EHS and preventing any associated sequelae.

Hydration Status, Sweat Rates, and Fluid Balance During an On-Ice Training Session in Women's and Men's Collegiate Ice Hockey Players
 Claiborne TL, Zdan K, Goetschius J:
 Adrian College, Adrian, MI

Context: Poor hydration can negatively impact athletes' cardiovascular, thermoregulation, and cognitive capacities leading to performance deficits. While most research has focused on sports where exertional heat illness is a concern, cold environment athletes are also at a risk of hypohydration due to high sweat rates, cold induced diuresis, respiratory water loss, and blunted thirst responses associated with warm clothing layers and other environmental factors. With limited research investigating hydration in ice hockey athletes, the purpose of this study was to assess and compare urine specific gravity (USG), % body mass (BM) loss, sweat rate, fluid loss, and fluid intake in women's and men's college ice hockey athletes during an on-ice hockey training practice. **Methods:** Women (N=22, mean age 20.5+1.3 years) and men (N=20, mean age 22.7+1.1 years) NCAA DIII ice hockey athletes volunteered for this descriptive cross-sectional study. Each participant's USG was assessed pre-practice and BM was assessed

pre and post-practice. Fluid intake during training was also recorded. Calculations for net fluid loss = [(pre-practice BM-post-practice BM) + fluid intake], and sweat rate = [net fluid loss/ exercise time]. We assessed USG, % BM loss, sweat rate, fluid loss, and fluid intake in the total sample and compared all variables between women's and men's ice hockey athletes using independent-samples t-test or Mann-Whitney U tests ($P \leq .05$). **Results:** In the total sample, 78.5% (33/ 42) arrived to practice hypohydrated with 52% (22/ 42) measuring > 1.021 USG indicating significant levels of hypohydration. Most (78.5%, 33/ 42) of the total sample did not drink enough to replace the amount fluid lost during exercise, and women and men ended the practice session at a fluid deficit of 413.5 and 1441.7 milliliters, respectively. While there were no gender differences in pre-practice USG ($P = .970$), men consumed more fluid ($P < .000$), exhibited higher sweat rates ($P < .000$), and lost a higher percentage of BM ($P = .004$) than women (Table 1). **Conclusions:** The main findings of this study were that 1) the majority of the ice hockey players arrived to practice significantly hypohydrated, 2) did not voluntarily replace the total fluids lost at the time of exercise, and 3) men exhibited greater sweat rates and fluid loss than women at the same competition level. Even

though men and women exhibited the same level of pre-practice hypohydration, men's sweat rates and net fluid loss were over three-times higher putting them at even greater risk of the ill effects of hypohydration. Although cold environment athletes are not as susceptible to exertional heat illness, they may be as prone to physiological strain and performance deficits. The results of our investigation raise awareness and highlight the importance of intentional hydration protocols that are sport and gender specific.

Table 1
Urine Specific Gravity (USG), % Body Mass (BM) Loss, Sweat Rate, Fluid Loss, & Fluid Intake in Women's & Men's Ice Hockey Athletes During a Single Practice

Measure (Mean ± SD)	Total Sample (N=42)	Women (N=22)	Men (N=20)
Pre-practice USG	1.017 ± .008	1.017 ± .01	1.017 ± 0.008
% BM loss (pre to post practice)	0.65 ± .69	.37 ± .56*	.96 ± .70*
Sweat rate (mL/h)	802.2 ± 552.3	408.5 ± 335.6*	1235.4 ± 395.9*
Net Fluid loss (mL)	903.4 ± 652.8	413.5 ± 335.17*	1441.7 ± 462.0*
Fluid intake (mL)	397.6 ± 367.4	166.2 ± 140.5*	652.2 ± 373.2*

* = The gender differences are significant at the 0.05 level

Case Studies and Series

Saturday, June 24, 2023; authors present 10:20 AM-11:15 AM; Poster Hall

Pubic Avulsion Fracture in a Collegiate Baseball Player: A Case Report

Parker H, Peebles RL, Jacobsen AP, Galbraith RM, Warner BJ, Cage SA: The University of Texas at Tyler, Tyler, TX; UT Health East Texas, Tyler, TX; The University of Texas Health Science Center at Tyler, Tyler, TX; Grand Canyon University, Phoenix, AZ

Background: A 24-year-old male collegiate baseball player reported to the athletic training staff after experiencing acute pain in his right hip and pelvis. The previous day when performing a Romanian deadlift, the patient felt paresthesia in his right inguinal area after feeling a popping sensation. The patient discontinued lifting at that time. Later in the day, the patient began experiencing numbness, tingling, and headache. The patient also presented with referred pain in his mid-abdomen upon palpation. The patient had full strength with resisted range of motion for the quadriceps, iliopsoas, and adductors. The patient reported no issues with incontinence or bowel movements, and no protrusion or ecchymosis in the area. The only treatment the patient underwent prior to seeking care was oral over-the-counter acetaminophen and ibuprofen. Given the neurological symptoms the patient was reporting, the decision was made for immediate referral to the team physician. **Differential Diagnosis:** Abdominal muscle strain, Hip adductor strain, Inguinal or ventral hernia, Athletic pubalgia. **Intervention & Treatment:** At the time of the initial evaluation, the patient was diagnosed with a strain to a muscle in the inguinal area. The patient was instructed to avoid vigorous physical activity,

batting, deep stretching, and any other provocative activities until symptoms began to improve. The patient began a rehabilitation program centered around core and hip strengthening. Following a week of relative rest and rehabilitation, the patient began to gradually increase physical activity. When attempting to dive for a ball during fielding practice, the patient reported an increase in pain at the initial site of injury. The patient attempted to run following the dive and felt another popping sensation accompanied by worsening pain. Following exacerbating the injury, the patient reported pain radiating into his periumbilical area and testicle. At this time an MRI was ordered for further evaluation. The patient's MRI revealed an avulsion fracture of the left superior pubic ramus along with inflammation of the left common adductor-rectus abdominis. These findings indicated the patient's right hip pain was referred from the site of injury. In addition to continued weight-lifting and practice restrictions, the patient was referred to a physical therapist who specializes in pelvic floor therapy. After eight weeks of relative rest and targeted therapy, the patient was cleared to begin to gradually increase his physical activity. Throughout the competitive season, the patient was able to participate without recurrence of symptoms. **Uniqueness:** While upper extremity avulsion fractures are well described in baseball players, there are few pelvic avulsion fractures reported in the current literature. Pelvic floor rehabilitation has been described in the literature when addressing incontinence and pain in males. However, the patients who have been prescribed this treatment are generally older than the patient described in this case. Additionally, in many communities, pelvic floor physical therapists are uncommon and

those that treat male patients are even more rare. **Conclusions:** When caring for patients, it is important clinicians consider all patient reported signs and symptoms. In the event that a patient's symptoms worsen following an injury, clinicians should utilize all available diagnostic options to obtain a diagnosis. Pelvic floor therapy is beneficial for patients recovering from groin pain regardless of gender. There is a known issue in male patients being reluctant to seek care from a pelvic floor therapist. Clinicians must advocate for the best treatment options for their patients, and work to educate reluctant patients on the benefits of said treatment.

**Rare Case of Intraneural Ganglion Cyst
Innervating the Sciatic and Tibial Nerve:
Type 4 CASE Study**

Kessler KG, Lindsey B, Skidmore
S, McDonough EB, Randolph TL,
Monseau AJ, Nguyen A: West Virginia
University, Morgantown, WV

Background: A 21-year old, Division I male wrestler, with no significant medical history, initially presented with low back pain and posterior knee discomfort, accompanied by numbness and tingling into the lateral aspect of the left leg and foot. Standard of care interventions for low back pain were performed that included strengthening exercises and trunk stability, therapeutic modalities for pain and manual therapy techniques. Therapeutic interventions were delivered on a consistent basis over several months with minimal improvements in symptoms. The athlete had a constant tight and painful feeling in the hamstring, knee and calf, along with palpable tightness and paresthesia for almost 2 years. Upon conclusion of the wrestling season, the athlete underwent surgery for an intraneural ganglion cyst. **Differential Diagnosis:** With these symptoms, the athlete had multiple differential diagnoses including lumbar disc herniation, sciatic nerve irritation, Baker's cyst, compartment syndrome, spondylolisthesis or spondylosis. **Intervention & Treatment:** The patient was referred to the team physician for a lumbar spine MRI which revealed no significant findings. Standard of care interventions were continued, and the patient continued to wrestle

with no improvement of symptoms. Prior to the start of the next wrestling season, the patient was again referred to the team physicians where bilateral lower extremity EMG testing revealed no significant nerve pathologies. Subsequent MRI of the knee noted a cyst in the posterior knee that extended proximally into the thigh. This finding prompted a long bone/femur MRI which revealed a cyst spanning the distance up to the mid-thigh. The patient was referred to an orthopedic oncologist where he was diagnosed with an intraneural ganglion cyst innervating the sciatic and tibial nerves. The patient completed the entire wrestling season, then underwent surgery, where an approximately 34cm cyst, extending from the mid-calf to the inferior gluteal crease, was removed from the sciatic and tibial nerves. Immediate relief was reported by the patient following surgery. During post-surgical recovery, the patient experienced an incisional infection. Following adequate wound healing, the patient gradually participated in conditioning and wrestling activities and was able to return to activities with no restrictions at approximately 5 months from the date of surgery. **Uniqueness:** Although idiopathic, ganglion cysts are fluid-filled sacs that are commonly found in the general population around joints like the wrist or hand but are less common around the knee. Additionally, ganglion cysts can innervate nerve sheaths causing paresthesia and immobility, but rarely, as in this case, do ganglion cysts innervate 2 nerves simultaneously and grow to a length of over 34cm. If left untreated, these cysts can result in permanent, neurological damage. Adding to the complexity of this case were

the multiple steps, including various health-care specialties and diagnostic tests, to attain a final diagnosis. Furthermore, through a team approach to healthcare, an accurate diagnosis and effective interventions resulted in positive outcomes where the patient was able to participate in the entire wrestling season, qualifying for the national tournament. **Conclusions:** The 21-year old patient sustained an extremely rare injury, resulting in constant pain and paresthesia for almost 2 years. He exhibited signs of pain accompanied by a mild limp, which hindered his wrestling at times. There was concern for the patient's well-being throughout the season because it was taking a toll on his mental health and his overall ability to perform, which exacerbated the symptoms. These cysts can present as neurological deficits but can only be diagnosed by MRI. Treatment can alleviate mild symptoms, but ultimately, surgery is the best solution. With the team approach used to determine the diagnosis, the patient returned to optimal physical and mental performance.

Bilateral Closed Barton's Distal Radius Fractures Using Both a Volar and Distal Approach to Open Reduction Internal Fixation on a 47-Year-Old Male: A Level 3 Case Study

Harrison NMJ, Dorf ER: Vail Summit Orthopaedics and Neurosurgery, Vail, CO

Background: Distal radius fractures are the most common fractures seen annually in orthopedics, with data showing an increasing prevalence over the past 40 years. Despite increasing frequency of this injury, there is very limited research related to the incidence, treatments, and outcomes regarding bilateral distal radius fractures especially for the young athletic adult population. This case aims to support the current limited findings of successful outcome following open reduction internal fixation (ORIF) with volar locked plating of a bilateral intra-articular comminuted distal radius fracture with high-energy injury in an athletic adult. **Patient:** A 47-year-old, right hand dominant, healthy male presented with bilateral wrist pain and deformity following a high-energy event. Two days prior he was involved in a dirt bike crash which resulted in him landing on outstretched arms with more impact on the left side. He was seen immediately at his local emergency room where imaging showed bilateral closed comminuted Barton's distal radius fractures with a left ulnar styloid comminuted fracture. Initial reduction was performed on the left side before bilateral splinting and presenting to the clinic. During the initial appointment, imaging was reviewed and the initial diagnosis was confirmed. Following a comparative discussion of risks vs. benefits for both nonoperative and operative treatment, a decision was made to perform a bilateral ORIF urgently as to give the patient the best chance of maintaining his active lifestyle. **Intervention & Treatment:** Two days after the initial visit, bilateral distal radius ORIF with volar plating was performed. The right was successfully reduced and properly aligned with the use of the volar plate. The left proved to be more complex which required a dorsal percutaneous pinning

approach to stabilize the fracture prior to plating. This side also had significantly more swelling combined with a pre-operative complaint of numbness and tingling in the thumb consistent with acute carpal tunnel syndrome which was treated with successful release of the Transverse Carpal Ligament. Follow-up appointment was completed 12 days postoperatively where splints were removed for incisional inspection. Bilateral removable splints were given to be worn constantly. At 3 week post-operatively, the patient was evaluated again with updated x-rays which showed early healing and no evidence of hardware loosening. He was instructed to maintain bracing for the next 1.5 weeks at which time he began slight range of motion at the wrist in all planes except supination or pronation. Evaluation at 6 weeks postoperatively showed near full range of motion of pronation but lacked full supination. Imaging continued to show adequate healing. Patient was prescribed formal physical therapy, instructed to start weaning out of the braces, and to follow-up in 4 weeks. **Outcomes or Other Comparisons:** At this time, a successful outcome for this patient is expected with no complications of tendon injury, nerve injury, malunion, infection, or complex regional pain syndrome (CRPS). Post-operative imaging thus far has revealed good alignment and adequate healing reducing the chances that any of these complications will arise. **Conclusions:** Although distal radius fractures happen frequently, especially in the athletic population, their variability leads to discrepancy in treatment. Due to the risk of decreased functional outcomes that are associated with bilateral distal radius fractures and the complexity following high-energy injuries, like those seen in athletics or extreme sport, ORIF with volar plating is supported as the preferred treatment choice. **Clinical Bottom Line:** Particularly in active young adults, restoring articular congruency and expediting the recovery process, by avoiding complications and restoring range of motion, should be paramount when deciding which treatment method to utilize following a distal radius fracture to ensure a successful outcome.

Tarsometatarsal Bone Fusion With Autograft Bone Grafting, Open Reduction and Internal Fixation and External Fixation Application on a 26-Year-Old Male: A Level 3 Case Study
Harkness GT: Vail Summit Orthopaedics and Neurosurgery, Vail, CO

Background: 26-year-old male who sustained a Type C Lisfranc fracture dislocation involving the first through fifth tarsometatarsal joints, dorsal and lateral dislocation of the 2-3 metatarsals at the tarsometatarsal joint with fracturing involving the plantar margins and comminuted fracturing involving the fifth metatarsal at the fifth tarsometatarsal joint with extensive-articular involvement while mountain biking. **Patient:** 26-year-old male **Intervention & Treatment:** Due to the closed injury secondary to significant displacement and instability of the injury, ecchymosis present on plantar and dorsal aspect and suspected soft tissue injury, surgery was indicated. An external fixation application with posterior splinting was performed mere hours after admission to emergency department. The physician manually reduced the first and second tarsometatarsal joints. A pointed reduction tenaculum at the first metatarsal base was done. K-wire was placed obliquely across the fourth and fifth metatarsal bases once they were manually reduced to the cuboid. Approximately twelve days post-injury, secondary surgery was performed. First, the external fixator was removed. The extensor hallucis profundus tendons were ruptured and irreparable at the musculotendinous junctions, while the extensor hallucis longus tendon was still intact. The second tarsometatarsal joint was fully unstable. The Lisfranc ligament completely ruptured and several full-thickness chondral defects to the articular surfaces of the second metatarsal and the intermediate cuneiform along with instability at the medial intercuneiform second metatarsal articulation. Physician found that there was significant trauma to the extensor digitorum brevis musculature and the ligamentous tissue about the third through fifth tarsometatarsal joints. Large dorsal intraarticular and multiple plantar fractures were identified at the third

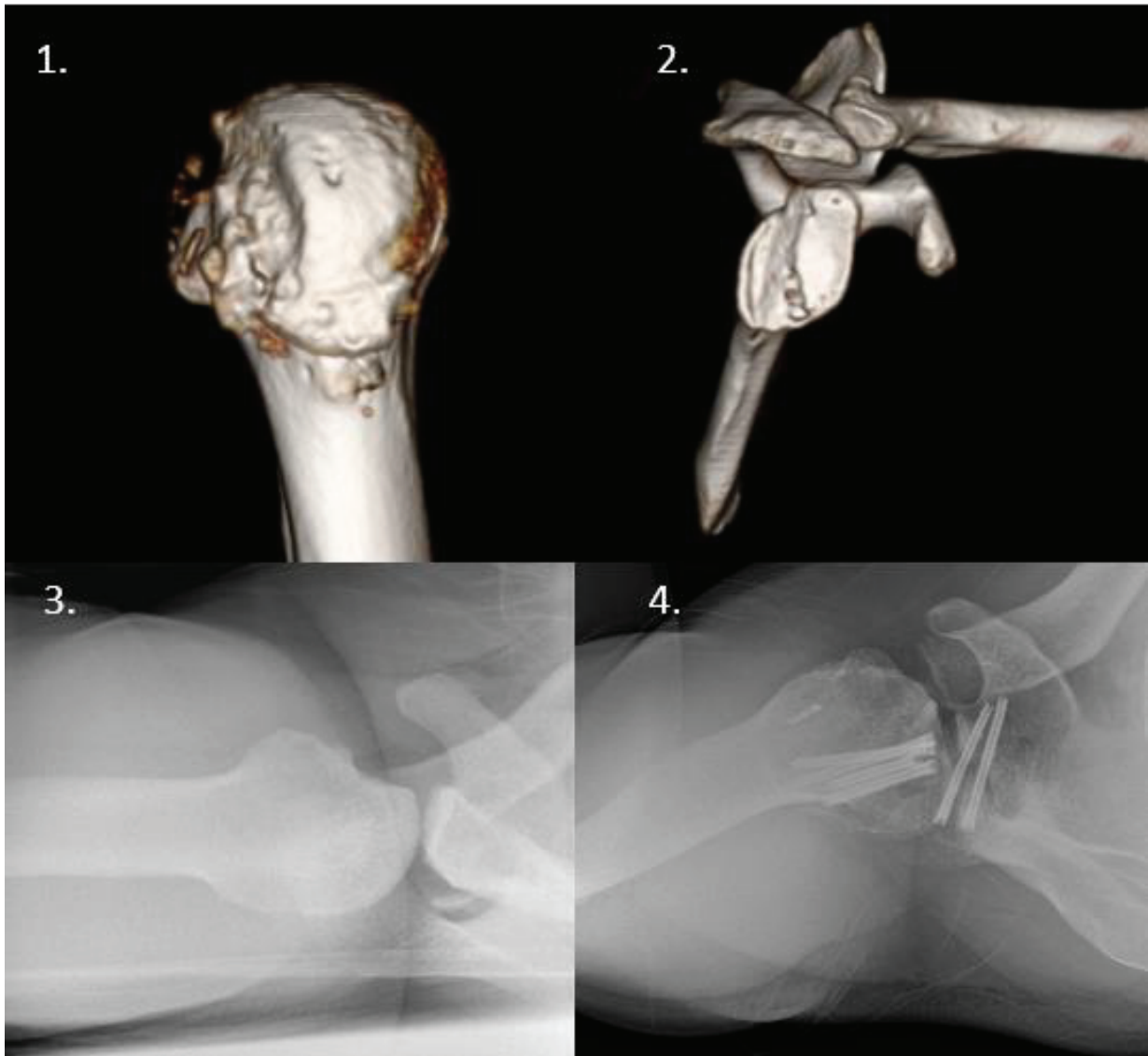
tarsometatarsal joint. Due to the extent of the injury in the multiple comminuted fracture segments, the physician elected to proceed with autograft bone grafting. Bone graft of cancellous autograft from the proximal tibia metaphysis was then applied to the second tarsometatarsal joint and anatomically reduced. The second tarsometatarsal joint was stabilized. The third tarsometatarsal joint was then fused and the first tarsometatarsal joint was compressed and stabilized. The graft was applied to the first through third tarsometatarsal joints. The fifth metatarsal base fracture at the tuberosity was reduced. The fifth tarsometatarsal joint was reduced and pinned with a K-wire maintaining anatomic reduction of the joint. The fourth tarsometatarsal joint was manually opened reduced and pinned across the joint with K-wire. **Outcomes or Other Comparisons:** Based on the symptoms presented when patient was admitted to the ER, differential diagnosis includes fracture, dislocation, compartment syndrome, and/or open fracture. **Conclusions:** Although rare, this case highlights important factors to consider that may be indicative of a Lisfranc injury. In cases where reported symptoms include midfoot pain, swelling, plantar ecchymosis and instability following a reported trauma to a plantarflexed foot it is important to consider immediately obtaining diagnostic radiographic images of the foot. **Clinical Bottom Line:** Lisfranc fractures are rare and only account for 0.2-0.8% of all fractures. The polytrauma and need for multiple surgeries to allow soft tissue healing makes this case especially unique. During the second surgery the utilization of a bone graft attributed to the uniqueness of the case. In a study done by Richter et al utilizing patients treated in a Level I Trauma Center, out of 85 patients, only 5 had a bone autologous bone transplant due to the severity of the injury. The mechanism of impact can be seen across varied settings and has relevant clinical applicability especially in the field of sports medicine. For this patient the utilization of external fixation to allow soft tissue healing, bony graft to aid in fixation, fusion utilizing plating and screws all resulted a good, reported outcome.

Posterior Instability With Concomitant Risk Factors: A Type III CASE Study
Leitch AC, Montjoy MG, Martin BM, Godin JA: The Steadman Clinic, Vail, CO, and Steadman Philippon Research Institute, Vail, CO

Background: Posterior shoulder instability is rare, accounting for 2-12% of all shoulder instability events. Chronic posterior instability has been described in dynamic posterior loading activities, such as weightlifters, football linemen, and baseball players. Acute posterior dislocations are a different entity often seen in patients with epilepsy, electrocution, or a direct anterior to posterior force. Knowing the mechanism of injury can provide significant assistance in diagnosing patients with posterior shoulder instability. Epilepsy, a mechanism for posterior shoulder dislocations, affects 1.2% of the U.S. population. People with epilepsy (PWEs) have often been advised against participating in sports, although recent research has changed the clinical recommendations regarding sports and epilepsy. This Type III CASE study highlights a high-level athlete's orthopedic injury associated with a seizure disorder, a rare case seen by athletic trainers. **Patient:** Patient is a 20-year-old male, right hand dominant, collegiate football player. He reported a right posterior labral repair in 2020 and uncontrolled epilepsy at the time, contributing to posterior shoulder instability. His chief complaints were generalized right shoulder pain and decreased strength. He reported

difficulty with full ROM, painful shoulder grinding, and night pain. He had not returned to overhead lifting or football. Physical exam demonstrated decreased and painful AROM and strength. His exam was positive for apprehension and relocation, posterior drawer, Jerk, and belly press test. Radiographs, MRI, and CT(see Figure I) showed significant bipolar bone loss of the posterior glenoid and the anterior humeral head, inferior glenohumeral ligament tear, humeral head posterior subluxation, and moderate to severe glenohumeral joint osteoarthritis. **Intervention & Treatment:** The patient has been working with neurology to optimize seizure control and was treated with arthroscopic assisted posterior glenoid distal tibia allograft(DTA), open talar allograft to the reverse Hill-Sachs lesion, and open biceps tenodesis(Figure I.). Post-operative care consisted of an abduction sling and limited ROM for 4 weeks, with a gradual progression back to full ROM and strength. The recommendations based on size and location of the defect, age, grade of disability, and the eventual association with unstable epilepsy, have been made to guide the surgeon during the decision-making process for surgical technique. Various soft tissue and bony procedures have been described to address both posterior glenoid and anterior humeral head bone loss. Different bone autografts and allografts have been used, but there is little literature reporting the functional outcomes of their use. **Outcomes or Other Comparisons:** Patient continues to progress without complications, reports no recent

seizure activity and looks forward to returning to football participation. Although there are few outcome studies for this surgical intervention, his continued progress provides a positive prognosis for his return to sport. **Conclusions:** Athletes, specifically those with concomitant epilepsy, participating in contact sports are at an increased risk of posterior instability. It commonly presents with generalized shoulder pain and decreased athletic performance and/or loss of strength. The management of bone loss in posterior glenohumeral instability is extremely complicated and outcomes are not well known. While PWEs have historically been restricted from participation in certain sports and activities, it has been shown that sport participation can have a beneficial influence on seizure frequency and severity. For this patient, his successful return to football will be largely based on both his rehabilitation and management of seizures. **Clinical Bottom Line:** A recent systematic review found that bipolar bone loss accounts for 2% of defects in patients with posterior glenohumeral instability. This defect in a young football player with concomitant epilepsy presents a challenge when deciding on the appropriate treatment. Understanding secondary injuries associated with an epileptic event, appropriately identifying posterior shoulder instability, and appropriate surgical decisions are all critical in the success of athletes in this small margin.



**Syndesmosis Sprain in a 19-Year-Old
Division 1 Collegiate Football Player:
Type 2 Clinical CASE Study Abstract**
Malven K, Pollard-McGrandy AM,
Rice L, Roskelly J, Nogle S, Covassin
T: Michigan State University Sports
Medicine and Performance, East
Lansing, MI

Background: Syndesmosis ankle sprains account for 25% of all ankle sprains in National Collegiate Athletic Association (NCAA) football athletes. Typical return-to-play (RTP) time for an ankle syndesmosis sprain is approximately 8 weeks, however, in a small randomized controlled trial, it was found that the platelet rich plasma (PRP) treatment group (one injection) had a mean RTP time of 40.8 ± 8.9 days. Ultrasound guided therapeutic PRP injections are an up-and-coming treatment to decrease RTP time in syndesmosis ankle sprains. **Patient:** A 19-year-old male, Division-1 collegiate football player, sophomore, with a diagnosed syndesmosis ankle sprain. The athlete presented with right lower leg pain during an on-field evaluation by the team athletic trainer (AT) during practice. The athlete had no previous right lower leg injuries. During practice, another player fell on the athlete's foot while it was plantar flexed and externally rotated. Following the incident, the athlete was unable to bear weight and removed from the field for further evaluation. The anterior portion of the athlete's right ankle was swollen and tender to palpate over the anterior distal tibiofibular ligament. The evaluating AT performed a Kleiger's and Squeeze test, both were positive. Imaging revealed no fractures, but an MRI revealed a grade 2 syndesmosis ankle sprain on November 10th, 2021. **Intervention & Treatment:** The team physician and AT decided 5 days after the injury, a PRP injection would add to the course of treatment and afford the athlete an opportunity to return at an accelerated rate. Following the PRP injection the athlete was partially weight bearing for one

week. The athletes' pain, swelling, and range of motion (ROM) were examined each day prior to rehabilitation by the AT. The start of rehabilitation, the athlete focused on light ROM, open kinetic chain exercises, and swelling control. Each week the athlete was able to progress through the rehabilitation plan, incorporating the hydroworx and alter-gravity treadmill to further advance the athlete to weight-bearing and closed kinetic chain exercises. Typical interventions in the literature do not include the hydroworx and alter-gravity treadmill with PRP injection. By the beginning of week 4, the athlete started RTP activity and functional training on the turf. By the end of week 4, the athlete was able to return for non-contact practice with physician clearance due to no swelling, point tenderness, and increasing function. The athlete had physician clearance for full participation in games 34 days post-injury. **Outcomes or Other Comparisons:** The athlete in the case presented was able to return for full-contact practice within 29 days of the initial injury with the use of PRP injection, hydroworx, and alter-gravity treadmill therapy. **Conclusions:** Syndesmotic ankle sprains can take a great deal of time to heal; however, the use of ultrasound guided PRP therapeutic injection, hydroworx, and alter-gravity treadmill allowed the athlete in this case to RTP at an accelerated rate. It is important to consider other factors that were involved such as early diagnosis of the injury, decision of the medical staff to use PRP, and the rehabilitation regimen. The athlete was able to return within 29 days of injury compared to the average 40 days but was consistently participating in rehabilitation twice a day, five days a week. Adherence to the rehabilitation program was essential for progression each week. **Clinical Bottom Line:** The addition of PRP into a treatment plan, including hydroworks and alter-gravity treadmill, for syndesmosis ankle sprains could be considered an alternative approach for an accelerated RTP although more research needs to be conducted to confirm the full benefits of PRP.

PRP Intervention for Iliopsoas Tear in a Division 1 Collegiate Dual Sport Athlete

Dufon S, Pollard-McGrandy AM, Smith L, Homer M, Worley J, Zita A, Mollitor E, Belhomme T, Rice L, Roskelly J, Scott R, Nogle S, Covassin T: Michigan State University, East Lansing, MI

Background: A 20-year-old male Division 1 collegiate redshirt sophomore athlete that plays both football (tight end) and basketball (forward/guard). The athlete was 4 months post-operative from sports hernia/adductor longus surgery (April 8, 2022). On August 6, 2022, the first day of shoulder pads during football training camp he was blocking, and another player took his legs out. In the process, his right (R.) leg was caught under him, and another player fell on top of him. He immediately felt a pop/tear in his R. side, finished practice, and was evaluated after by the athletic trainers (AT). Upon evaluation he had a 3+/5 muscle strength in the hip flexors, 4/5 muscle strength in the adductors, and 4/5 muscle strength in the quadriceps. Range of motion was limited in hip external rotation, internal rotation, and flexion. The athlete was point tender on ASIS and along the length of hip flexor muscles. The athlete was neurologically unremarkable in the hip region with a positive figure 4 strength testing. **Differential Diagnosis:** Retear of the sports hernia mesh, Pectineus strain, Iliopsoas strain, Adductor longus strain **Intervention & Treatment:** MRI and ultrasound imaging showed a grade 1 tear to the iliopsoas muscle. Based on imaging results, the team physician opted for a conservative treatment. In addition, to conservative rehabilitation the athlete received a platelet rich plasma (PRP) injection at the injured site. For 3-4 days he was limited to open kinetic chain exercises. During

week two, the athlete was able to progress to weight bearing exercises and running progression utilizing the Alter G anti-gravity treadmill. By the third week, the athlete started on-field exercises as well as on-land progressive running. Week 4, the athlete was cleared by the team physician to practice as tolerated and for game play. **Uniqueness:** The sports hernia mesh from the initial surgery prevented the adductor longus from re-tearing, but subsequent injury results in a tear of the iliopsoas. The athlete was given a PRP injection on August 8, 2022, accelerating the healing time. Estimated recovery time for an iliopsoas tear with a PRP injection is 6 weeks, and without an injection is around 8 weeks. After a 3-week rehabilitation protocol, he returned to play and participated in the first football game of the season. **Conclusions:** It is not common to see injuries involving the hip musculature among athletes. Only 6% of injuries in athletes are hip related. Moreover, contact related hip flexor injuries are less likely than non-contact hip flexor injuries. While there is limited literature on a tear of the iliopsoas, we can use surrounding muscles as a guideline. The average return to play following a significant muscle injury to the quadriceps, hamstrings, and gastrocnemius was 21.1 ± 3.1 days with PRP injection and 25 ± 2.8 days without PRP. The case presented adds to the literature on utilization of PRP injections to improve recovery time following an iliopsoas tear. This case shows the validity of using PRP injections to improve recovery time following an iliopsoas tear. The projected recovery time for this athlete was 6 weeks, however, was able to return in 3 weeks. Furthermore, the athlete has continued to participate fully in sport following return to play without further complication. Future research should be conducted regarding PRP injection to confirm its full benefits

Syndesmosis Ankle Sprain in a 21-Year-Old Division 1 Collegiate Football Player

Worley J, Pollard-McGrandy AM, Dufon S, Smith L, Homer M, Zita A, Molliter E, Belhomme T, Roskelly J, Rice L, Scott R, Nogle S, Covassin T: Michigan State University, East Lansing, MI

Background: Syndesmotic injuries make up 12% of all ankle sprains, but 25% of ankle sprains in football. Historically, screw fixation has been the predominant type of surgery, which provides stabilization to the syndesmosis joint. However, the strong fixation procedure can cause a loss of movement in the early recovery phase, an inability to bear weight, and typically needs the screw to be removed. The tight-rope procedure provides athletes with a faster recovery, as there is no need for removal and allows for early weight bearing. Typical recovery timeline for a screw fixation is 4-6 months, compared to the tightrope procedure taking 2-3 months. The use of blood flow restriction (BFR) could be an effective addition to rehabilitation intervention to decrease the time to return to sport (RTS). **Patient:** A 21-year-old, Caucasian, male, Division I collegiate football athlete, defensive end, junior presented with left (L.) lower leg pain the day after a game. During the game, the athlete was rushing when he was forced into plantar flexion and inversion as another player fell on top of him. He continued to play the entirety of the game without reporting the injury. The evaluating athletic trainer (AT) performed the squeeze test and kleiger, which was positive. Imaging revealed no fractures, but an MRI revealed a L. syndesmosis ankle sprain and a fracture of the fibula. **Intervention & Treatment:** The team physician and the AT decided that a surgical treatment with the addition of BFR as part of the rehabilitation would afford the athlete an opportunity to return at an accelerated rate. Rehabilitation started by targeting edema with soft tissue mobilization, ankle exercises,

as well as BFR to assist with the acute phase of healing. The athlete started his progression to weight bearing beginning with seated exercises, then assisted exercises, working his way to full weight bearing by the 12th day. BFR continued to be performed 4 days a week to strengthen the surrounding musculature. To further assist in the athlete's recovery, a run progression was introduced by using the alter-G to increase strength and range of motion. During week 4, the athlete was introduced to tempo running, which is a gradual building of speed for a certain length of yards, as well as performing sport-specific functioning drills with the AT, and training fully with strength and conditioning staff. A week after physician clearance 9/17 injury 10-11-physician practice, the athlete was able to begin progression back to practice, and the subsequent week (10-18), was able to play as tolerated in the following game, while being braced and taped.

Outcomes or Other Comparisons: The athlete made excellent progress with tightrope surgery and BFR. The athlete recovered in 33 days compared to the average 64 days after a tightrope procedure, with the use of BFR during rehabilitation. **Conclusions:** The main priority after an injury is to RTS in the shortest and safest amount of time as possible. Tightrope procedure facilitates recovery exponentially, when compared to screw fixation surgery. Incorporating the use of BFR during the recovery phase could potentially accelerate this process even further, as shown in this case. The recovery time was reduced by almost half when compared to the average of 64 days. In athletic populations, the tightrope procedure is the most favorable intervention for a syndesmotic ankle sprain. **Clinical Bottom Line:** Tightrope procedure for a syndesmotic ankle injury can significantly reduce the return to play time in the athletic population, along with the assistance of BFR during rehabilitation. The use of BFR to aid in the healing process of a syndesmotic ankle injury is a practical application that can be used in a variety of patient populations because it can be personalized to the patient.

Return-to-Sport Following Deltoid Ligament and Syndesmosis Repair in a Division 1 Football Defensive Back: Type 4 CASE Study

Blankenship VT, Foster SZ, Kessler KG, McDonough EB, Waldrop NE, Nguyen A: West Virginia University, Morgantown, WV, and Andrews Sports Medicine, Birmingham, AL

Background: A 22-year-old, Division I male football defensive back, with no previous history of ankle injury, sustained a left ankle injury during competition. The mechanism of injury was direct contact to the lateral lower leg from an opponent forcing the ankle toward eversion. Initial on-field evaluation revealed palpable pain over the medial ankle with no sign of fracture or obvious deformity; and the athlete was assisted off the field NWB. Sideline evaluation revealed pain and point tenderness over the medial and anterior ankle, decrease dorsiflexion flexion and eversion active range of motion, and pain with eversion ligamentous stress testing with increased laxity. The athlete was able to fully weight-bear but was not able to perform functional movements, removing him from continuing with the competition. On-site radiographs were negative for fracture or dislocation. The athlete was fitted with a walking boot, instructed to weight-bear as tolerated, and follow-up the following day with the sports medicine team.

Differential Diagnosis: Based on the initial signs, symptoms, and radiographs, differential diagnoses included: deltoid ligament sprain, anterior inferior tibiofibular ligament sprain, syndesmosis sprain. **Intervention & Treatment:** Follow-up evaluation revealed gross swelling around the ankle and discoloration over the medial ankle. Standard of care treatment was initiated which included cryotherapy, pain-free PROM exercises, isometric strengthening, and NSAIDs. The athlete was referred to the team physician for repeat radiographs and MRI. Diagnostic testing noted a complete rupture of the deltoid ligament, grade II anterior inferior tibiofibular ligament sprain and bone contusions of the medial malleolus and talus. The athlete was referred to a physician with specialization in foot and ankle injuries for further evaluation.

The evaluation conclude that the athlete suffered a complete rupture of the deltoid ligament and syndesmosis. There was also gross instability in the ankle and surgical intervention was indicated. The athlete underwent surgery that included a primary repair of the deltoid ligament combined with a syndesmotic Tight Rope fixation. Following post-surgical recovery, the athlete completed an aggressive intervention and return to sport program that included: progressive strengthening and proprioceptive ankle exercises with blood flow restriction, early initiation of a weight-supported gait/running program, progressive functional and sport specific agility drills, and gradual return to sport activities. The athlete was able to return to sport in 5 weeks with no restrictions and returned to the starting line-up at week 6 from the date of surgery. The athlete continued full participation with the use of an external ankle brace, modified spartan taping, and custom fitted orthotics.

Uniqueness: Ankle injuries that include a deltoid ligament rupture, combined with syndesmotic disruption are not commonly reported in the athletic population. This traumatic injury requires surgical fixation to stabilize the ankle and the typical time to return to sport varies, on average, from 4-6 months. We present a unique case where early access and frequency of an aggressive rehabilitative program, integrating a multi-disciplinary healthcare team, resulted in positive outcomes where the athlete was able to safely and successful return to high level sport in 5 weeks. **Conclusions:** Ankle injuries that result in rupture of the deltoid ligament and syndesmosis result in gross ankle instability. This injury is rare in sports and requires an extensive surgery that combines multiple surgical procedures. A 22-year-old football player sustained this traumatic ankle injury that commonly requires 4-6 months of recovery. Through an integrated healthcare team approach, an aggressive intervention program was successful in positive outcomes with the athlete returning to sport in 5 weeks. This unique case challenged the conventional recovery times as a result of early access and frequency of an aggressive rehabilitative program, while taking into account the physiological and patient response to the injury and rehabilitation.

Thoracic Outlet Syndrome in a Collegiate Woman Basketball Player: A Level 4 Case Study

Lee D, Pollard-McGrandy AM, Jefferson L, Covassin T: Michigan State University, East Lansing, MI

Background: A 19-year-old, previously healthy, female division I freshman basketball player presented with persistent left (L) hand pain across the base of her hand with no known trauma/mechanism of injury. Athlete additionally reported intermittent symptoms of numbness/tingling of the 1st, 2nd, and 3rd digits, pain around the anatomical snuffbox, and blanching of the 2nd and 3rd digits. Initial examination by the Athletic Trainer (AT) revealed L. hand coolness to the touch and a diminished brachial pulse compared bilaterally. Furthermore, the athlete reported the intermittent symptoms had persisted over the past 3 weeks, however, she did not report symptoms to the AT as she believed they would eventually resolve. **Differential Diagnosis:** Carpal Tunnel Syndrome or Thoracic Outlet Syndrome **Intervention & Treatment:** Athlete was referred by the team physician to a vascular surgeon for consultation. One day prior to the scheduled consultation the athlete appeared in the athletic training room (ATR) with purple cyanosis and coolness of the L. hand, as well as cubital fossa/elbow pain. The patient was immediately referred to the emergency department (ED). The vascular surgeon determined an emergency thrombectomy was necessary which was performed within 24 hours. The procedure successfully removed a thrombus from the ulnar artery, but physicians determined the radial artery thrombus couldn't be removed after multiple attempts over the next two days. Following hospital release and thrombectomy recovery, the athlete was examined by a TOS Specialist,

who recommended the athlete have TOS decompression due to a CT scan which revealed an ectatic L. Subclavian Artery. Two weeks post TOS decompression surgery the athlete described a reoccurrence of the symptoms resulting in immediate referral to the ED for another thrombectomy of her ulnar and radial artery. Since the procedure, the athlete has seen various specialists to diagnose the origin of the thrombi and has been prescribed multiple blood thinners for up to one year. For the first six weeks post final procedure the athlete performed range of motion (ROM) at the neck, shoulder, elbow and wrist, scar mobility work, and breathing exercises. At week 7, the athlete started gradual lower extremity lifting and by week 9 the athlete started upper body lifting. Currently, the athlete performs daily ROM and treatment in an attempt to modulate residual symptoms, as well as non-contact, functional activities, such as shooting and ball-handling as tolerated. **Uniqueness:** This case study examines an athlete's unique TOS and potential life-threatening complications associated with the syndrome. Arterial blood clots are far less common than venous blood clot cases. Due to the mechanics of basketball, development of TOS in players is rare. Basketball mechanics typically require overhead motions to shoot the ball, rebound, and contest shots, however most of the motions in basketball do not require a consistent/repetitive amount of force to efficiently perform these skills. Conversely, TOS is commonly found in sports with constant overhead and/or repetitive motions that compress the brachial plexus and subclavian vessels exiting the Thoracic Outlet, like swimming, baseball, and rowing athletes. **Conclusions:** Overall, this case study presentation is used to inform athletic trainers on the possible complications associated with TOS. Although TOS is not common in basketball, ATs should not rule out the possibility of a life threatening differential diagnosis.

Tear of the Anterior Inferior Tibiofibular Ligament Resulting in a Tight Rope Surgery and Achilles Tendon Tendinopathy: Type 4 CASE Study
Williamson H: Marshall University, Huntington, WV

Background: A college-aged male football athlete complained of left ankle pain after planting and twisting his ankle when attempting to make a play on the ball. The initial report from the athletic trainer revealed mild edema and ecchymosis. The athlete was tender to palpate over the lateral malleolus, lateral ligaments of the ankle, and the peroneal tendon complex. Due to pain, the range of motion and manual muscle testing could not be evaluated. The positive special tests were the talar tilt and anterior drawer. During post-operation rehabilitation, the subject complained of Achilles Tendon pain that continued for about two months. **Differential Diagnosis:** From the initial examination, a differential diagnosis is a grade 2 lateral ankle sprain. Based on the subject's complaints during post-operative rehabilitation, an additional differential diagnosis is Achilles Tendon Tendinopathy. **Intervention & Treatment:** The physician's evaluation revealed diffuse swelling throughout the ankle. The subject had tenderness over the syndesmosis with the squeeze test. The subject was also tender over the medial malleolus and the fibula. X-rays of the left ankle ruled out a fracture. MRI of the left ankle without contrast revealed bone marrow edema in the posterior malleolus secondary to edema. The anterior inferior tibiofibular ligament and anterior-posterior tibiofibular ligament were amorphous and discontinuous. The deltoid ligament was mildly thickened, indicating a sprain. The physician diagnosed left ankle cartilage damage, left ankle

syndesmosis injury, anterior inferior tibiofibular ligament tear, and left ankle synovitis. The orthopedic surgeon and the patient decided on an operation with a tightrope surgical approach. The tightrope procedure involves surgically inserting a wire through the tibia and fibula that stabilizes the ankle mortise (Street et al., 2021). Four weeks post-operation, the subject was moved from a boot to a lace-up brace and instructed to begin functional ankle rehabilitation. The subject was experiencing a lot of Achilles Tendon tenderness during his post-operative rehabilitation. Seven weeks post-operation, the subject received an injection in the pre-Achilles bursal tissue; the athlete returned to practice one-week post-injection. **Uniqueness:** The incidence of high ankle sprains in the United States is 2.09 injuries per 100,000 people; the incidence in collegiate football players is about 2.5 per 10,000 (DeWeber, K, 2021). **Conclusions:** The subject experienced a left ankle syndesmosis injury that resulted in surgical repair using the tightrope technique. Following the operation, during the rehabilitation process, the subject developed pain in the Achilles Tendon, leading to an injection seven weeks post-operation. The subject returned to play one week after receiving the injection. This CASE reveals a pathology for Achilles Tendon Tendinopathy that research does not explore in depth. The incidence of Achilles Tendon Tendinopathy following this type of surgical syndesmosis repair is unknown; therefore, this CASE study can inspire an investigation into this incidence in a larger population. The research that can be done based on this CASE study can reshape the rehabilitation protocol of this injury to prevent others from developing issues with their Achilles tendons post-operation.

Subtalar Osteoarthritis in an Adolescent Student-Athlete: A Level 4 Clinical CASE Study

Cook TC, Hawkins J, Marshall AN:
Appalachian State University, Boone,
NC, and Appalachian Regional
Healthcare System, Linville, NC

Background: The patient was a 12 year-old football player when the initial injury occurred, without any pertinent medical history. He reported two episodes where his right foot/ankle was stepped on during a football game Fall of 2019 and 2020, respectively. Following a period of normal function (8 months), the patient noted that an increase in physical activity progressively increased pain and decreased function without any known subsequent mechanisms of injury. **Differential Diagnosis:** Based on the patient's presentation and function, initial differential diagnoses included chronic ankle instability, adhesive capsulitis, and bone marrow contusion. **Intervention & Treatment:** The patient was referred to an orthopedic physician 2.5 years following the initial injury, and was diagnosed with a chronic ankle sprain. In addition, radiographs revealed a healed 4th metatarsal fracture. The physician recommended use of an external ankle support and aggressive rehabilitation for 4-6 weeks. After 12 weeks, the patient appeared to be regressing and was referred to a foot and ankle specialist. An MRI

revealed bone marrow contusions in the lateral talar body and lateral calcaneus of the right foot/ankle. The patient was prescribed Celebrex (celecoxib) for pain and inflammation and continued with rehabilitation. After three months of rehabilitation, the patient sought a second opinion from an orthopedic surgeon. The physician observed a stiff flatfoot deformity on exam and subtalar osteoarthritis upon review of his previous MRI. Since his initial injury, treatment and rehabilitation has been comprehensive and the patient's compliance and adherence with the protocol has been very good (3-5 days per week). Rehabilitation has consisted of foot and ankle strengthening, range of motion, gait training, and therapeutic interventions (electrical stimulation, ice, heat, ultrasound, manual therapies). Joint mobilizations were attempted, but increased the patient's pain dramatically. Four years following his initial injury, the patient is still exhibiting deficits in both clinician-rated (Table 1) and patient-rated outcome measures. He rates pain with activity as 6/10, pain with walking as 3/10 and pain with rest as 0/10. Additionally, the patient scored a 2/24 on the Cumberland Ankle Instability Tool, 9/9 on the Ankle Instability Instrument, 65.5% on the Foot and Ankle Ability Measure Activities of Daily Living Subscale, 35.7% on the Foot and Ankle Ability Measure Sport Subscale and 30/37 on the Identification of Functional Ankle Instability questionnaire. **Uniqueness:** Osteoarthritis is often diagnosed at the knee and hip and in an

older population; however, this diagnosis is much less common in an adolescent patient and subtalar osteoarthritis has just recently emerged as a more frequent area of research. The patient's history includes two acute episodes where his foot and anterior ankle were stepped on. However, subtalar osteoarthritis was noted on his MRI, suggesting that his change in function over time may have contributed to subtalar cartilage degeneration. Furthermore, the patient has met the diagnostic criteria for chronic ankle instability, as put forth by the International Ankle Consortium, based on his responses to the patient-reported outcome measures. Patients with chronic ankle instability often exhibit foot and ankle motion limitations in multiple planes, which may be due to osteoarthritis or a consequence of the condition. **Conclusions:** It is rare for an adolescent athlete with no significant previous medical history to be diagnosed with osteoarthritis. The patient underwent conservative treatment for approximately 4 years; however, he still exhibits significant deficits in patient and clinician-rated outcome measures. These findings suggest that additional research on these progressive and chronic conditions should be conducted within the adolescent population in an effort to guide clinicians during the evaluation, rehabilitation, and return to sport process.

Table 1. Clinician-Rated Outcome Measures 4-Years Following Initial Injury

	Value
Range of Motion	
Dorsiflexion - Active	0°
Dorsiflexion - Passive	6°
Plantarflexion - Active	33°
Plantarflexion - Passive	40°
Inversion - Active	3°
Inversion - Passive	12°
Eversion - Active	16°
Eversion - Passive	20°
Strength	
Dorsiflexion	5/5
Plantarflexion	5/5
Inversion	3/5
Eversion	2/5

A Multi-Disciplinary Approach for a Highschool Cheerleader: A Level 3 Case Study on Behavioral Health Concerns

Butz LE, Owen JW, Knapp J, Snyder MM: Western Carolina University, Cullowhee, NC; Mission Sports Medicine, Asheville, NC; Mountain Area Heath Education Center, Asheville, NC

Background: Disordered eating, depression, and anxiety are reported at an increasing rate in the high school population in the United States. The combination of the three conditions is associated with greater symptom severity, poorer prognosis, and higher burden of illness. Early identification of disordered eating has been suggested to be part of a preparticipation examination as best practice. Researchers have also found that student athletes are at higher risk for developing anxiety and depression. However, most state athletic associations do not require screening for disordered eating, depression, or anxiety. **Patient:** A 15-year-old female varsity cheerleader reported muscle cramps in thighs and lower legs. Initial treatment included ice and stretching. The athletic trainer was concerned about low caloric intake after assessing for the potential cause of her muscle cramps. She reported that she started to develop cramps while exercising at the beginning of the fall

sport season and were persistent during practices and were mainly located in the athlete’s quadriceps and hamstrings. The patient was seen earlier when the cramps started by her primary care provider and blood labs were ordered, which were within normal ranges. Because of the athlete’s extremely low reported food intake and persistent muscle cramps, the athletic trainer referred her to a primary care sports medicine physician for further evaluation. **Intervention & Treatment:** The patient saw the primary care sports medicine physician. Patient reported to the physician that she lost weight since the start of the sport season. Her dietary intake typically consisted of an apple for breakfast, and she skips lunch. The patient typically ate a protein bar or crackers for snack. Dinner usually consisted of rice, meat, and a vegetable. Water is consumed throughout the day, and she felt she is diligent about drinking water to help with muscle cramps. She had recently started to increase her fitness activities to lose weight. The patient also had a history of using sport to affect her body shape and size. During her menstrual cycle she felt a lot of discomfort and wants to eat less during that time. Also noted during her visit, she had two recent family friends pass away. The physician used four questionnaires that helped assess the patient as having generalized disordered eating, depression, and anxiety (see table). The mother was asked to leave the patient room with the primary care sports medicine physician

while screening the patient for abuse, behavioral health, and anxiety (standard protocol). Instead of just leaving the room, the mother became upset and left the facility. **Outcomes or Other Comparisons:** The patient was referred to both a counselor and nutritionist. The family didn’t follow-up with the provider about the referrals. The family felt uncomfortable about the diagnoses and didn’t understand the correlation of disordered eating to her behavioral health nor to muscle cramps. Additionally, the family is on Medicaid, which restricted where they can seek care. The patient had strong feelings against seeking care in the schools because of previous poor interactions with the school-based counselor. The interdisciplinary team continued to support to support the patient as best they could within their roles. **Conclusions:** The patient had many barriers to seeking healthcare, such as Medicaid restrictions on who she can visit, previous bad experiences, and family misperceptions of her conditions. The healthcare team that worked with this patient advocate for similar screenings to be part of the preparticipation examination so that issues can be addressed at the primary level before there are effects on health. This patient could have been treated earlier if her signs and symptoms were recognized at the time of the preparticipation examination. **Clinical Bottom Line:** Screenings for disordered eating, depression, and anxiety should be part of the preparticipation examination.

A Multi-Disciplinary Approach for a Highschool Cheerleader: A Level 3 Case Study on Behavioral Health Concerns

Table. Questionnaires Used to Diagnose Patient		
Questionnaire	Score Interpretation	Patient’s Score
Sport Mental Health Assessment Tool 1 (SMHAT-1)	<16 no further action is needed	19 further assessments are needed
General Anxiety Disorder-7 (GAD-7)	>4 indicated an anxiety disorder	15 (severe anxiety disorder)
Patient Health Questionnaire (PHQ)	>4 indicates depression	15 (moderately severe depression)
Brief Eating Disorder in Athletes Questionnaire (BEDA-Q)	>4 indicates disordered eating	6 (disordered eating)

Scapular Fracture With Suprascapular Nerve Involvement in a Collegiate Football

Smith SJ, Williams JP, Johnson PD:
University of Michigan, Ann Arbor, MI

Background: The objective of this case study is to provide understanding of scapular fracture and potential complication in football. Scapular fractures are relatively rare, accounting for less than 1% of all fractures¹ and 3-5% of fractures that occur in the shoulder girdle.² The mechanism of injury is high impact forces such as those seen in motor vehicle accidents.¹ The suprascapular nerve is susceptible to injury due to its path through the suprascapular and spinoglenoid notches.³ The supraspinatus and infraspinatus muscles are innervated by the suprascapular nerve, which also has sensory branches in the glenohumeral joint and the acromioclavicular joint.³ **Patient:** The patient is a 24 year-old caucasian male defensive lineman in his 5th year of college football participation. He engaged a blocker during spring practice and suffered a high impact, direct blow to his anterior and lateral shoulder. He experienced acute pain and inability to raise his left arm. He had no feeling of instability or dislocation. He reported no neck pain and no numbness or tingling in his arm. Initial differential diagnosis included deltoid contusion, rotator cuff contusion, brachial plexus injury, and glenohumeral joint subluxation. MRI and CT revealed an acute, comminuted scapular fracture extending from the base of the coracoid process through the glenoid neck and scapular spine, down the lateral border. Also noted was an extension of the fracture to the superior-most aspect of the articular surface of the anterior glenoid. The patient's goal was to return to full participation in football. **Intervention & Treatment:** The non-surgical care plan began with a six week period of immobilization in a shoulder sling along with comprehensive treatment and rehabilitation. The patient returned from a 4 week trip at 12 weeks post injury, when

a significant deficit in shoulder external rotation strength was discovered. Suspected etiology of the weakness included muscle atrophy due to the period of inactivity versus nerve injury from the initial trauma. EMG studies showed evidence of suprascapular nerve injury and active, ongoing reinnervation by collateral sprouting in the infraspinatus muscle. In the setting of normal supraspinatus and deltoid function, the injury to the suprascapular nerve was most likely at or distal to the spinoglenoid notch. The rehabilitative plan combined local and global progressive strengthening exercises in both the open and closed kinetic chain. Specific focus was placed on proprioceptive exercises. Electromagnetic and electrical neuromuscular re-education modalities were employed to provide direct stimulus to the suprascapular nerve as part of a holistic treatment and rehabilitative plan. **Outcomes or Other Comparisons:** The acute trauma caused a scapular fracture and secondary injury to the suprascapular nerve resulting in infraspinatus atrophy leading to profound external rotation strength deficit. Hand Held Dynamometry (HHD) strength testing of the infraspinatus muscle (seated, neutral external rotation) improved from 14.6 lbs to 32.9 lbs over the course of his recovery, which was within 3% of the patient's uninvolved limb. The patient completed a successful RTP progression with full return to participation in football activity at 6 months post injury. **Conclusions:** This case proved challenging due to suprascapular nerve involvement during rehabilitation of the shoulder girdle following scapular fracture. Isolating the atrophied infraspinatus with proper exercise technique to minimize compensation and objectively tracking progress was critical to successful outcome. **Clinical Bottom Line:** While this case is rare it confirms the importance of serial evaluation through the rehabilitative process. Using a simple device we were able to collect valid objective data and use it to track progress and help the patient build confidence toward return to full activity.

Non-Contact Avulsion Fracture of the Right Iliac Crest in a Male High School American Football Player

Selcuk BB, Thompson BL, Martinez

RE: Florida International University, Miami, FL

Background: This was a Level 3 case study focused on the diagnosis, treatment, and rehabilitation of a football athlete with non-contact avulsion fracture of the right iliac crest. Avulsion fractures at the pelvis are rare and tend to occur when a tendon contracts suddenly and forcefully removing a part of the bone it is attached to. They are commonly seen affecting the growing apophyses of adolescents, and are often missed on initial evaluation. **Patient:** 16-year-old male varsity high school football defensive lineman endured a non-contact avulsion fracture to the right iliac crest during a scrimmage on 8/13/22. Previous injuries include a blow to the right hip by a helmet and chronic right quadriceps and hip flexor tightness. Upon the evaluation, the athletic trainer noted a non-contact mechanism of injury. The patient planted their right foot and immediately fell to the ground. Upon palpation, no deformities were felt. The pain was greatest over the greater trochanter and iliac crest, rated a 10/10 out of the pain scale. **Intervention & Treatment:** Dorsal pedal pulse was assessed during the initial evaluation; an attempt was made to get the athlete off the field, but collapsed stating they “blacked out” but did not lose consciousness. Dorsal pedal pulse was reassessed with no changes found. The patient was released to the parent and referred to Urgent Care for further examination. No range of motion, gait, strength, or special tests were done due to the discharge of the patient to the parent. The diagnosis made at the time was a

right hip subluxation. The differential diagnosis was a femoral or pelvic fracture to the right side. X-ray confirmed an avulsion fracture of the right iliac crest. No surgical procedures, casting, or splinting was necessary to treat the athlete for their injury. The patient was non-weight bearing with crutches for three weeks. After the three weeks, the patient progressed to weight bearing activities and began rehabilitation at the high school clinic and at an outside physical therapy facility. Both clinics focused on pain-free movements, strengthening, range of motion, and help provide joint capsule stability. The injury was not career or season ending and returned to sport two months later. **Outcomes or Other Comparisons:** In relation to literature, the outcome of this athlete’s injury is as expected. Most athlete’s rehabilitation programs were similar and are able to return within a timely manner to their sport. However, this patient’s mechanism of injury was what made this injury different. Many avulsion fractures come from contact rather than non-contact injuries. The reporting of this case study is important to athletic training because it is important to note how to handle injuries that are rare. **Conclusions:** Patient was able to return to play after 2 months of rehabilitation. Based on the amount of time spent with both the off campus physical therapy facility and the athletic training facility on campus, his return to play was as expected. The patient’s mechanism of injury was a rare case based solely on the fact that he suffered an avulsion fracture without external force applied to the area. **Clinical Bottom Line:** Athletic trainers need to be aware of the various signs and symptoms associated with avulsion fractures to be able to diagnose injuries presented with non-tradition mechanisms.

Free Communications, Poster Presentations: Lateral Ankle Sprains and Chronic Ankle Instability

Saturday, June 24, 2023; authors present 10:20 AM-11:15 AM; Poster Hall

Relationships Between Sensorimotor Function and Vibration Induced Gait Changes in People With Chronic Ankle Instability

Migel KG, Mueller CD, Wikstrom EA:
University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Chronic ankle instability (CAI) is associated with sensorimotor dysfunction (e.g. poor proprioception^{1,2} and postural control²) which may lead to gait changes including increased inversion³ and a lateral center of pressure⁴ (COP) in stance. Gait retraining techniques using vibration feedback can reduce these biomechanical gait alterations following a single training session^{5,6}, however, we do not understand how baseline sensorimotor function influences an individual's susceptibility to the intervention. The purpose of this project is to identify the relationships between baseline sensorimotor function and changes in the COP trace and inversion angle following a single session of gait retraining with vibration feedback in people with CAI. **Methods:** 15 participants with CAI (Age 22.58±4.18 yrs, Height 170±10.63 cm, Mass 72.07±14.78, Foot and Ankle Ability Measure (FAAM) ADL 81.27±8.31% /Sport 64.41±10.12%) Absolute inversion joint position sense (JPS), plantar cutaneous sensation assessed via Semmes-Weinstein monofilaments,

and postural sway (anterior-posterior and medial-lateral COP velocity during single limb stance with eyes open) were obtained. Participants then completed a 10-minute treadmill training session with vibration feedback. COP position and inversion angle change scores were calculated as the difference between posttest and pretest walking mechanics for 10 subphases of stance phase. Spearman's bivariate correlations ($\alpha < 0.05$) with bootstrapped 95% Confidence Intervals (BCa 95% CI) were completed to assess the relationship among sensorimotor and biomechanical outcomes for each subphase.

Results: In phase 4 and 5 there were moderate negative correlations between cutaneous sensation under the 5th metatarsophalangeal joint (MTP) and COP change (Phase 4: $r_s = -0.551$, $p = 0.027$, BCa 95% CI (-0.862, 0.007); Phase 5: $r_s = -0.577$, $p = 0.019$, BCa 95% CI (-0.836, -0.116). In Phase 10 there was a strong negative correlation between absolute JPS and COP change ($r_s = -0.677$, $p = 0.004$, BCa 95% CI (-0.934, -0.215)). Cutaneous sensation at the 1st MTP and postural sway did not correlate with COP change in any stance phase. Ankle inversion position during gait did not correlate with any proprioception measure for any phase of stance. **Conclusions:** In midstance, those with better plantar cutaneous sensation (i.e: smaller Semmes-Weinstein scores) had larger medial shifts in the COP location following gait

retraining. Similarly, participants with less joint repositioning error had larger medial shifts in the COP location at toe off. These results indicate that better sensorimotor function at baseline in people with CAI may be required to utilize vibration feedback to make biomechanical gait changes following gait retraining. Continuing to identify subgroups of people with CAI who may experience greater gains in response to particular treatments allows clinicians to make more informed treatment decisions to personalize care for each patient.

This work was supported in part by a Promotion of Doctoral Studies I Scholarship from the Foundation for Physical Therapy Research.

The Role of Supervised Rehabilitation After a Lateral Ankle Sprain on Recurrent Injury and Physical Activity Levels

Gribble PA, Kosik KB, Ohrnberger E, McCann R: University of Kentucky, Lexington, KY, and Old Dominion University, Norfolk, VA

Context: Following a lateral ankle sprain (LAS), the risk for re-injury remains high and physical activity levels are known to decline, particularly in the first year after injury. Supervised rehabilitation is believed to be a successful protective factor to reduce LAS re-injury and promote a return to regular physical activity. With up to 70% of LAS patients developing chronic ankle instability, it is important to examine if supervised rehabilitation for the acute LAS is effective for reducing LAS re-injury and promoting physical activity. **Methods:** Fifty participants (M:18; F: 32; age: 21.56±9.21yrs; height:171.96±11.93cm; mass:74.82±17.88kg) from the local community who had sustained an acute LAS one week prior to enrolling volunteered for this survey-based study. This analysis was part of a larger study in which these participants completed surveys throughout a 12-month follow-up period. All participants completed a standardized survey when they returned to their pre-injury activity status. This survey asked participants to indicate if they attended supervised rehabilitation with a health care professional such as an athletic trainer or physical therapist. Subsequently, participants were placed into cohorts that did (SUP; n=31) or did not (NoSUP; n=19) participate in

supervised rehabilitation. We examined the distribution of self-reported LAS re-injury at the 12-month follow-up timepoint between both groups using a Chi-Square test. Physical activity was assessed with the Godin Leisure-Time Exercise questionnaire, represented on a scale from 0-infinity. Physical activity was compared between the groups at 3 different follow-ups [return-to-activity (RTA), 6-month and 12-month] using independent t-tests. Alpha levels were set a priori at $p < 0.05$. **Results:** The Chi-Square test identified no significant differences in the distributions of self-reported LAS re-injury at 12-months between SUP and NoSUP ($p=0.30$). However, we noted that 22% of those in SUP reported additional LAS at 12-months, while only 11% of NoSUP reported a LAS at 12-months. Those in SUP had better physical activity than NoSUP at RTA (SUP: 70.73±27.91; NoSUP: 49.61±19.42; $p=0.003$), 6-Months (SUP: 70.91±32.10; NoSUP: 55.95±26.18; $p=0.045$), and 12-Months (SUP: 73.81±27.82; NoSUP: 58.00±25.56; $p=0.025$). **Conclusions:** In this general population sample, SUP for an acute LAS did not significantly impact recurrent LAS rates at a 12-Month follow up; but we did note a slightly higher rate of re-injury in SUP. However, SUP did associate with better levels of self-reported physical activity. It is possible that having SUP promotes better physical activity which could introduce more risk of an additional LAS. We did not collect information regarding the components of the SUP protocols, so it is unknown if the SUP received was perhaps insufficient at impacting recurrent LAS. This work is an important step towards optimizing SUP for acute LAS to reduce recurrence and CAI development.

Static and Dynamic Balance Differ Between Civilians and Service Members with Chronic Ankle Instability

Song K, Green BS, Fraser JJ, Heebner NR, Heimark NE, Kosik KB, Sessoms PH, Silder A, Torp DM, Hoch MC: University of Kentucky Sports Medicine Research Institute, Lexington, KY; Warfighter Performance Department Naval Health Research Center, San Diego, CA; Leidos, Inc, San Diego, CA

Context: Chronic ankle instability (CAI) is a prevalent condition in the military and general population. While CAI is commonly associated with balance deficits, it is unknown if these impairments are similar across military and civilian patients. Examining CAI-associated balance impairments across these groups may enhance our understanding of response patterns to rehabilitation and injury prevention programs. Therefore, the purpose of this study was to compare static and dynamic balance between active-duty service members and civilians with CAI. **Methods:** A total of 17 civilians (10 males, 7 females; 32.2±8.9yrs; 173.8±10.9cm; 83.1±19.2kg) and 15 active-duty service members from the U.S. Marine Corps (14 males, 1 female; 22.9±3.1yrs; 176.7±10.0cm; 86.1±16.1kg) with CAI were included in this analysis. Static balance was assessed from 10-second trials of single leg stance on the CAI limb with eyes open. Time-to-boundary (TTB) minima means (seconds) in the mediolateral (ML) and anteroposterior (AP) directions and center of pressure 95% confidence ellipse area

(COPA) (cm²) were calculated. Averaged scores from three successful trials were used for analysis. Lesser TTB and greater COPA values indicated worse static balance. Dynamic balance was assessed using a hop-to-stabilization task. Participants performed a double-limb forward jump at a distance of 40% of their height over a 30cm hurdle. They were instructed to land on an involved limb, obtain their balance, and remain as still as possible for 3 seconds. Three-axis linear accelerations (m/s²) were recorded during the stabilization phase using an inertial measurement unit placed on the participant's lower back. The root mean square value in each axis was used to calculate the medial/lateral stability index (MLSI), anterior/posterior stability index (APSI), and vertical stability index (VSI) during the stabilization phase. Averaged scores from five successful trials were used for analysis. A greater index indicates less dynamic stability. Separate multivariate and univariate analyses were used to compare static and dynamic balance between groups while controlling for age and sex with an a priori alpha level of 0.05. **Results:** Means, standard deviations, and effect sizes for all variables are reported in the Table. While controlling for sex and age, civilians with CAI showed worse single-limb static balance (i.e. TTBML, TTBAP) compared to service members with CAI (p<0.04). Also, civilians with CAI had lesser APSI (p<0.001) and greater VSI (p=0.01) during the hop-to-stabilization task. **Conclusions:** Overall, civilians with CAI had worse static and dynamic balance abilities compared to active-duty service members with CAI. Also, different strategies during the hop task were used between military and non-military participants with CAI. These

results indicate that the occupational demands of active-duty service members may mitigate CAI-associated balance impairments. Further understanding the impairments in civilian and military populations with CAI may enhance rehabilitation and injury prevention programs in future studies.

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Table. Static and dynamic balance between civilian and active-duty service members subjects with CAI.

	Civilians (n=17)	Service Members (n=15)	P-values	η ² effect sizes
Static Balance				
COPA (cm ²)	12.49±7.60	7.68±3.54	0.09	0.10
TTBML (s)	1.44±0.52	1.83±0.46	0.04	0.14
TTBAP (s)	3.81±1.22	5.14±1.78	0.03	0.16
Dynamic Balance				
MLSI (m/s ²)	2.91±0.75	2.95±0.84	0.98	<0.001
APSI (m/s ²)	2.55±1.06	4.45±1.60	<0.001	0.38
VSI (m/s ²)	10.22±0.60	9.53±0.93	0.01	0.24

Chronic Ankle Instability and Cutaneous Reflex Patterns of the Lateral Gastrocnemius During the Stance Phase of Gait

Friedman AMH, Madsen LP: Indiana University, Bloomington, IN

Context: Individuals with CAI have demonstrated altered sural nerve cutaneous reflexes while walking, including the lack of a protective unloading response in the lateral gastrocnemius (LG) during stance. The purpose of this study was to further explore LG cutaneous reflex modulation in people with CAI by measuring both middle latency (MLR) and long latency (LLR) reflex amplitudes post sural nerve stimulation. **Methods:** Twenty-eight participants (CAI: 19.8±1.6yrs, 65.9±4.1in, 148.2±41.7lbs, Control: 20.4±2.1yrs, 65.7±3.7in, 139.2±20.5lbs) volunteered for the study. Test limb was determined as the most affected limb in CAI subjects via the IdFAI, while controls were matched according to limb dominance. EMG for the LG was measured via surface electrodes. A stimulating bar electrode was used to administer non-noxious stimulations over the ipsilateral sural nerve. Subjects walked on a treadmill at 4km/hr and received random stimulations at 3 phases of stance (10 stimulations per phase). Ensemble averages from the stimulated and unstimulated trials were subtracted, producing a net reflex waveform at each phase. Average reflex amplitudes were calculated post-stimulation at the middle (80-120ms) and long (120-150ms) latencies and normalized as a percentage of each subjects' maximum EMG amplitude during unstimulated trials. **Results:** A three-way mixed ANOVA

revealed a statistically significant three-way interaction between stance phase, latency and group, $F(2,52)=4.624$, $p=.014$, $\eta^2=.151$. There were statistically significant simple two-way interactions between stance phase and latency for both controls, $F(1.366,17.763)=6.920$, $p=.011$, and CAI, $F(2,26)=4.835$, $p=.016$. The simple main effect of stance phase on MLR amplitude was statistically significant for both groups ($p<.05$). Pairwise comparisons found that the control group had significantly different MLR amplitudes at phases 2 ($-7.58\%\pm4.8$) and 3 ($-5.72\%\pm2.6$) compared to phase 1 (7.39 ± 3.1), while the CAI group had significantly different MLR amplitudes between phase 1 ($.945\pm4.263$) and phase 2 ($-22.96\%\pm5.7$). The simple main effect of stance phase on LLR amplitude was only statistically significant for controls, $F(2,26)=4.781$, $p=.017$, indicating that phase has no effect on LLR amplitudes within the CAI group. The control group experienced significantly different LLR between phase 2 ($21.93\%\pm7.1$) and phase 3 ($42.94\%\pm8.1$). **Conclusions:** The MLR for both groups showed LG inhibition during stance which varied by phase, an unloading response expected in controls but contradicts previous CAI literature. Control subjects experienced greater LLR facilitation in the LG when the sural nerve was stimulated later in the stance phase. The CAI group did not demonstrate the same phase dependent LLR modulation but maintained consistent LG facilitation throughout their stance. Since the LLR is likely mediated by supraspinal input from the brain, repetitive ankle sprains may cause a learned motor response that impedes phase dependent modulation of long latency cutaneous reflexes.

Strong Relationships Between Soleus Spinal Reflex Excitability During Standing and Functional Disability Following Acute Lateral Ankle Sprain

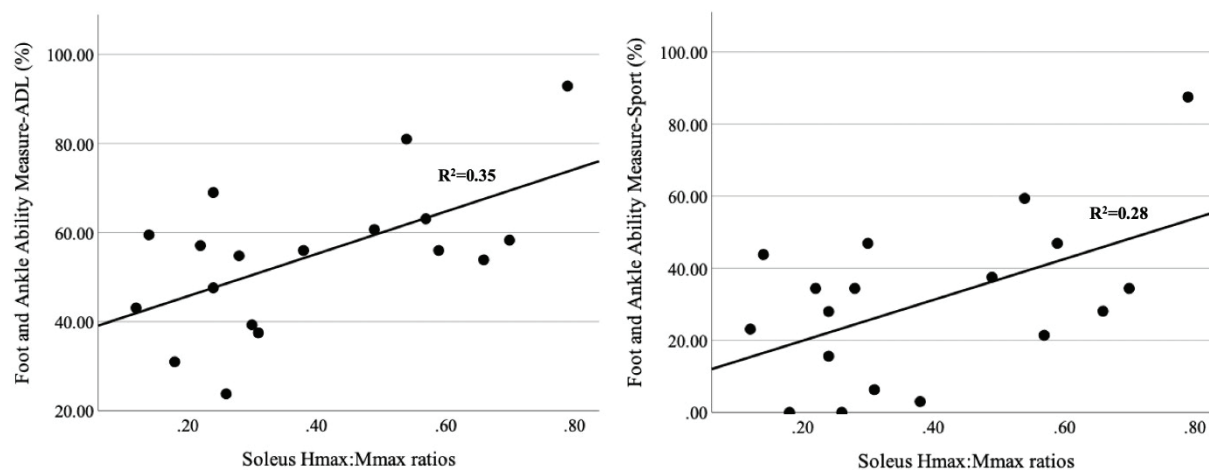
Kim JS, Kim KM: Department of Kinesiology and Sport Sciences, University of Miami, Coral Gables, FL, and Department of Sport Science, Sungkyunkwan University, Suwon-si, Korea

Context: Acute lateral ankle sprain (ALAS) can induce maladaptive neuroplastic changes in spinal reflex pathways affecting postural muscles. Although altered neural excitability in soleus has been shown to contribute to functional disability in patients with chronic ankle instability (CAI), there is a lack of evidence of this potential relationship between soleus spinal reflex excitability and functional disability in patients with ALAS. Moreover, previous findings on spinal reflex excitability following ALAS are limited because the neural excitability was only examined at rest where functional disability cannot be assessed. Therefore, the purpose of this study was to investigate the relationship between soleus spinal reflex excitability during standing and functional disability in patients with ALAS. **Methods:** The current investigation was an observational study. Nineteen patients with ALAS (10 males and 9 females,

21.4±2.7yrs, 173.5±9.1cm, 71.7±11.7kg) participated. Patients with ALAS had an acute injury in the three days (72 h) prior to participation and did not report any other lower extremity injuries other than lateral ankle sprains. Hoffmann reflex (H-reflex) was used to quantify spinal reflex excitability during standing. We measured maximal soleus H-reflex (Hmax) and maximal M-wave (Mmax) to calculate Hmax/Mmax ratios as a study outcome for normalized spinal reflex excitability. We also quantified functional disability with the Foot and Ankle Ability Measure-Activities of Daily Living (FAAM-ADL) and Sport (FAAM-S) scales. Lower percentage scores in FAAM measures indicate a worse functional disability following ALAS. For the statistical analysis, Pearson product-moment correlation tests were performed between the soleus Hmax/Mmax ratios and FAAM measures. The Pearson correlation coefficient (r) was interpreted as follows: < 0.3 as weak, < 0.5 as moderate, and < 1.0 as strong. The alpha level was set a priori at p<0.05. **Results:** There were significant strong positive correlations between the soleus Hmax/Mmax ratios and FAAM measures (FAAM-ADL: r = 0.589, R²=0.35, p = 0.010; FAAM-S: r = 0.525, R²=0.28, p = 0.025). These strong relationships indicate that ALAS patients with a lower soleus spinal reflex excitability would have a greater functional disability during activities of daily living and sports. These results suggest that soleus spinal reflex

excitability could explain 28% of the variance in functional disability perceived during ADL and 35% during sports, shown in Figure 1. **Conclusions:** We found that soleus spinal reflex excitability during standing may play a significant role in functional status following ALAS. These similar findings were also documented in patients with CAI while no prior studies with ALAS observed this relationship when assessed at rest. Our findings suggest that the examination of soleus spinal reflex excitability during natural standing should be considered when determining physical functioning of patients with ALAS.

Figure 1. Soleus Hmax:Mmax ratios positively correlate with both FAAM-ADL and -Sport scores in patients with ALAS.



An External Biofeedback Via a Laser Did Not Improve Dynamic Stability During a Hop-To-Stabilization Task Between Individuals With and Without Chronic Ankle Instability

Torp DM, Song K, Porter KH, Hoch MC: University of Kentucky, Lexington, KY

Context: Individuals with chronic ankle instability (CAI) have altered neuromuscular control strategies when performing functional tasks. There is a need to develop targeted intervention techniques to correct erroneous strategies. A laser device showed promise as a useful biofeedback tool to improve static postural control in individuals with CAI, however its effects during dynamic postural control is unknown. Before making a clinical recommendation for the use of a laser biofeedback device during rehabilitation, its application during a more challenging task should be assessed. The purpose of this study was to determine if an external biofeedback during a hop-to-stabilization task would improve dynamic balance between individuals with and without CAI. **Methods:** Twelve adults with CAI (Females=9; 22.2±4.2years; 172.4±8.9cm; 84.3±23.6kg) and fourteen healthy adults (Females=10; 21.2±4.1years; 168.7±9.3cm; 67.2±9.9kg) volunteered for this

cross-sectional study. In a random order, participants performed a hop-to-stabilization task under two conditions (traditional and external) by a double-limb forward jump from 40% of their height over a 30cm hurdle placed at 20% of their height. They were instructed to land on a involved limb, obtain their balance, and remain as stable as possible for 3 seconds. During the external biofeedback condition, a laser was attached to the ankle of the test limb which projected onto a board 3m away from the landing zone. Participants were instructed to focus on keeping the laser as still as possible upon landing. Three-axis linear acceleration was recorded during the landing and stabilization phase using an inertial measurement unit placed on the participant's lower back. The root mean squared was used to calculate the resultant dynamic postural stability index (DPSI) for linear acceleration (m/s²). Average scores were obtained from 3 successful trials during each condition. Larger indices indicate worse dynamic balance. A group (CAI and Control) by condition (traditional and external) mixed-methods analysis of variance was applied with significance set a priori at p<0.05. Cohens d effect sizes and 95% confidence intervals were calculated. **Results:** Demographics did not differ between group except the CAI group had a larger mass (p=0.02). There was no significant group-by-condition interaction (p=0.704) for DPSI values (m/s²)

during the hop-to-stabilization task. Also, there was no significant group (p=0.074) or condition (p=0.734) main effect. Between-group effect sizes were large with confidence intervals that crossed 0 (Table 1). **Conclusions:** The addition of external biofeedback during a complex hop-to-stabilization task did not significantly improve dynamic stability in either CAI or Controls. An external biofeedback provided by a laser was previously reported to improve static balance strategies, however the hop-to-stabilization task may have been too physically challenging to elicit differences in our sample. Perhaps other forms of external biofeedback or more exposure would improve performance on more complex motor tasks in individuals with CAI.

Table 1. Dynamic Postural Stability Index (mean ± standard deviation) during Traditional and External Biofeedback Hop-To-Stabilization Task in CAI and Control Groups

	CAI (N=12)	Control (N=14)	ANOVA Interaction p-value	Group Effect p-value	Condition Effect p-value	Between-Group Cohens d effect size (95% CI)
Traditional (m/s²)	7.53 ± 2.07	6.54 ± 0.91	0.704	0.074	0.734	0.64 (-0.17, 1.40)
External (m/s²)	7.69 ± 1.72	6.53 ± 1.47				0.73 (-0.09, 1.50)

CAI: chronic ankle instability; ANOVA: analysis of variance; CI: confidence intervals

Associations of Salivary Oxytocin and Immunoglobulin A Levels With Breathing Mechanics in Adolescent Female Athletes With Lateral Ankle Sprain

Terada M, Uchida M, Shimozawa Y, Kurihara T, Sugiyama T, Hori M, Kusagawa Y, Tanaka T, Ueta K, Isaka T: Ritsumeikan University, Shiga, Japan, and Kokushikan University, Setagaya, Japan

Context: The prevalence of dysfunctional breathing mechanics is high among youth adolescent female athletes. Altered breathing mechanics have been linked to lateral ankle sprain (LAS) that is one of the most commonly observed musculoskeletal injuries in adolescent female athletes. Physical and psychological impairments following a LAS contributes significantly to an increase in stress levels. A previous study has documented that breathing mechanics could modulate physiological stress levels in general populations. To date, no research has investigated an influence of breathing mechanics on physiological stress levels in adolescent female athletes with LAS. Therefore, the purpose of this study was to examine physiological stress levels in adolescent female athletes with a history of LAS who have dysfunctional and diaphragmatic breathing patterns. **Methods:** A case-control study design was used for this investigation. Participants were recruited from middle and high schools, and 55 adolescent female athletes, who have a history of LAS, volunteered to complete a single testing session at each school. The biomechanical dimension of breathing patterns was assessed using the Hi-Lo breathing test in the supine position. Observational breathing mechanics was categorized as dysfunctional and diaphragmatic breathing patterns from the Hi-Lo test scores which were determined based on the presence or absence of anterior-posterior abdominal expansion, superior rib cage migration, and shoulder

elevation. To assess physiological stress levels, salivary samples were acquired and analyzed for oxytocin and immunoglobulin A (IgA) concentrations using a commercial enzyme-linked immunosorbent assays kit. Independent t-tests were employed to compare salivary oxytocin and IgA levels between adolescent female athletes with dysfunctional breathing patterns and diaphragmatic breathing patterns. Significance was set at $P < 0.05$. Cohen's d effect sizes using the pooled standard deviations were calculated, along with 95% confidence intervals (CI) for each comparison to determine the magnitude of difference in salivary biomarkers between groups. **Results:** Twenty-two adolescent female athletes with a LAS history were classified as dysfunctional breathers (Age=14.74yrs, Height=157.97 \pm 6.68cm; Mass=51.12 \pm 7.84kg). The diaphragmatic breathing group included 33 athletes with a LAS history (Age=14.75 \pm 1.72yrs, Height=157.14 \pm 5.53cm; Mass=51.00 \pm 8.95kg). The dysfunctional breathing group had significantly higher salivary IgA levels compared to the diaphragmatic breathing group (dysfunctional: 61.79 \pm 46.55ug/ml, diaphragmatic: 38.12 \pm 47.75 ug/ml, $P=0.04$, $d=0.50$, 95%CIs: -0.05, 1.04). Salivary oxytocin levels were lower in the dysfunctional breathing group (29.28.09 \pm 22.71ug/ml) compared to the diaphragmatic breathing group (59.09 \pm 90.23 ug/ml, $d=-0.43$, 95%CIs: -0.99, 0.14) and while the difference approached statistical significance ($P=0.05$), it did not meet our criterion alpha (0.05). **Conclusions:** Dysfunctional breathers with a previous history of LAS had significantly higher physiological stress levels compared to diaphragmatic breathers with a history of LAS. The findings from this study indicate that screening breathing patterns may be an important step towards the development of effective stress management strategies for adolescent female athletes with a LAS history.

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Secondary School Athletic Trainers' Clinical Management Decisions of Low Socioeconomic Status Patients

Hernandez MI, Miller EC, Biese KM, Columna LA, Andreae S, McGuine TA, Snedden TR, Eberman LE, Bell DR: Sam Houston State University, Huntsville, TX; University of Wisconsin-Madison, Madison, WI; University of Wisconsin-Oshkosh, Oshkosh, WI; Indiana State University, Terre Haute, IN

Context: A plethora of information has demonstrated that patient socioeconomic status (SES) and their social determinants of health (SDOH) influence clinical management decisions made by physicians. Secondary school athletic trainers (SSATs) are uniquely positioned health care professionals who provide direct care to low SES patients of various SDOHs. However, there is a significant gap in knowledge regarding how a patients' SES influences SSATs' clinical management decisions. The purpose of this cross-sectional study was to describe SSATs' perceptions of clinical management decisions of their low SES patients. **Methods:** This study was an online cross-sectional survey (Qualtrics®, Provo, UT) distributed by NATA's research service. Five ATs and one youth sport specialty MD completed the content validity index (CVI) process for each survey question (CVI = 0.83 for relevancy). The survey was piloted with two focus groups of currently practicing SSATs. A link to the survey was emailed to 7,177 NATA SSATs and remained open for six weeks with reminder emails sent every two weeks (6.7% response rate). SSATs were asked about their perceptions of clinical management decisions for their low SES patients. Questions were developed to address all five SDOH (health care, economic stability, education, neighborhood and built environment,

and social and community context). Questions were ranked on a 4-point Likert scale on level of relevance ("not relevant," "slightly relevant," "somewhat relevant," "very relevant") and agreement ("strongly disagree," "disagree," "agree," "strongly agree"). Data were summarized by means and standard deviations (SD), frequencies and proportions (%), and median scores, where appropriate. **Results:** A total of 380 SSATs participated (years of experience mean±SD=14.9±11.7). When providing care, 71.3% SSATs believed that their patient's health care opportunities to be somewhat/very relevant of the 5 SDOH. However, patient's economic stability, neighborhood and built environment, and patient/guardian's education, and social and community context were less than 60%. Most SSATs agreed/strongly agreed that patient SES impacts referral for advanced care (67.4%) and reliance on conservative treatment before referral (71.2%). When SSATs were asked if their ATP prepared them on how to provide care to low SES patients, 59.2% strongly disagreed/disagreed. SSATs identified patient/guardian compliance (70.2%), type of health insurance (61.5%), and home support (60.5%) as barriers to providing care to low SES patients. **Conclusions:** SSATs perceived health care opportunities as the most relevant SDOH when providing care to low SES patients. When SSATs further considered the SES of patients, they identified all SDOHs as barriers they were ill equipped to navigate as they delivered care and engaged in patient referral. Knowing SSATs' perceptions on how SES affects clinical management decisions can inform amelioration efforts by highlighting specific challenges to providing high-quality care. Future research can help us understand how this data impacts SDOH management in various settings.

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Secondary School Athletic Trainers' Perceptions of Providing Care to Lesbian, Gay, Bisexual, Transgender, and Queer Patients

Daniels MR, Martin AL, Armstrong KJ: James Madison University, Harrisonburg, VA, and University of Richmond, Richmond, VA

Context: Healthcare disparities, often resulting from stigma, insensitivity, or lack of awareness from healthcare providers of the patient's unique needs, negatively impact LGBTQ+ patients. Secondary school athletic trainers (ATs) have a unique relationship with LGBTQ+ patients, often serving as the primary healthcare providers for these patients during stressful times of mental and physical development. The purpose of this investigation was to explore the perceptions of secondary school ATs approach, quality of care, and comfort in providing patient-centered care to LGBTQ+ patients. **Methods:** We used a cross-sectional survey design including 1,000 secondary school ATs recruited via the NATA. A total of 79 ATs (32 males, 40 females, 3 gender identify not specified; 41.1 + 12.9 years old; 17.8 + 11.6 years certified) completed the electronic survey consisting of 8 demographic questions, 3 questions regarding experiences with LGBTQ+ individuals, 7 questions regarding the approach, quality of care, and comfort providing care to LGBTQ+ patients, and 2

questions regarding formal education in caring for LGBTQ+ patients. Additionally, 3 open-ended questions were included. Cronbach's alpha determined internal consistency, $\alpha = 0.918$. Descriptive statistics were computed for all items. A Kruskal-Wallis determined differences between demographic characteristics and approach, quality of care, and comfort providing care to LGBTQ+ patients. The alpha level was set at .05. An interpretive coding method was used to analyze respondents opened-ended comments. **Results:** Overall, secondary school ATs reported positive perceptions of providing care to LGBTQ+ patients, with most participants (87.3%, $n=62$) having a friend or family who identifies as a member of the LGBTQ+ community and 73.2% ($n=52$) provided care to an LGBTQ+ patient. Only 43 participants (60%) completed formal education regarding LGBTQ+ healthcare. Participants' approach, quality of care, and comfort treating LGBTQ+ patients were not significantly different from the care provided to heterosexual patients. Respondents reported significantly less comfort in helping patients navigate their sexuality ($K=11.430$, $P = 0.010$) and assisting patients to navigate their sexuality regarding sport participation ($K=8.455$, $P = 0.037$). Differences also existed regarding care for transgender patients, specifically noting a difference in approach, less quality of care, and less comfort providing care (Table 1). Respondents' comments indicated a desire to make an inclusive environment for

their patients but feared making mistakes regarding identity or pronoun usage. Comments also acknowledged the different healthcare needs of LGBTQ+ patients; however, a lack of confidence exists regarding individual knowledge about LGBTQ+ patients. **Conclusions:** Despite overall positive perceptions regarding approach, quality of care, and comfort in treating LGBTQ+ patients, secondary school ATs reported less comfort in providing care for transgender patients and helping a patient navigate their sexuality. The need exists for secondary school ATs to participate in formal education on LGBTQ+ healthcare needs, specifically related to the unique healthcare needs of transgender patients.

Table 1. Comparison by Athletic Trainer's Sex & Gender Identity

Statement	Population	Mean ± SD (Range)				P Value
		Males (n=30)	Females (n=34)	Transgender Male (n=1)	Gender Not Identified (n=1)	
Does your approach to providing health care change when providing health care to a student-athlete who identifies as ____? ‡	Lesbian	1.43 ± 0.73	1.50 ± 0.83	1.00 ± 1.00	1.00 ± 1.00	0.823
	Gay	1.47 ± 0.73	1.53 ± 0.86	1.00 ± 0.00	1.00 ± 0.00	0.821
	Bisexual	1.43 ± 0.73	1.53 ± 0.86	1.00 ± 0.00	1.00 ± 0.00	0.813
	Transgender	1.73 ± 1.14	2.06 ± 1.01	1.00 ± 0.00	1.00 ± 0.00	0.317
	Queer	1.50 ± 0.86	1.68 ± 0.91	1.00 ± 1.00	1.00 ± 1.00	0.606
Does the quality of healthcare you provide Differ between student-athletes who identify as ____? ‡	Lesbian	1.13 ± 0.35	1.09 ± 0.38	1.00 ± 0.00	1.00 ± 0.00	0.765
	Gay	1.13 ± 0.35	1.09 ± 0.38	1.00 ± 0.00	1.00 ± 0.00	0.765
	Bisexual	1.13 ± 0.35	1.09 ± 0.38	1.00 ± 0.00	1.00 ± 0.00	0.765
	Transgender	1.17 ± 0.38	1.12 ± 0.41	1.00 ± 0.00	1.00 ± 0.00	0.782
	Queer	1.13 ± 0.35	1.12 ± 0.41	1.00 ± 0.00	1.00 ± 0.00	0.914
How comfortable would you feel providing healthcare to a student-athlete who identifies as the following? †	Lesbian	4.30 ± 1.15	4.85 ± 0.56	5.00 ± 0.00	5.00 ± 0.00	0.130
	Gay	4.30 ± 1.15	4.74 ± 0.86	5.00 ± 0.00	5.00 ± 0.00	0.274
	Bisexual	4.27 ± 1.14	4.74 ± 0.86	5.00 ± 0.00	5.00 ± 0.00	0.178
	Transgender	4.03 ± 1.19	4.56 ± 0.93	5.00 ± 0.00	5.00 ± 0.00	0.180
	Queer	4.23 ± 1.14	4.62 ± 0.89	5.00 ± 0.00	5.00 ± 0.00	0.419
How comfortable would a student-athlete who identifies as ____ feel seeking care from you? †	Lesbian	4.21 ± 0.82	4.65 ± 0.60	5.00 ± 0.00	5.00 ± 0.00	0.088
	Gay	4.24 ± 0.83	4.53 ± 0.86	5.00 ± 0.00	5.00 ± 0.00	0.246
	Bisexual	4.24 ± 0.83	4.50 ± 0.90	5.00 ± 0.00	5.00 ± 0.00	0.288
	Transgender	4.24 ± 0.83	4.38 ± 0.85	5.00 ± 0.00	4.00 ± 0.00	0.580
	Queer	4.24 ± 0.83	4.42 ± 0.87	5.00 ± 0.00	5.00 ± 0.00	0.449
How comfortable would a student-athlete who identifies as ____ feel seeking care from your facility? †	Lesbian	4.14 ± 0.95	4.61 ± 0.56	5.00 ± 0.00	4.00 ± 0.00	0.149
	Gay	4.14 ± 0.95	4.61 ± 0.56	5.00 ± 0.00	4.00 ± 0.00	0.149
	Bisexual	4.21 ± 0.86	4.61 ± 0.56	5.00 ± 0.00	4.00 ± 0.00	0.171
	Transgender	4.07 ± 1.07	4.42 ± 0.83	5.00 ± 0.00	3.00 ± 0.00	0.181
	Queer	4.17 ± 0.89	4.55 ± 0.56	5.00 ± 0.00	4.00 ± 0.00	0.263

Secondary School Athletic Trainers' Practices and Perceptions of Family-Centered Care

Uriegas NA, Torres-McGehee TM, Mensch JM, Montgomery CE, Winkelmann ZK: University of South Carolina, Columbia, SC

Context: Family-centered care (FCC) includes collaboration between families and healthcare providers; creation of flexible policies and procedures; the need for patient and family education; and the family taking an active role in the delivery of care. Secondary school athletic trainers (SSATs) provide care for underage patients in school-based health systems, making them responsible for maintaining communication with parents, guardians, and/or caregivers. However, the concept has not been studied in athletic training. Therefore, the purpose of this study was to examine SSATs practices and perceptions of FCC. **Methods:** This cross-sectional, online survey investigated the extent to which SSATs (n=205) include aspects of FCC in their daily secondary school clinical practice (current practices=CP) and whether they believe that aspect of care is necessary for FCC to be provided in athletic training (perceived necessary=PN)

in their everyday clinical practice. We recruited participants using the NATA's research database for 8 weeks between May-June and September-October 2022 (response rate=6.5%). Participants were mostly 25-34 years old (n=77, 35.2%), women (n=113, 51.6%) working in public secondary schools (n=143, 65.3%). We utilized the 45-item Family-Centered Care Questionnaire-Revised (FCCQ-R; CP: $\alpha=0.945$, PN: $\alpha=0.946$) comprised of 9 subscales including; 1) family is the constant, 2) parent and professional collaboration, 3) recognizing family individuality, 4) sharing information with parents, 5) developmental needs, 6) parent-to-parent support, 7) emotional and financial support, 8) design of healthcare system, and 9) emotional support for staff. Participants indicated on a 5-point Likert scale (1=strongly disagree to 5=strongly agree) their practice and perception of each item. Means were calculated for the 2 scales and 9 subscales. Data were analyzed using paired samples t-tests to explore differences between the CP and PN scales. **Results:** Mean scores and paired samples t-test on the practice and perception scales of FCC are presented in the Table 1. The total mean score for the CP scale (mean=26.83 \pm 4.36) was significantly lower ($p\leq 0.01$) than the PN scale (mean=35.33 \pm 4.17). The subscale parent-to-parent support had both

the most practiced (mean=3.93 \pm 0.85) and highest perceived need (mean=4.61 \pm 0.73). In addition, the developmental needs subscale had both the lowest score for CP (mean=2.62 \pm 0.79) and was considered by SSATs as the least necessary element of FCC (mean=3.23 \pm 0.76). All FCC subscales compared between CP and PN were significantly different ($p\leq 0.01$) with each being higher importance than CP in athletic training

Conclusions: SSATs reported performing all FCC aspects significantly less in their CP than they PN. SSATs felt they helped keep the child in touch with their family, accurately described the healthcare experience, and maintained familiar routines. Attention should be placed on developing resources and interventions for SSATs to collaboratively work with children and their support system through parent support groups, extended family programming, and creating an area in the ATF for the family.

Table 1: Differences between athletic trainers' practices and perceptions of FCC

Subscales	Scales		t-statistic	p-value
	Practices (Current)	Perceptions (Necessary)		
Family is the constant	3.76 (0.61)	3.92 (0.58)	-5.11	< .01
Parent & professional collaboration	3.06 (0.53)	3.40 (0.56)	-10.50	< .01
Recognizing family individuality	3.87 (0.66)	4.26 (0.52)	-11.65	< .01
Sharing information with parents	3.73 (0.66)	4.26 (0.50)	-13.21	< .01
Developmental needs	2.62 (0.79)	3.23 (0.76)	-13.77	< .01
Parent-to-parent support	3.93 (0.85)	4.61 (0.73)	-13.83	< .01
Emotional & financial support for families	3.75 (0.68)	4.09 (0.62)	-9.50	< .01
Design of health care system	3.04 (0.71)	3.79 (0.62)	-16.72	< .01
Emotional support for staff	3.01 (0.76)	3.84 (0.64)	-15.89	< .01
Total Scale	26.83 (4.36)	35.33 (4.17)	-28.90	< .01

A Qualitative Study of the Psychosocial Experiences of Collegiate Athletic Trainers During the COVID-19 Pandemic

Post EG, Abdenour TE, Eason CM, Root HJ, DiSanti JS: Indiana State University, Terre Haute, IN; San Diego State University, San Diego, CA; Korey Stringer Institute, University of Connecticut, Storrs, CT; Northern Arizona University, Phoenix, AZ; Duquesne University, Pittsburgh, PA

Context: As college athletics' governing bodies grappled with decisions related to resuming sports amidst the COVID-19 pandemic, it was critical to enact policies to promote safe sport participation. Athletic trainers (ATs) employed in the collegiate setting played a vital role in developing policies and guiding the safe resumption of sport during the pandemic. While previous research examined the impact of the pandemic on the physical and mental health of student-athletes, less is known about the pandemic's impact on the psychosocial health of athletic trainers, who faced a unique set of challenges to their mental and social well-being. Therefore, the purpose of this study was to examine the psychosocial lived experiences of ATs as they practiced during the COVID-19 pandemic. **Methods:** Following a qualitative study design, semi-structured interviews were conducted with 38 ATs employed in the NCAA collegiate setting, all of whom were involved in the creation and implementation of COVID-19 return-to-sport policies at their institution. Participants were recruited via purposeful and snowball sampling procedures. All interviews were video recorded and transcribed by Zoom, and interviews lasted approximately 45-60 minutes.

Data analysis followed an exploratory inductive analysis approach to identify emerging themes. Field notes, multiple-analyst triangulation, and intercoder reliability were utilized to help establish trustworthiness. **Results:** Three themes emerged from our data: 1) internal psychosocial experiences, 2) inter-personal factors, and 3) identity. Under the theme of "internal psychosocial experiences", athletic trainers reported experiencing burnout due to excessive work hours and lack of time away from work, as well as a feeling of pressure to rise to the challenge of protecting the health of student-athletes during the pandemic. Participants reported challenges navigating the uncertainty of making decisions and recommendations while evidence regarding COVID-19 constantly changed. Within this theme, participants emphasized the importance of self-care and managing their mental health, by directly seeking resources, assistance, or counseling. Under "inter-personal factors", ATs reported a collective level of stress among their colleagues and patients. Additionally, the lack of social engagement opportunities with family or friends due to the pandemic limited the ability of our participants to "de-stress" outside of work. These challenges resulted in many of the participants indicating that their awareness of the importance of strong social support increased as a result of the pandemic. The final theme of "identity" focused on participants' perceptions of their value, tasks, and role as an AT, as well as their identity outside of the work setting. A common report was the feeling that the novel demands of the pandemic stretched their job responsibilities beyond what they typically were responsible for as an AT. Participants reported having to "wear a lot of hats" and develop public-health skills that they were previously not trained for. This included translating and

disseminating policies and guidelines to campus stakeholders and student-athletes, as well as enforcing COVID-19 protocols, or as multiple participants called it, being "the COVID Cop". Finally, participants reported struggling to maintain any semblance of work/life balance, due to non-stop job demands and new information related to COVID-19. **Conclusions:** Our results indicate that collegiate athletic trainers experienced a great deal of psychosocial stress, both professionally and personally, as a result of the COVID-19 pandemic. Since psychosocial stress is linked with job attrition and poorer patient care, it is important to consider the potential implications of the COVID-19 pandemic for the profession of athletic training, regardless of job setting. The themes identified in this study can serve as a starting point for developing strategies and resources for enhancing athletic trainer psychosocial health and for ensuring the health of the athletic training profession.

Cultural Competence of Athletic Trainers in the Delivery of Healthcare

Mussa JS, Barrett JL, Mullin EM, Simon M: Springfield College, Springfield, MA

Context: Cultural competency in athletic training is demonstrated by understanding and incorporating cultural differences into daily care, and working efficiently in cross-cultural situations. A majority of Athletic Training professionals identify as white, while national demographic statistics and athletic populations are trending more racially and ethnically diverse. Given the differences in demographics, there is a high chance an athletic trainer will need to work in cross-cultural situations and demonstrate culturally competent care. Yet, little is known about the ability of athletic trainers to provide culturally competent care. We aimed to evaluate levels of cultural competence of practicing athletic trainers. **Methods:** A descriptive survey, the Cultural Competence Assessment tool, was used to assess cultural competence. Gender identity, race/ethnicity, years of experience and organizational support were also explored. Participants included members in good standing with the National Athletic Trainers Association (NATA). Data were collected via online questionnaire. 10,000 emails were sent; 771 participants responded (7.71%). After data cleaning, 565 fully completed responses were analyzed. The participants were 62.1% (n = 351) males, 35.2% (n = 199) females, and 2.7% (n = 15) identified as other. 78.2% (n = 442) of participants identified as white, and 21.8% (n = 123) identified as BIPOC. 45.8% (n = 259) reported being a newly credentialed athletic trainer (0-5 years) and 54.2% (n = 306)

identified as experienced (6+ years). Just over half, 52.2% (n = 295) of participants reported receiving organizational support related to providing culturally competent care, while 47.8% (n = 270) reported the opposite. **Results:** Mean cultural competence scores for the overall sample were 95.01+13.4. Females reported higher mean cultural competence scores (97.22+12.2) than males (91.77+14.1, $p < .001$). Participants who identified as white reported lower mean cultural competence scores (94.67+13.4) than BIPOC participants (96.29+13.2), though not significantly ($p = .235$). Newly credentialed athletic trainers reported significantly higher mean cultural competence scores (96.58+11.7) than experienced athletic trainers (93.70+14.6, $p = .009$). Lastly, participants who reported having organizational support had significantly higher mean cultural competence scores (97.14+12.9) than those who reported not having support (92.71+13.6, $p < .001$). **Conclusions:** Groups of athletic trainers that would specifically benefit from cultural competence training include people who identify as white, males, and those with 6+ years of experience. Cultural competence educational initiatives should be incorporated into athletic training curricula and in continuing education courses to reach all groups of athletic trainers. Further, organizations should supply cultural competence resources. The most common and helpful resource participants reported was having continuing educational courses provided by their employers. This may be particularly beneficial if the courses target the populations typically seen by their employees.

Springfield College Graduate Student Research Fund

The Allocation of Workload Among Athletic Training Faculty
Del Rossi G: Creighton University,
Phoenix, AZ

Context: The objectives of this survey study were to evaluate the percentage of total work time that current athletic training faculty dedicate to their assigned academic responsibilities, and to assess how various factors impact the proportional allocation of those duties. **Methods:** An online survey was used to collect data related to the workload assignment of athletic training faculty. The survey consisted of questions designed to gather demographic and institutional information, details related to academic appointment, and workload data. To determine construct and content validity, the survey was sent to 5 established athletic training faculty who provided feedback related to content and delivery. Study participants were recruited with assistance from the National Athletic Trainers' Association (NATA), which distributed the survey to those employed as university or collegiate faculty members. Data collection occurred over a six-week period with reminder emails sent at various intervals. The survey instrument was sent to a total of 716 faculty members. Although 223 recipients responded to the invitation to participate, only 179 participants completed the survey in its entirety, which resulted in a 25.0% return rate. Along with descriptive statistics, analyses of variance and Welch's tests were used to determine if academic rank, tenure status and institutional Carnegie Classification (i.e., independent variables) were

associated with the quantity of time dedicated to each of their assigned responsibilities which could have included teaching, research/scholarship, service, administrative duties, and clinical practice (i.e., dependent variables). Significant results were further evaluated using Games-Howell and Bonferroni post hoc tests. **Results:** On average, athletic training faculty spend approximately 52.0% of their time on teaching and teaching-related duties, 19% on research and scholarship, 13% on service, 2% on clinical responsibilities, and 14% on administrative obligations. The proportion of time faculty spent on teaching was significantly impacted by their institutional Carnegie Classification ($F_{4,173} = 7.641, P < .001$), academic rank ($F_{2,171} = 2.632, P = .025$) and tenure status ($F_{3,174} = 3.546, P = .016$). Time allocated to research/scholarship was impacted by Carnegie Classification ($F_{4,57} = 20.417, P < .001$) and tenure status ($F_{3,49} = 7.694, P < .001$). Finally, time dedicated to service was significantly impacted by Carnegie Classification ($F_{4,51} = 4.235, P = .005$), whereas time spent on administrative duties was influenced by tenure status ($F_{3,41} = 3.941, P = .015$). **Conclusions:** The present study revealed that, in general, athletic training faculty spend most of their time performing teaching duties, followed by research commitments and administrative responsibilities. Also, the way athletic training faculty members allocate their time, particularly the time they dedicate to teaching and teaching-related duties, appears to be impacted by institutional (Carnegie Classification) and demographic factors (faculty rank and tenure status).

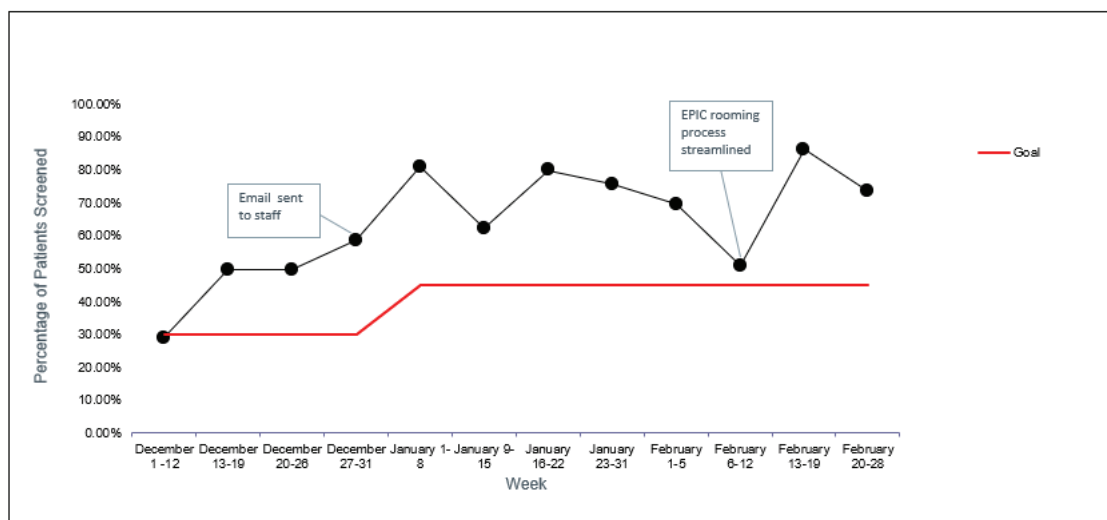
Implementation of a Social Determinants of Health Screening Tool into Rural Family Medical Clinics Freiburger RL, Picha KJ, Snyder Valier AR: A.T. Still University, Mesa, AZ

Context: Evaluation of social determinants of health (SDH) is becoming a standard element of care because of their impact on the health of patients and populations. While a SDH screening tool was available in EPIC, the hospital's electronic medical record system, there was no universal process to routinely screen patients for SDH and this feature was not used by healthcare providers. Therefore, the specific aim of this quality improvement (QI) project was to increase SDH screening during patient family medical clinic visits from 0% to 30% by March 2022. **Methods:** The Model for Improvement guided this QI project. A multi-professional QI team, consisting of an athletic trainer, provider representative, nurse representative, quality improvement administrator, and clinic manager led the SDH screening initiative within a rural hospital system that consisted of 5 family medical clinics, with 9 healthcare providers. The team evaluated the local healthcare system using a Fishbone diagram and process maps to identify reasons for the quality issue and opportunities for improvement, respectively. Two opportunities to increase SDH screening were

identified related to 1) staff awareness of the screening tool and knowledge of SDH impact on patient health and 2) current rooming processes. Implementation occurred over 12 weeks and included 3 Plan-Do-Study-Act (PDSA) cycles. In the "planning" phase of this project, there was a brief 45-minute educational session developed and delivered to nursing staff and family medical clinic providers that highlighted the new SDH screening process and provided background information on SDH. The "do" phase of this project, was administering the SDH tool during the rooming process of physicals, six-month follow-up, and one year follow up visits by nurses and certified medical assistants. The "study" phase of this project measured success by calculating the administration (yes) or lack of administration (no) of the SDH screening tool during visits and is presented as a percentage (total number of patients visits with screens divided by total number of eligible patient visits). The "act" phase of this project, was to repeat the PDSA cycle while adding adjustments, such as increasing our goal percentage based on success, email reminders to prompt providers, and an updated rooming process within the EPIC system. Each PDSA cycle was run for 1 month and focused on screening at physicals, six-month follow-ups, and one-year follow-ups. **Results:** Screening exceeded the 30% goal over the 12-week QI project (Figure 1). The first PDSA cycle resulted in 39.3% (309

/ 787) of patients screened for SDH. Following this cycle, the project goal was increased to 45% and email reminders were sent to prompt providers to screen for SDH. The second PDSA cycle resulted in 73.4% (455 / 620) of patients screened for SDH, an improvement of over 30%. After the second PDSA cycle, EPIC's rooming process was streamlined for efficiency, so that all screening tools, except the SDH screen were moved into their own activity tab; however, the SDH screening tool remained within the rooming tab. The third PDSA cycle resulted in 68.4% (299 / 437) of patients screened for SDH. **Conclusions:** A 12-week QI initiative to increase awareness and screening of SDH, through education and a technology change, produced an over 65% improvement and reflects hundreds of patients being screened for these factors. Administering SDH screening tools, such as the one used in this QI project, will give providers the opportunity to become aware of and the ability to address the SDH impacting their patients. Creating a culture that invested the staff and healthcare providers in the QI project was critical to success. Institutions with an interest in better addressing the SDH in their patients may find benefit from using a similar process.

Figure 1: Percentage of Patients Screened for Social Determinants of Health by Week



Athletic Trainers' Varying Levels of Awareness and Use of Disablement Model Frameworks

Haffey RT, Rivera MJ, Young JP, Winkelmann ZK, Eberman LE:
Indiana State University, Terre Haute, IN, and University of South Carolina, Columbia, SC

Context: The use of disablement model frameworks provide a whole-person approach to health care. In athletic health care, disablement model frameworks can improve the delivery of patient-centered care through the recognition of patient factors beyond impairments, restrictions, and limitations, which include personal, environmental, and societal factors. Current literature provides data regarding the components and benefits of disablement model frameworks; however, there is no literature investigating the lived experiences of athletic trainers (ATs) integrating such frameworks into clinical practice. The purpose of this study was to investigate ATs' recognition and use of disablement frameworks in current clinical practice. **Methods:** We used a phenomenological approach to investigate the research question with 13 practicing ATs (age=36+ / -12y, women=8, men=5, years of experience=11+ / -11y). Criterion sampling was used where participants who identified as currently practicing from the NATA were recruited. Recruitment and data collection were continued until data saturation was achieved. Participants engaged in an online, audio-only semi-structured interview (Zoom, San Jose,

CA) that was audio-recorded and transcribed verbatim. A consensual qualitative research (CQR) approach was used to analyze the data. A data analysis team of three individuals used a multi-phase process to construct a consensus codebook that identified common domains and categories among the participants' responses. Frequency counts were calculated for each domain and category based on participant responses as: general (n=11-13), typical (n=6-10), or variant (n=2-5). Trustworthiness and credibility were established by member checking, multi-analyst triangulation, and auditing. **Results:** Four domains emerged regarding ATs' experiences and recognition of disablement model frameworks (Table 1). The first three domains were related to the application of disablement model frameworks: 1) patient-centered care, 2) limitations and impairments, and 3) environment and support. Participants described varying degrees of consciousness regarding these domains including: expressed desire, conscious competence, conscious incompetence, and unconscious incompetence. Expressed desire included when participants spoke about a desire for integrating the components of a disablement model framework into their practice. For instance, nearly all participants described wanting to be more patient-centered in their approach to care. Conscious competence was demonstrated when participants accurately acknowledged or implemented a domain related to disablement model framework use. For example, many participants shared how they integrate the patients' limitations and impairments into their decision-making. Participants displayed conscious

incompetence when they actively acknowledged they did not know or did not actively use the domain. Participants commonly acknowledged they do not rely upon such disablement model frameworks. Unconscious incompetence was demonstrated where participants expressed they knew about or implement a component of the disablement models but were not accurately applying the concepts. For example, most participants did not appropriately identify environmental and support factors when considering integral aspects of patient-centered care. Exposure, the fourth domain, included how participants were introduced to disablement model frameworks, which was primarily through informal or self-directed education. Less than half of the participants received formal education on disablement model frameworks, while the remaining participants acknowledged they informally sought out available evidence on frameworks. **Conclusions:** Disablement model frameworks provide ATs a comprehensive approach to improving the delivery of patient-centered care. Findings suggest ATs largely demonstrate unconscious incompetence regarding the use of disablement frameworks in clinical practice. Due to the comprehensive nature of disablement model frameworks and usefulness in clinical practice, increased awareness of such frameworks should be integrated. Moreover, implementation research regarding the effective application of disablement model frameworks is needed to better understand how and why these frameworks have not been implemented in athletic training.

Table 1. Codebook Frequency Counts

Domain, Sub-Domain, Category	Frequency (N = 13)	Commonality
<i>Patient-Centered Care</i>		
Expressed Desire	84% (n = 11)	General
Conscious Competence	84% (n = 11)	General
Conscious Incompetence	38% (n = 5)	Variant
Unconscious Incompetence	69% (n = 9)	Typical
<i>Limitations and Impairments</i>		
Expressed Desire	15% (n = 2)	Variant
Conscious Competence	77% (n = 10)	Typical
Conscious Incompetence	0% (n = 0)	None
Unconscious Incompetence	31% (n=4)	Variant
<i>Environment and Support</i>		
Expressed Desire	38% (n = 5)	Variant
Conscious Competence	77% (n = 10)	Typical
Conscious Incompetence	31% (n = 4)	Variant
Unconscious Incompetence	54% (n = 7)	Typical
<i>Exposure</i>		
Formal	38% (n = 5)	Variant
Informal	54% (n = 7)	Typical

Police Officers' Perceptions of Athletic Trainers and Athletic Training Services

Gaudette R, Burnstein B, Ostrowski JL: Moravian University, Bethlehem, PA, and Kitman Labs, Dublin, Ireland

Context: Athletic trainers (AT) are unique healthcare providers skilled in injury prevention, first aid, emergency care, evaluation, and treatment. While athletic trainers are often found on the sidelines of athletic events, public safety is emerging as a growing field. Police officers work in physically demanding environments with required protective equipment and high work demands, placing them at heightened risk for musculoskeletal injury and soft tissue pain. The implementation of AT services within this demographic can positively impact injury prevention and workers' compensation costs, and improve the operational efficiency within police departments. The purpose of this study was to investigate police officers' perceptions of athletic trainers and athletic training services. Questions referenced perceptions on injuries, healthcare options, and experiences with ATs.

Methods: This was a qualitative study using a phenomenological approach. Individual interviews were conducted over Zoom using a semi-structured interview guide that included open ended questions modeled after the Practice Analysis and consisted of ten questions. Active police officers in the United States were recruited through convenience sampling, criterion sampling, and snowballing. Subjects included four male and three female officers from Florida and Las Vegas (mean age 35 +/- 9 years) with various levels of job experience. Participants were included with or without prior experience with an AT and included police officer first class, detective, and deputy. Exclusion criteria included inactive officers, police academy trainees, departments already employing an AT, and anyone currently out of work due to injury or on workers' compensation. Interviews were

recorded via Zoom with audio only and transcribed verbatim by the lead researcher. Data saturation was determined by a new information threshold set at 0-5% and was reached after the seventh interview. Transcriptions were analyzed using a general inductive content analysis with researchers first individually coding interview answers before discussing together and formulating themes based on the agreed-upon codes. To ensure trustworthiness, both research independently coded interview questions before reviewing together utilizing multiple-analyst triangulation. Once codes were agreed upon, a peer reviewer was used to ensure the codes were unbiased. **Results:** Four main themes emerged: misconception of the AT profession; specialization of education and skills; providing value; and injury response. Police officers who had previous experience with ATs had better understanding of the services they provide, while those without experience often compared ATs to personal trainers. Police officers with and without previous experience recognized ATs' specialized scope of practice and educational requirements. All participants viewed ATs as healthcare providers. Participants expressed the normality of dealing with pain and described physical, mental, and emotional components to dealing with injury. Due to the familiarity of working with pain, police officers expressed the value of having an AT in-house to evaluate and treat injuries, especially when considering the lengthy workers' compensation process. **Conclusions:** With heightened risk of injury while on duty, ATs can be used for injury prevention, evaluation, and management. Agencies should be educated on how AT skills and services can be used to both prevent and manage work-related injuries. Athletic training programs should consider specialized education and clinical experiences to prepare athletic trainers to work with the public safety population. Implementation of an in-house AT may result in reduced injury rate, injury cost, workers' compensation costs, and time loss due to injury.

**Examining the Level of Emergency
Preparedness in South Carolina
Middle School Athletics**

O'Mara C, Yeargin S, Mensch J,
Hirschhorn R, Wham G: University
of South Carolina, Columbia, SC

Context: The National Athletic Trainers' Association (NATA) has best practice recommendations for emergency action plans (EAP), yet the presence of EAPs in United States schools is inconsistent. Previous research addresses the high school level, but there has been no study of care provided to middle school athletics. **Methods:** The Middle School Appropriate Medical Care Survey was used to assess emergency preparedness based on the NATA Position Statement on Emergency Planning in Athletics. Items assessed potential influences on the presence and contents of an EAP. Presence of and number of athletic trainers served as explanatory variables. **Main Outcome Measures:** The score from the survey provided a quantitative measure of emergency preparedness and served as the response variable. The score was determined based on the responses to the items relating to the NATA Position Statement recommendations. Participants were categorized based on their level of emergency preparedness into high, intermediate, and low. **Results:** The survey yielded 59 responses. Most participants (56%) reported the presence of an AT at their middle school(s). An EAP was reported in 52.5% of responses, yet only 20.3% of responses were categorized into the high EPI index. Only 1 respondent reported the adoption of all 14 recommendations. Our findings reveal relationships between the presence of an AT and the level of emergency preparedness, as well as the number of athletic trainers and the level of emergency preparedness. **Conclusions:** : Most EAPs had less than 5 recommendations such as rehearsal, distribution, and postage. With participation in sport increasing, there is a heightened demand for AT services. Although high school athletics tend to be more established, this should not exclude middle school athletes from participating safely. These results support the need for improved EAP compliance in middle school athletics.

Integration of Patient-Centered Care and the Biopsychosocial Model by Athletic Trainers in the Secondary School Setting

Mendoza AM, Drescher MJ, Eberman LE: Indiana State University, Terre Haute, IN

Context: Patient-centered care (PCC) has become a fundamental component of health care, defined as delivering care that is respectful of and responsive to patient preferences, needs, and values. Taking on a biopsychosocial (BPS) approach to healthcare enables athletic trainers, specifically in the secondary school setting, to provide whole person health care aiming to address the complex and all-encompassing nature of patient needs in this population. The purpose of our study was to explore the degree to which secondary school athletic trainers (SSATs) perceive they are integrating the principles of PCC and the BPS model in their practice. **Methods:** We used a cross-sectional design to explore if secondary school athletic trainers were integrating the principles of PCC and the BPS model in their practice. A web-based survey, comprised of demographic questions, the Global Perceptions of Athletic Trainer Patient-Centered Care tool (GPATPCC), and the Biopsychosocial Model of Health (BPSMH) tool was sent to 5,665 SSATs through the NATA. The GPATPCC tool (previously validated) contains 14 items measured on a 4-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree, with an unscored “unsure” option). The BPSMH tool (Content Validity Index Score = 1.0) contains 3

questions measured on the same 4-point Likert scale as the GPATPCC. SSATs ($n = 422$) accessed the survey (access rate = 7.4%) and 404 participants responded (response rate = 7.1%) (age = 37.81 ± 12.59 [range = 22-73 years], years clinically practicing = 13.51 ± 11.51 [range = 1-49 years], years employed in current position = 8.15 ± 8.945 [range = 0-40 years]) and completed the instrument (96% completion rate). Descriptive statistics were used to characterize the data. **Results:** Results indicated that participants expressed strong agreement (mode = 4) with 7 of the 14 statements and agreement (mode = 3) with the remaining 7 statements of the GPATPCC tool (grand mean = 3.35 ± 0.80) (Table 1). However, on average, the two lowest ranked statements addressed the athletic trainer’s ability to recognize any conflict of interest that could adversely affect the patient’s health (mean = 2.95 ± 1.19) and address the patient’s access to care including transportation, ease of scheduling, and accessibility to specialist referral (mean = 2.82 ± 1.11). Overall participants rated their level of agreement on the BPSMH as agree for each item (grand mean = 3.04 ± 1.04). **Conclusions:** SSATs perceive they are integrating the principles of PCC and the BPS model in clinical practice. These findings align with two previous studies that concluded collegiate student-athletes and parents of minor student-athletes perceive athletic trainers provide PCC. These collective findings support the conclusion that patients, parents, and providers believe athletic trainers are providing care that is patient-centered and focused on whole-person healthcare.

Analysis of Athletic Trainers Employed by NCAA Division I Institutions by Number of Varsity Teams and Conference Affiliation

Marcelino M, Grace A, Stearns RL, Eason CM, Casa DJ: Korey Stringer Institute, Department of Kinesiology, University of Connecticut, Storrs, CT

Context: National Collegiate Athletic Association (NCAA) Division I institutions are recommended to employ certified athletic trainers (ATs) based on the number of athletic teams and athletes at the institution. While institutions have a large range for the number of teams and number of ATs employed, it is unknown if recommended medical staffing ratios are being met. The purpose of this study was to examine the mean ratio for the number of varsity teams per AT for 1) all Division I schools, and 2) for each NCAA Division I conference. **Methods:** The NCAA Division I Membership Directory is a publicly available database which was used to determine the number of institutions, the members of each conference, and provided links to athletic websites of each institution which determined number of ATs employed and number of existing varsity sports teams. The mean and standard deviation of the number of ATs employed per school, mean number of ATs per school within a conference, and the ratio of the mean number of teams worked per employed AT in a conference were calculated. Results for AT employment and teams were rounded to whole numbers so that data are presented as

the mean \pm SD. **Results:** All Division I institutions, except three, ($n=360$), were included in the calculations. Reasons for removal was either due to being “independent” for most varsity sports teams or for unverifiable employment of ATs. The mean number of ATs employed at any Division I school is 10 ± 5 and the mean number of varsity teams is 17 ± 4 which provides a mean overall ratio of 2 teams per AT throughout Division I schools. When split by conference affiliation, the highest ratio is 5 teams per AT in the Southwestern Athletic Conference. The lowest ratio is 1 team per AT in the Southeastern Conference. The mean ratio for the number of teams worked per AT in a conference is shown in Figure 1. **Conclusions:** Conferences have a variety of ratios of mean number of teams worked per AT. It appears that there are more ATs employed at Power-5 conferences (ratio of 1.1 teams per AT) than non Power-5 conferences (ratio of 2.0 teams per AT) which could support the thought that Power-5 conferences have more resources than others. Institutions should use the Recommendations and Guidelines for Appropriate Medical Coverage of Intercollegiate Athletics (AMCIA) created by the National Athletic Training Association to help ensure the standard of medical staffing ratios for the number of teams worked per AT is being met. The guidelines use a variety of metrics to decide what the standard would be for a university and further research into other metrics, such as the number of athletes per AT, could help clarify why there are inconsistencies between conferences.

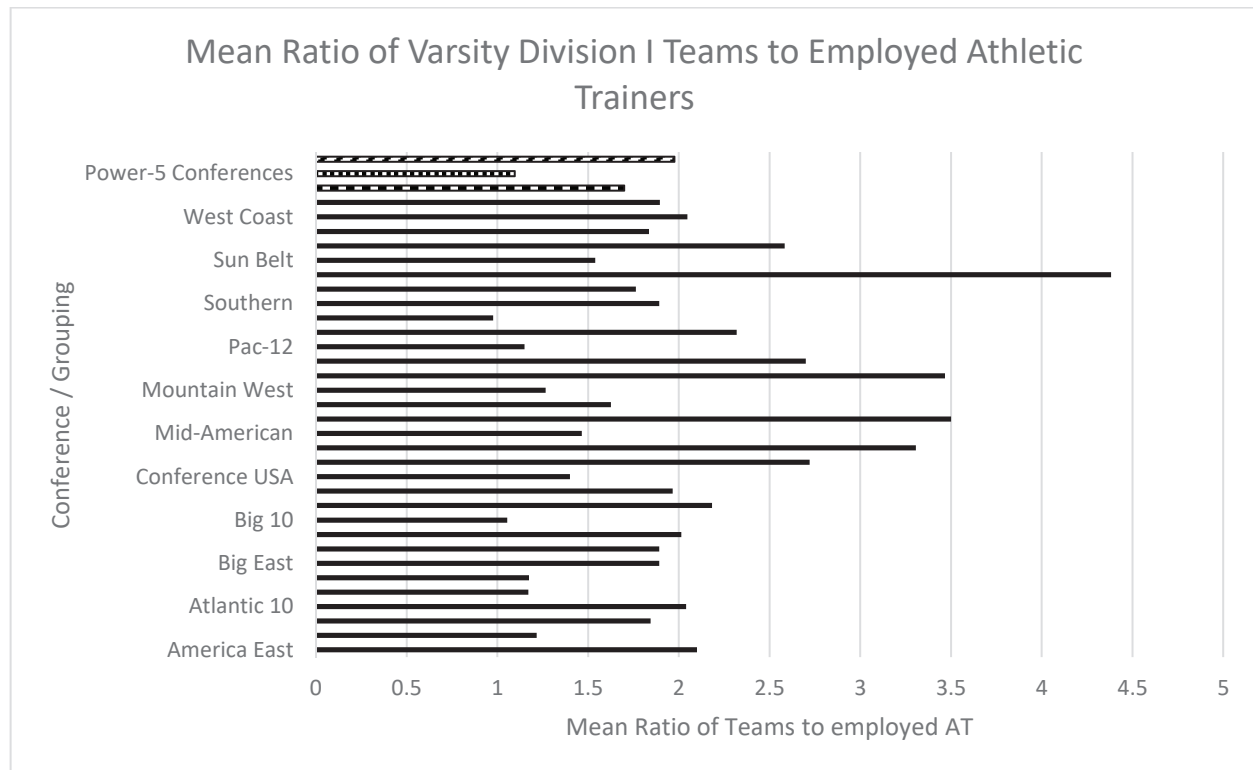


Figure 1. Mean number of teams worked per athletic trainer (AT) in a conference. “Power-5 Conferences” are the Atlantic Coast Conference, Big 12, Big 10, Pac-12, and Southeastern Conference. “Non Power-5 Conferences” are all of the others. “All of DI” includes all of the institutions not separated by conference affiliation.

National Sanctioning of Athletic Training Credentials by the Board of Certification

Pataky BE, Yeargin SW, Winkelmann ZK, Eason CM, McCullough GA, Scarneo-Miller SE: West Virginia University, Morgantown, WV; University of South Carolina, Columbia, SC; Korey Stringer Institute, University of Connecticut, Storrs, CT

Context: Standards of competence and professional development through continuing education units (CEUs). Research has identified that athletic trainers (ATs) are often hesitant to perform best practices due to fear of performing a skill that may result in legal action and sanctions. As ATs must be in good standing with the BOC to practice in most states, the purpose of this research was to investigate the national sanctioning of ATs credentials by the BOC. **Methods:** In this study, the disciplinary actions involving ATs were analyzed using deductive content analysis. The BOC Disciplinary Action Exchange (DAE) provides public information that has been finalized by the BOC to assure the protection of the public. Using the information from the BOC DAE website, a predetermined variable list was used to recognize common variables which included: action(s) taken, committee providing action, charge (e.g., reason for action), explanation (e.g., additional detail for the reason for the charge), and outcome (e.g., BOC credential retention). All cases posted to the DAE through September 2022 (n=365; n=3 removed for insufficient information, n=24 removed as duplicates) were analyzed by two research assistants

independently. During the content analysis, 20 cases were reviewed by both research assistants who then met to review their findings and identify a consensus on the common variables. The remaining n=338 cases were divided equally between researchers. Statistical analysis included proportions (%) calculated for the common variables. **Results:** Actions were taken either by the BOC (84.0%, n=284/338) or by a state credentialing committee (16.0%, n=54/338; Ohio=5.9% n=20/338, Pennsylvania=4.4%, n=15/338). A majority of the charges against ATs included continuing education unit (CEU) audits (n=67.8%, n=229/338, Table 1). The most common action taken by the BOC or other committees was a suspension (65.1%, n=220/338). A majority of ATs were revoked of their BOC credential (73.7%, n=249/338), with 73.5% (n=183/249) of these due to CEU infractions. The ATs who did not lose their BOC credential (17.9%, n=65/363), were investigated for CEU audits (51.7%, n=46/89), violated a professional responsibility (40.4%, n=36/89), or were charged with a crime (6.7%, n=6/89). **Conclusions:** Findings from this investigation describe CEU audits as the most common charge against ATs in the evaluation of maintaining the BOC credential. As the profession of athletic training continues to advance and to ensure the highest quality of services rendered, a call to action is needed to identify the barriers for ATs to maintain the BOC credential. Specifically, identifying strategies to increase CEU availability may decrease AT sanctioning. ATs concerns with legal implications resulting in sanctioning of BOC credentials due to performing best practices appear to be unfounded from these data.

Table 1. Description of the BOC DAE charges, actions and loss of certification.

Variable	n (%)	Charge explained	n (%)
Continuing Education Units	229 (67.7)	2015/2016 -2019/2020	146 (63.7)
		2009/2010- 2014/2015	78 (34.1)
		2020/2021 - September 2022	3 (1.3)
		Undefined year	2 (0.9)
Criminal	55 (16.3)	Sexual Misconduct with a minor	28 (50.9)
		Other	11 (19.8)
		Sexual misconduct	7 (12.7)
		Drug/alcohol related	4 (7.5)
		Improper relationship	3 (5.5)
		Civil penalty fee	2 (3.6)
Professional Responsibility	53 (15.7)	Failure to be Licensed	31 (58.3)
		Other	8 (15.2)
		Violated professional ethics code, Unknown	6 (11.4)
		Knowledge and professional competence	4 (7.5)
		Failure to complete physical/mental exam	2 (3.8)
Unknown	1 (0.3)	Failure to be Certified	2 (3.8)
Action		Suspension	220 (65.1)
		Censure	45 (13.3)
		Other	36 (10.7)
		Suspension - Reinstated	24 (7.1)
		Voluntary Surrender	13 (3.8)
Outcome		Loss of Certification	249 (73.7)
		Did not lose Certification	89 (26.3)

Job Resignations During the COVID-19 Pandemic Among NCAA Collegiate Athletic Trainers

Rynkiewicz KM, Singe SM: Springfield College, Springfield, MA, and University of Connecticut, Storrs, CT

Context: The COVID-19 pandemic has had a significant impact on the way individuals work and live, including negative effects on health-care providers because of increased working demands. The purpose of our study was to explore how the COVID-19 pandemic impacted athletic trainers during the 2020-21 academic year. Specifically, due to a high percentage of job transitions that occurred among our initial participant pool, we sought to identify what factors led athletic trainers to resign from their positions. **Methods:** This study was a qualitative, longitudinal study and was part of a larger, mixed-methods research project. This study followed a descriptive phenomenological approach. Athletic trainers working clinically in the NCAA Division I, II, and III settings were recruited to participate. Purposeful sampling procedures were used to recruit participants from a variety of backgrounds (i.e., NCAA Division, relationship status, and family status). Twenty-eight athletic trainers initially participated. Of those 28, 8 participants (29%) left their jobs and transitioned to new positions and were thereby included in this study. The 8 participants (male=3, female=5) were on average 29 ± 3 years old, were certified as athletic trainers for 8 ± 4 years, and had various work

(DI=3, DII=4, DIII=1) and family demographics (single=3, married=2, married with children=3). A semi-structured interview guide was developed and reviewed by members of the research team. The interview questions were then evaluated by three peer reviewers for relevance and clarity. Participants were interviewed in the Fall of 2020 and again in the Spring/Summer of 2021. Data from the second interview from the 8 participants who resigned from their jobs were included in the analyses. All interviews were conducted over the phone by the lead author and were recorded. During the interviews, the researcher took field notes to summarize information. Interviews lasted from 30 minutes to an hour on average. After all interviews were completed, the interviews were transcribed verbatim by a professional transcription agency. Participants' anonymity was maintained, and no identifying information was retained in the final transcripts that were analyzed. Multiple strategies were used to establish credibility including member checks and multiple analyst triangulation. Participants were sent their de-identified transcript to confirm the accuracy and interpretation of their interview responses. Using a phenomenological framework, the authors coded the data independently and came to an agreement upon emergent themes. **Results:** Poor mental health, lack of work-life balance, and a lack of support were identified as the emergent themes of the data. These factors contributed to the job resignations of our 8 participants. Poor mental health was defined as diagnosed and undiagnosed mental health disorders and challenges (e.g., anxiety, burnout, depression) that

lead to an overall negative sense of well-being. Lack of work-life balance was categorized as an imbalance between home and life roles which caused strain on individuals' various demands and responsibilities of their personal and professional lives. Lack of support was described as the absence of assistance in the workplace to help individuals fully participate in their work roles. **Conclusions:** We captured a unique time and situation during the COVID-19 pandemic in which our participants transitioned to new positions during the data collection period. The results highlight the factors that affect job transition and can help the athletic training profession better understand how to retain athletic trainers in the field and in the collegiate setting. Participants who resigned from their positions reported experiencing burnout, among other mental health challenges, during the COVID-19 pandemic which demonstrates the continued impact of burnout in the profession. Overall, this study further highlights the importance of work-life balance, support, and prioritization as a means to increase retention in the athletic training field.

Impact of Socioeconomic Status on Athletic Trainer Services in The Mid-America Athletic Trainers' Association

Olson MB, Huggins RA, Yoshihara A, Casa DJ: Korey Stringer Institute, Department of Kinesiology, University of Connecticut, Storrs, CT

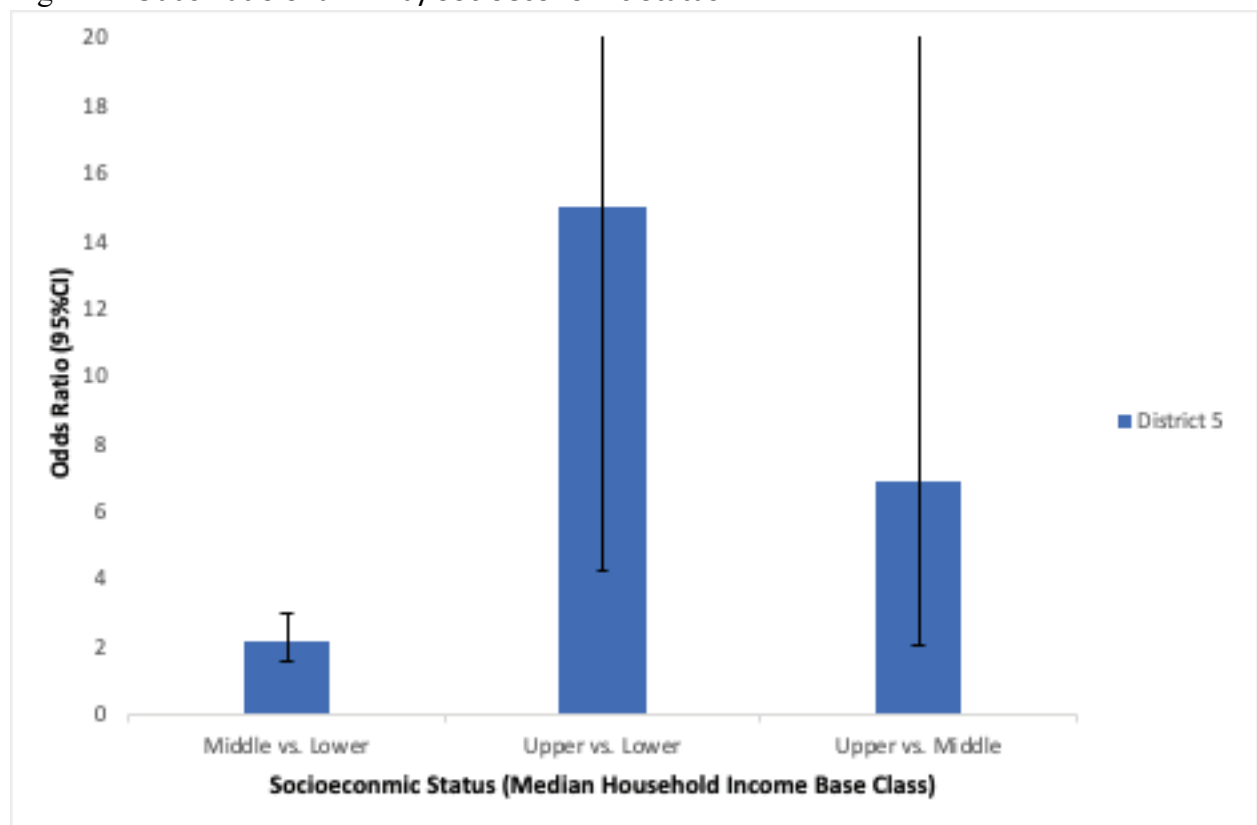
Context: Previous research has demonstrated the economic impact and savings that athletic training (AT) services provide to school districts, military service members, and individual families. A significant trend was previously established that the likelihood of AT services was based upon socioeconomic status (SES) status. These findings suggest that region-specific analyses are warranted. Therefore, the purpose of this study was to examine the odds of a secondary school (SS) having AT services based on SES within the Mid-American Athletic Training Association (MAATA). **Methods:** AT employment data and the zip codes in the following states (IA, KS, MO, ND, NE, SD, OK) were extracted from the Athletic Training Locations and Services (ATLAS) database. SSs with unknown AT services were excluded and the survey responses from June 2018 to April

2021 were included in the analyses. Median income (MI) for households was extracted from the US Census database. MI of each SS was identified based on the zip code. SSs were categorized into 3 classes based on the state's MI: lower class (LOW) = <67%, middle class (MID) = 67-200%, and upper class (HIGH) = >200%. Separate 2x2 chi-square analyses (χ^2), odds ratios (ORs), and prevalence ratios (PRs) with 95% confidence intervals (CI) were calculated to determine the relationship between SES and access to an AT. Significance levels were set at $p < 0.05$ a-priori. **Results:** Of all SSs in the MAATA region with athletics programs (100%; $n=2206$), 49% ($n=1088$) had access to an AT while 51% ($n=1118$) did not. The frequency distribution of SSs by SES were: HIGH (1.08%, $n=24$), MID (91%, $n=2006$), and LOW (7.9%; $n=176$). Findings indicate, see Figure 1, that HIGH SES schools had greater odds of having an AT, compared to LOW SES schools (OR=15.00; [CI: 4.29-52.38]; $\chi^2=27.65$; $P < 0.001$) and MID SES schools (OR=6.89; [CI: 2.05-23.17]; $\chi^2=13.06$; $P < 0.001$). Similarly, MID SES schools had at greater odds of having an AT than LOW SES (OR=2.18 [CI: 1.57-3.03]; $\chi^2= 22.35$; $P < 0.001$). The proportion of schools with an AT was more prevalent in the

HIGH SES schools, compared to both MID (PR=1.02, [CI: 1.01-1.03]) and LOW (PR=1.34, [CI: 1.17-1.54]) schools. **Conclusions:** Over 50% of SSs did not have access to an AT in the MAATA. Our finding highlighted that SES is one of the major factors limiting access to an AT. Given the economic impact and cost-effectiveness provided by Athletic Training, schools with a lower SES should be targeted to provide care to the athletes without AT services. Strategic placement of services has the potential cost savings to both school districts and families and to improve emergency response and overall care, especially in the rural SSs in the MAATA.

The Korey Stringer Institute is a non-profit organization within the Department of Kinesiology at the University of Connecticut. Corporate partners of KSI include the National Football League, Gatorade, the National Athletic Trainers' Association, Nielsen-Kellerman, CamelBak, Defib Tech, and First Line Technology. This original research abstract utilizes data from the Athletic Training and Locations Services (ATLAS) Project, which is co-owned by the NATA and KSI.

Figure 1. Odds Ratio of an AT by Socioeconomic Status



Free Communications, Poster Presentations: Professional Development

Saturday, June 24, 2023; authors present 11:45 AM-12:40 PM; Poster Hall

Perceptions of Cognitive Overload During Athletic Training Students' First Interaction With a Standardized Patient

Armstrong KJ, Austin J, Taylor Remsburg K: James Madison University, Harrisonburg, VA; Rocky Mountain University of Health Professions, Provo, UT; Franklin College, Franklin, IN

Context: The use of simulation-based learning, including standardized patients, has increased in athletic training education. Simulations provide a safe environment for learning, allowing students to practice patient care skills in a context that mimics clinical practice. The first encounter with a standardized patient is overwhelming. Previous researchers reported a high degree of cognitive overload and stress during these initial interactions with standardized patients. Cognitive overload impairs learning, as memory capacity for new information has been surpassed. The simulated learning environment is complex, with novel skills being completed simultaneously. Thus, a high cognitive load must be recognized and managed for students to transfer learning to the patient care environment successfully. No research exists within athletic training examining the impact of cognitive overload in students during standardized patient encounters. Therefore, this investigation aimed to understand students' perceptions of cognitive load and stress during their first standardized patient encounter. **Methods:** We used a phenomenological qualitative design to understand participant's perceptions of cognitive overload while completing a non-orthopedic standardized patient evaluation. Following a semi-structured guide, two focus groups were conducted with 13 professional master's students (7 females, 6 males; 23.38±1.3 years old) to understand perceptions of cognitive load. Both focus groups were completed via videoconferencing 24 hours after completing their first standardized patient

encounter. Focus group sessions were transcribed, de-identified, and checked for accuracy. Data collection occurred until data saturation. Researchers independently coded and analyzed the data using a multi-pass approach to identify significant statements, code the statements, and group them into themes. Trustworthiness was established through member checks and peer review. **Results:** Overall, participants perceived the interaction as a positive learning experience despite the high levels of cognitive overload experienced. To reduce cognitive overload, participants recommended portraying a standardized patient for another student would be beneficial before examining a patient. Participants expressed that portraying a standardized patient would provide knowledge of what to expect during the encounter, decreasing overall cognitive overload. Two themes emerged, benefits and challenges of simulated learning. The theme benefits included comments regarding how the standardized patient encounter positively impacted learning. Researchers noted three sub-themes: realism, the importance of clear communication, and transfer to patient care. The sub-theme of realism stressed how the authenticity of the standardized patient encounter allowed students to engage as though they were evaluating an actual patient. The sub-theme importance of clear communication included comments emphasizing the need for clear and concise non-medical language when communicating with a patient. The sub-theme transfer to patient care included comments regarding how lessons learned from the encounter will transfer directly to patient care. The theme challenges included comments related to difficulties experienced during the encounter. Researchers noted three sub-themes: feeling overwhelmed, difficulty identifying positive physical findings, and the need for more resources. The sub-theme of feeling overwhelmed included comments about cognitive overload, unclear expectations during the encounter, and uncertainty in responding/reacting to the patient. The sub-theme on difficulty

identifying positive physical findings included comments regarding the difficulty in finding positive findings in a patient when they do not exist. The sub-theme need for more resources included comments emphasizing the need for more information and preparation prior to the standardized patient encounter. **Conclusions:** Cognitive overload can negatively impact student performance during simulated learning. As implementation of standardized patients continues within athletic training education, faculty need to understand how cognitive overload and stress negatively impact student experiences during these encounters. Great care must be taken before engagement in simulation-based learning to ensure students are adequately prepared for what to expect within the simulated learning environment. Clear instructions and expectations from faculty will minimize cognitive overload and stress.

Athletic Training Students' Mental Health Recognition and Referral Skills: A Sequential, Explanatory Mixed-Methods Study

Anderson AS, Armstrong KJ, Kinslow BL, Pitney WA: Rocky Mountain University, Provo, UT; North Park University, Chicago, IL; James Madison University, Harrisonburg, VA; University of Wisconsin-Stevens Point, Stevens Point, WI; Northern Illinois University, DeKalb, IL

Context: Increased prevalence of mental health conditions has exposed gaps in the educational preparation of athletic training students. Identifying effective pedagogical strategies to increase knowledge and confidence in the recognition and referral of mental health conditions is imperative. A standardized curriculum, such as Mental Health First Aid (MHFA) training, is promising, as is the use of standardized patient (SP) encounters and case-based learning (CBL); however, there is a lack of evidence to determine best practice for achieving these learning goals. The purpose of this study was to examine the effect of MHFA training on students' knowledge and confidence and compare the use of CBL and SP encounters following MHFA training. Further, we sought to explore students' perceptions of the CBL and SP encounters. **Methods:** This study used a sequential, explanatory, mixed-methods design with 2 phases: 1) randomized control trial with pre-test, post-test design, and 2) individual interviews. The study was set in an online learning environment using Zoom™. A convenience sample of 70 students (25 male, 44 female, 1 nonbinary; age 23.38±2.27 years) from graduate-level CAATE-accredited professional athletic training programs (representing 6 NATA districts) participated in this study. All participants completed MHFA training followed by no intervention (control), an SP encounter, or CBL activity completed after 3 to 4 weeks. A validated (face

and content validity) electronic knowledge assessment and self-reported confidence scale measured knowledge and confidence with mental health recognition and referral at the study's commencement and after intervention. A mixed-model ANOVA with an a priori level set a $p<.05$ was used to analyze differences between groups. Analyses were conducted with Intellectus Statistics (Intellectus Statistics, Version 1.01, 2019). Twenty-two participants (11 from each intervention group; 45.5% male, 54.5% female; age 24.59±2.3 years) were interviewed. Interviews were recorded using Zoom™ and then transcribed. The Qualitative Analysis Guide of Leuven (QUAGOL) method was used to identify emergent themes. Strategies to enhance trustworthiness included an audit trail, member checks, and peer debriefing. **Results:** A mixed-model ANOVA showed significant improvement between pre-test and post-test scores for knowledge and confidence. (Knowledge - $F(1,67) = 70.31, p<0.001$. Confidence - $F(1,67) = 206.41, p<0.001$.) This result was similar among all 3 groups. No significant change in knowledge or confidence was found between the control, SP and CBL groups. Five higher order themes emerged from the interview data: 1) perceived value of MHFA training, 2) engaged learning and facilitated feedback, 3) capability, 4) comfort/confidence, and 5) authentic experience. These were organized into 3 overarching dimensions: knowledge, skills, and pedagogy. Participants described how the opportunity to apply their knowledge and practice their skills with an athletic training specific scenario helped them feel more equipped for future patient care. In line with the significant difference in knowledge and confidence scores following the training, students perceived MHFA training as a beneficial method to acquire knowledge as it provided a valuable strategy for approaching mental health challenges and distinguishing crises from noncrises. Simulation activities (SP and CBL) were perceived to increase students' capability, comfort and confidence in mental health recognition and referral. Engaged

learning via peer interactions and facilitated feedback through real-time debriefing were key facilitators of student learning in these simulated activities. **Conclusions:** To meet the 2020 CAATE Standards for behavioral and mental health content, programs should incorporate MHFA training to improve student content knowledge and confidence in skills. While this study showed no numerical difference between the groups, the opportunity to practice via simulation with CBL or SP influenced participants' knowledge and feelings of confidence and capability. To better prepare students for clinical practice, MHFA training should be followed by athletic training specific simulated encounters.

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Athletic Trainers' Perceptions of Different Continuing Education Formats for Learning Clinical Documentation

Nottingham SL, Kasamatsu TM, Cavallario JM, Welch Bacon CE: University of New Mexico, Albuquerque, NM; California State University Fullerton, Fullerton, CA; Old Dominion University, Norfolk, VA; A.T. Still University, Mesa, AZ

Context: Previous research has identified that athletic trainers (ATs) from nearly all clinical settings and backgrounds have expressed a strong desire for continuing education (CE) opportunities specific to clinical documentation. CE can be delivered in various formats, and it is important to identify the most effective formats for delivering CE. In an earlier stage of this study, we developed and validated two web-based CE educational resources specific to clinical documentation: 1) an active learning resource, Personalized Learning Pathway (PLP), and 2) passive learning resources (PAS) (Figure 1). Participants were randomly assigned to one of the educational resource modules. This second stage of the study aimed to explore participants' perceptions of their experiences completing the documentation educational resources.

Methods: We used a Consensual Qualitative Research (CQR) approach within a sequential mixed-methods design to explore participants' perceptions of their experiences completing web-based CE modules specific to clinical documentation. Using purposeful criterion sampling,

we recruited participants from a group of 83 clinically practicing ATs who completed a web-based CE module during a previous stage of this study. Twenty-nine individuals participated, including 15 from the PLP group and 14 from the PAS learning group, including 16 women and 13 men, averaging 36.89 ± 10.49 years of age, representing 23 U.S. states and seven different clinical practice settings. Participants were interviewed via Zoom using semi-structured interview guides developed and validated by four experts in qualitative research and piloted with two individuals. Interview guides focused on participants' experiences learning about clinical documentation, thoughts about the educational resources provided, knowledge and confidence with documentation concepts, and suggestions for improving the resources provided. Data saturation guided the number of participants. Zoom-transcribed audio files were deidentified and reviewed by a research assistant for accuracy before analysis. Data were analyzed using the CQR approach. The primary research team of 3 individuals inductively analyzed interviews and developed and refined the codebook throughout four rounds of coding and consensus meetings before review by an external auditor. Trustworthiness was implemented throughout the research process, using a peer reviewer, external auditor, multiple-analyst triangulation, and source triangulation. **Results:** Three themes emerged from the data, including benefits of the educational resources, structure of the educational modules, and barriers to reviewing the educational resources. Participants of both groups described several benefits of reviewing

the educational resources, including improved knowledge and confidence, intention for changing behavior, and general satisfaction with the materials provided. Regarding the structure of the educational modules, PLP participants enjoyed the variety of resources and ease of completing the modules and thought the PLP was a great format for CE. Conversely, participants in the PAS group noted both pros and cons of the structure of their resources. Positively, they thought the content was valuable, and they liked the ability to download the materials for later use. Critically, many in the PAS learning group found challenges with a lack of variety of resources and the density of the materials. Both groups had similar barriers to reviewing the educational resources, primarily the time required to complete them, while some participants experienced technology challenges. **Conclusions:** Our findings confirm that ATs desired educational resources related to clinical documentation, and participants were satisfied with both types of learning experiences. Although participants of the PAS group found the information valuable, many struggled with the volume of documents and only having one type of resource to review. In contrast, PLP participants praised the variety of learning resources and engaging nature of the PLP and desired more CE to be formatted in this way. Educators, future researchers, and developers of CE should consider using the PLP format when developing future CE courses.

Funded by NATA Foundation Grant #2021GGP02.

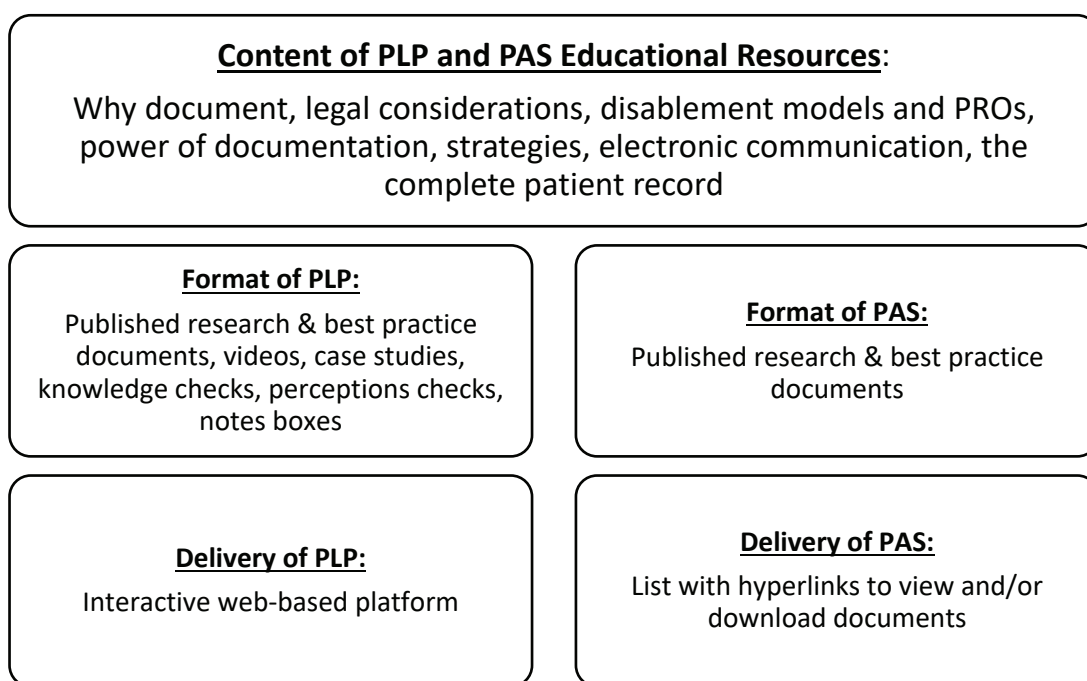


Figure 1. Overview of Educational Resources

Effectiveness of a Personalized Online Learning Experience to Improve Knowledge of Clinical Documentation

Kasamatsu TM, Welch Bacon CE, Bay RC, Nottingham SL: California State University Fullerton, Fullerton, CA; A.T. Still University, Mesa, AZ; University of New Mexico, Albuquerque, NM

Context: Professional development activities to address athletic trainers' (ATs) desire to improve their knowledge of clinical documentation are sparse. Therefore, we investigated the effectiveness of a personalized online learning experience versus passive learning method to improve ATs' knowledge of clinical documentation.

Methods: We used a sequential exploratory mixed-methods design and a previously published randomized control trial protocol to evaluate the effectiveness of an educational intervention. Following comprehensive development of documentation resources, all materials for this study were validated via a rigorous process by 3 content experts and then pilot-tested with 20 ATs. To recruit participants, we emailed 18,981 practicing ATs across multiple settings and provided the scope of the study and a hyperlink to enroll. Interested participants provided consent (n=524), were randomly enrolled into a group [online personalized learning pathway (PLP=178), passive online reading list (PAS=176), control (CON=170)], took the pre-knowledge assessment, completed the intervention, and took the post-assessment (Figure). There were 160 ATs (age = 37.6±11.2y; years certified = 13.9±10.7y; education = 29 bachelor's, 119 master's, 8 clinical doctorate, 3 academic doctorate, 1 professional degree) who completed all phases of the study (PLP=39,

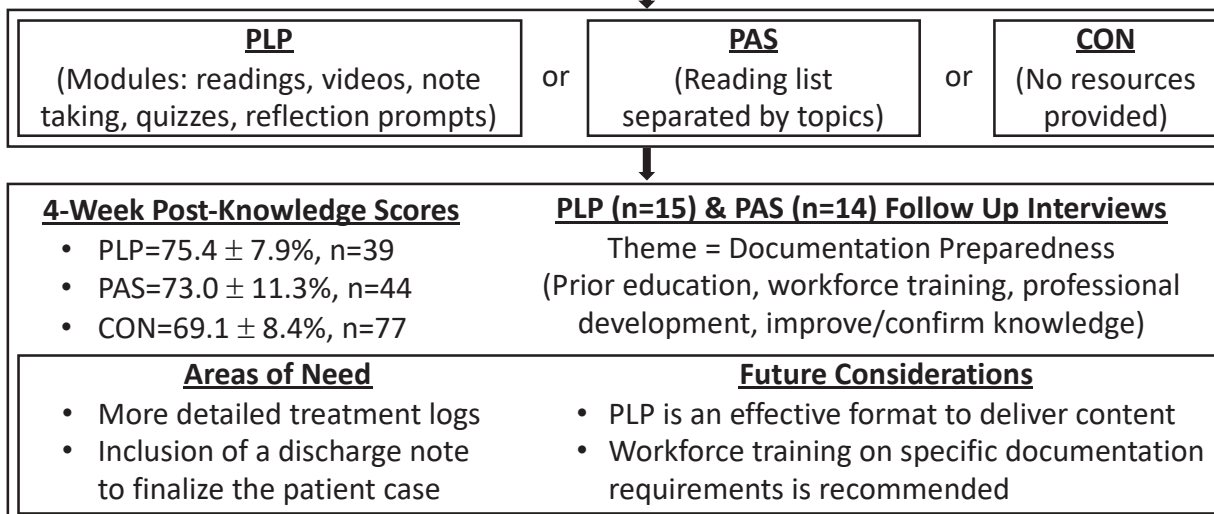
PAS=44, CON=77). Groups did not significantly differ in age, years certified, gender, race / ethnicity, employment setting, or documentation approach. Independent variables included group (PLP, PAS, CON) and time (pre-test, post-test). Knowledge scores (dependent variable) were calculated by summing the correct answers (1 point each, maximum 34 points), and mean changes between pre- and post-assessments were identified. A 2X2 repeated-measures analysis of variances ($P \leq .05$) and post hoc Tukey HSD were used to evaluate between-group and within-group differences. After completion of the intervention, one researcher conducted 29 semi-structured individual interviews (PLP=15, PAS=14), which were recorded and transcribed verbatim. Interview guides were developed based on the literature, validated by 4 qualitative researchers, and piloted with 2 practicing ATs. The consensual qualitative research tradition guided the analysis. The primary research team (n=3) coded 3 transcripts individually, met to discuss codes and develop a codebook, completed 3 additional rounds of coding using a rotating auditor approach, and determined data saturation had been obtained. An external auditor reviewed the coding scheme and resolved discrepancies among primary research team codes. Trustworthiness was established from incorporation of expert reviews, member checking, multi-researcher analysis, and triangulation of qualitative and quantitative data. **Results:** Upon study enrollment, ATs agreed they were comfortable ($M=4.2/5.0 \pm 0.6$) and competent ($M=4.0/5.0 \pm 0.7$) regarding their knowledge of clinical documentation. No differences were observed between-groups in the pre-knowledge assessment. We observed a group x time interaction ($F(2,157)=15.30$,

$P < .001$; partial eta-squared=0.16) for pre-post knowledge scores. PLP had greater mean change pre-post knowledge scores ($M=3.0 \pm 2.7$) than PAS ($M=1.7 \pm 3.0$, $P=.049$) and CON ($M=0.4 \pm 2.2$, $P < .001$). PLP scored higher on the post-knowledge assessment ($M=25.6/34.0 \pm 2.8$) than PAS ($M=24.8/34.0 \pm 3.9$) and CON ($M=23.5/34.0 \pm 2.8$). Descriptively, more PLP correctly answered items regarding necessary details to include in treatment logs (100%, n=39/39) and writing a discharge note at the completion of the patient's care (94.9%, n=37/39) than PAS (86.4%, n=38/44; 93.2%, n=41/44) and CON (83.1%, n=64/77; 75.3%, n=58/77), respectively. Follow-up interviews revealed that most ATs obtained essential knowledge about documentation during their professional or post-professional education, identified how workforce training on documentation requirements were helpful, had rarely participated in professional development on documentation previously, and found the educational resources useful in improving or confirming their knowledge of documentation. **Conclusions:** The PLP and PAS groups improved their knowledge and confidence after the educational intervention on clinical documentation; however, the PLP group exhibited greater increases in knowledge compared to PAS and CON groups. Targeted professional development for ATs is still needed to ensure completion of high-quality documentation. The PLP format should be considered to deliver future professional development.

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Pre-Knowledge Assessment Scores

- PLP=66.6 ± 8.1%, n=178
- PAS=68.1 ± 9.9%, n=176
- CON=68.3 ± 8.4%, n=170



Comparison of Immersive and Non-Immersive Clinical Experiences in Preparing Athletic Training Students for Autonomous Clinical Practice: A Longitudinal, Time-Diary Study

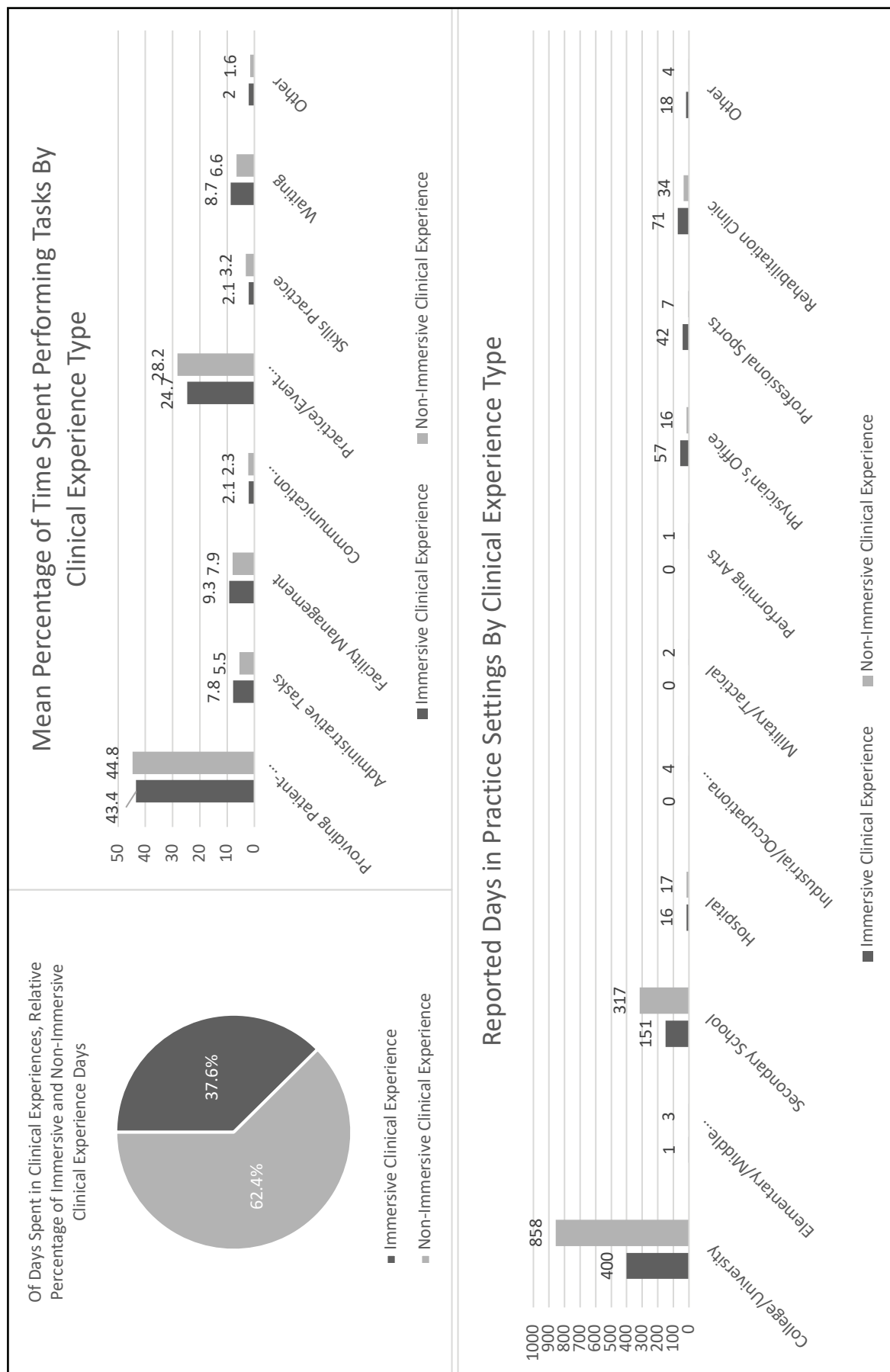
Cavallario JM, Pribesh SL, Walker SE: Old Dominion University, Norfolk, VA, and Ball State University, Muncie, IN

Context: One identified reason to move professional athletic training education to the graduate level was to allow for increased use of immersive clinical experiences (ICE) to promote patient care and administrative opportunities for students outside of standard afternoon clinical education times. The purpose of this study was to determine if athletic training ICEs and Non-ICEs differ in terms of time spent at clinical as well as time spent performing patient care or other professional tasks. **Methods:** We used a longitudinal, time-diary design to send bi-weekly surveys (n=196) via text message to 53 athletic training students enrolled in 21 CAATE-accredited professional master's degree athletic training programs over a two-year period. Prior to data collection, the survey was reviewed for content validation by three experts and piloted among students not included in the final study. Students identified which type of clinical experience they attended that day (ICE or Non-ICE), and then documented the amount of time spent at clinical experience along with the percentage of that time spent performing activities associated with patient care and administrative tasks and then subtasks within patient care. The patient care and administrative tasks were designed using the CAATE standards and the BOC Practice

Analysis. We describe the data in a Figure and used an independent samples t-test to compare the percentage of time performing an activity or on subtasks for any student who entered a response, and then repeated the analyses for all students who experienced both ICE and Non-ICEs. **Results:** We found the two groups were significantly different in five areas. Participants reported significantly higher proportion of time spent on administrative tasks ($p=0.001$), facility management ($p=0.039$), and waiting ($p=0.004$) when in an immersive environment. They spent more time on practice/event coverage ($p=0.007$) and skills practice ($p=0.012$) when in a non-immersive environment. We compared percentage of time in patient care subtasks and found a significant difference in means for performing diagnostic tests ($p=0.002$) and applying/fabricating or customizing protective equipment ($p=0.003$) with students in Non-ICEs spending more time on these tasks. When participants experienced Non-ICEs, they spent more time (as a percentage) on skills practice than in immersive settings ($p=0.010$). **Conclusions:** ICEs provide more time for students to engage in administrative tasks that likely occur during the day and not right before, during practice, or other events. Non-ICEs allow more time spent on practice/event coverage, skills practice, diagnostic testing, and applying/fabricating protective equipment. The results of our study demonstrate that, by and large, ICEs are not being implemented in a way that achieves the aims set forth by the profession's leadership organizations.

Funded by NATA Foundation Grant #1920EGP01.

Figure: Descriptive Statistics of Immersive and Non-Immersive Clinical Experiences



The Impact of an Interprofessional Practice and Education (IPE) Experience on Students in Pre-Professional Educational Programs
Cuchna JW, Collins K, Hines T, Salley, S: Longwood University, Farmville, VA

Context: Interprofessional practice and education (IPE) is widely accepted and expected across medical professions. Researchers and educators in pre-professional educational programs recognize the value and need for implementation of such practices in school settings, as they play a primary role in health and human services of school-aged populations. Intentional placement of IPE experiences within educational curricula is paramount to students learning and implementing IPE in practice. Therefore, the purpose of this investigation was to examine the impact of an IPE experience on undergraduate and graduate students from a variety of education and health preparation programs at a small university. **Methods:** A mixed-methods design using a pre-post survey associated with a college-wide IPE event was implemented. A convenience sample of 114 students (12 males, 102 females, aged 23.263 years \pm 6.62) from 13 different majors participated in the experience. The event included three parts: 1) opening session, 2) facilitated small group sessions with two activities (one on assumptions and the other used a case study for care planning), and 3) a reflective dinner discussion. Students' integration of interprofessional core competencies were analyzed using a pre-post survey (Interprofessional Socialization and Valuing Scale ISVS-9A and ISVS-9B) examining changes in student attitudes about interprofessional

collaboration. Descriptive statistics were computed for all survey items and Alpha levels were set at 0.05. Qualitative data theme analysis was used to explore students' written responses to prompts examining their lived experiences of the day. **Results:** Overall students felt the event was a beneficial experience and recognized direct transferability of the collaborative and teamwork aspects to their individual profession. The means of the survey questions were compared at pre and post test using a two-tailed dependent T-test. The results showed there was a significant difference in the recognition of IPE and team role concepts following the event ($M = 5.83$, $SD = 0.06$) compared to pre event ($M = 5.19$, $SD = 0.22$), $t(9) = -4.49$, $p < .002$. Three themes emerged from the qualitative analysis: 1) assumptions exist even among same student profession groups, 2) multidisciplinary team collaboration helps to provide holistic intervention for students and families, and 3) planning and coordination is necessary for successful outcomes. **Conclusions:** The event allowed for multidisciplinary discussion, helping participants recognize misconceptions of other professions, allowing students to recognize the various professional roles of others involved in a team. Students' increased understanding of the importance of the professional roles of others was a key takeaway that also highlighted the importance of including health professions in schools, given the current climate in our society related to COVID-19, mental health, and overall well-being and support for students and families. Further research is needed related to the impact of IPE and the training of pre-service professionals.

Athletic Trainers' Perceptions of the Role of Residency Training for Clinical Practice Advancement

Welch Bacon CE, Eberman LE, Cavallario JM, Fagan AN, Wetherington JJ, Pecha FQ, Van Lunen BL: A.T. Still University, Mesa, AZ; Indiana State University, Terre Haute, IN; Old Dominion University, Norfolk, VA; St. Luke's Health System, Boise, ID; Steamboat Orthopaedic and Spine Institute, Steamboat Springs, CO

Context: As professional athletic training education evolves, accredited athletic training residencies have emerged as a route for individuals to develop their clinical skills in a specialty area beyond the entry level. Historically, advanced knowledge attainment for athletic trainers (ATs) within a specialty area has been via continuing education courses varying in content, type of delivery and length, and/or completion of focused experiences. Evidence is sparse concerning the perceptions of individuals who have completed an accredited athletic training residency program. Therefore, we aimed to explore ATs' perceptions of residency training to foster athletic training clinical practice advancement. **Methods:** We used a consensual qualitative research design and purposeful sampling. We asked residency program directors with 1) graduates of a 2) CAATE-accredited orthopaedic-focused residency program 3) between 2016-2019 to forward our participation request to ATs that met the inclusion criteria. Data saturation was achieved following individual videoconference interviews with 13 ATs (5 men, 8 women; average age=31.6±3.5 years; AT experience=8.6±3.5 years) from 4 orthopaedic-focused athletic training residency programs. A 14-item, semi-structured interview guide was used; following development, the guide was reviewed by 3 residency experts for content validity and piloted with 2 residency-trained ATs not included in data analysis to ensure clarity and comprehensibility of the interview questions. Following transcription, a 5-person analysis team coded the data into themes and categories. Four researchers coded the data and met regularly throughout a 3-phase consensus process. Trustworthiness of the data was ensured by member-checking, multi-analyst triangulation, and use of auditors. The fifth analysis team member served as internal auditor and reviewed the data after each phase to ensure accuracy of

data reporting. An external auditor also reviewed the final data to ensure representativeness of the participant voice. **Results:** Two predominant themes regarding ATs' perceptions of residency training emerged. Participants discussed their perceptions of practice advancement and the role residency training had on those perceptions. Interestingly, participants discussed characteristics of generalist practice and specialist practice, but did not necessarily perceive residency training to enhance their role as a specialist. They also shared their views on the BOC specialty certification; responses varied regarding their personal interest to be specialty certified and its impact on the profession as a whole. ATs' perceptions of residency training included how residency training added value to themselves as clinicians and how they perceive the value they add to the overall healthcare system because of residency training. They discussed the respect they receive from other healthcare professionals within their current practice settings because they are residency-trained, and how the training has greatly enhanced their self-efficacy as an AT. Participants also remarked how residency training fostered their own conscious incompetence; they perceive themselves to be more self-aware following residency training and are more capable of identifying quality gaps in their own knowledge and skills. They highlighted how residency training fostered a growth mindset and several participants shared how residency training opened their minds to being willing to grow and improve self-identified areas of weakness. **Conclusions:** Residency-trained ATs described having a growth mindset both during and after residency training, which has allowed them to continue to grow and develop their clinical skills even after they completed the program. Residency-trained ATs also felt the residency experience made them more valuable to prospective employers and colleagues, more confident in their skills, and were optimistic about how their training added value to the overall healthcare system in which they practice. However, our participants' descriptions and understanding of practice advancement and clinical specialists were widely varied, indicating a continued need for professional leadership to define the novice-to-expert continuum of competence to ensure public awareness of the range of ATs' practice capabilities.

The findings presented in this abstract are from a study funded by the NATA Foundation (#1819EGP01).

Athletic Trainers' Experiences With Orthopaedic Residency Training

Fagan AN, Van Lunen BL, Eberman LE, Cavallario JM, Wetherington JJ, Pecha FQ, Welch Bacon CE: A.T. Still University, Mesa, AZ; Old Dominion University, Norfolk, VA; Indiana State University, Terre Haute, IN; St. Luke's Health System, Boise, ID; Steamboat Orthopaedic and Spine Institute, Steamboat Springs, CO

Context: Although athletic training residency programs have existed for more than a decade, recent changes to professional education have led to an emergence of new residency program growth. The intent of residency training in athletic training is to develop athletic training specialists in one of the eight focused areas of athletic training practice. However, little is known about the experiences of athletic trainers who completed residency training or the impact residency training has on the profession. The purpose of this study was to explore former athletic training residents' experience with completing residency training in orthopaedics.

Methods: Thirteen athletic trainers (ATs; 8 women, 5 men; average age=31.6±3.5 years; AT experience=8.6±3.5 years) that completed 1 of 4 different orthopaedic-focused residency programs between 2016-2019 were individually interviewed via videoconference by the senior researcher. We emailed CAATE-accredited residency program directors and asked them to forward our participation request to former residents that completed orthopaedic residency training between 2016-2019. We used a semi-structured, 14-item interview guide which was reviewed by 3 residency content experts for face and content validity; after validation, the guide was piloted with 2 former residents that did not meet the inclusion criteria to ensure clarity and comprehensibility of the interview questions. Following transcription, a 5-person analysis team used a 4-phase consensual qualitative research approach to guide data analysis. Four researchers independently coded the data and then met as a team to reach consensus during each phase. The fifth researcher served as the internal auditor to ensure accurate reporting of the data. An external auditor, who was not a member of the research team, also reviewed the emergent findings to confirm the participant voice was well represented. We established saturation and trustworthiness of the data by employing

member-checking, multi-analyst triangulation, and the use of auditors. **Results:** Two themes emerged during data analysis regarding residency program mechanics and structure and experience gained. Participants described the various mechanisms involved in residency training and highlighted how specific didactic, clinical, and research considerations impacted their training. Participants explained the immense value the direct and guided mentorship they received from residency core faculty and physicians had on their professional growth. They recounted how the constant exposure and repetition of orthopaedic patient cases and the numerous interprofessional collaborative opportunities they received shaped their residency training experience. Participants also discussed the professional growth and in-depth clinical experience they gained by completing an athletic training residency program in orthopaedics. More specifically, they shared how the unique structure of residency training (i.e., exposures, repetition, interprofessional collaborative opportunities, understanding of the full healthcare landscape) socialized them for the setting they were currently employed in, enhanced their clinical knowledge and skills regarding orthopaedics, and instilled strong scholarly behaviors regarding best available evidence to inform their clinical decision-making process. **Conclusions:** ATs' experiences across orthopaedic residency programs varied slightly in structure and mechanics. Despite these subtle differences, participants shared the valuable didactic and clinical opportunities and experiences provided during residency training, which often included interprofessional interactions and incorporated research and mentorship components. Our participants indicated their residency program provided them planned, structured opportunities to engage in high volume patient care with a variety of healthcare providers. Residency training prepared them for work in the practice setting in which they aspired to work or seek employment in after residency completion. Regardless of the structure or mechanics, our participants felt that residency programs have the immense potential to aid ATs in developing and enhancing essential clinical skills and offers an opportunity to fully immerse in a guided experience within their desired practice setting.

The findings presented in this abstract are from a study funded by the NATA Foundation (#1819EGP01).

Athletic Training Students' Experiences With Translating Knowledge from Classroom to Clinical Practice

Donahue BC, Cavallario JM, Pike Lacy AM, Welch Bacon CE: A.T. Still University, Mesa, AZ; Winona State University, Winona, MN; Old Dominion University, Norfolk, VA; University of Maine, Orono, ME

Context: Knowledge translation (KT) has been well studied among many healthcare professions, but only recently investigated within athletic training. Previous researchers have highlighted the topics athletic training students (ATS) perceive they have been successful at translating into clinical practice and their ability to engage with KT. However, the available evidence fails to thoroughly demonstrate which factors, if any, influence ATS' experiences with translating knowledge from the classroom into clinical practice. Therefore, we aimed to explore final-term professional ATS' experiences with KT. **Methods:** Our study was guided by the consensual qualitative research (CQR) training and included individual videoconference interviews conducted with final-term ATS enrolled in CAATE-accredited professional ATPs. We developed a 7-item semi-structured interview protocol that was reviewed and deemed to have face and content validity by two content experts. Pilot testing was conducted with 2 ATS not included in data collection to ensure clarity and comprehension of the interview questions. Data saturation guided the number of interviews and was achieved following interviews with 9 final-term ATS (6 women, 3 men; age=24.8±3.3 years, 8 enrolled in a graduate ATP, 1 enrolled in an undergraduate ATP) from programs across 5 states. Interviews were recorded via Zoom, transcribed verbatim, and analyzed using a 3-member research team employing the CQR approach to code data and reach consensus on major themes and categories throughout 3 data analysis phases. Trustworthiness of the data was established via member-checking, multi-researcher triangulation, and an external auditor who verified the accuracy of the findings that emerged. **Results:** Three major themes emerged

during data analysis: 1) positive influencers and 2) negative influencers for KT, and 3) intrinsic factors affecting knowledge translation. ATS discussed several positive influencers that helped them translate knowledge from the classroom into clinical practice including opportunities for hands-on experience, classroom didactic training and resources (e.g., simulation, standardized patients) that promoted repetition and application of content taught, and effective quality communication with educators, preceptors, and patients. Conversely, negative influencers that hindered KT included lack of exposure to athletic training-related knowledge and skills during clinical experiences, lack of congruence between didactic education and clinical practice, as well as perceived student role during clinical experiences (i.e., observer versus a more active hands-on role). Interestingly, the role of the preceptor was identified as both a positive and negative influencer depending on the preceptor's willingness to foster students' growth mindset and create positive preceptor-student interactions. Students also described how their own self-confidence level and mindset for the development of knowledge and skills served as intrinsic factors affecting KT. **Conclusions:** Our findings suggest that KT among ATS is impacted by positive influencers, negative influencers, as well as intrinsic factors. The preceptor was identified as having a significant role in KT for students, demonstrating the ability to influence KT both positively and negatively. Students found that increased opportunities for hands-on experience involving patient contact was beneficial for improving KT, while academic and clinical incongruence hindered KT. Furthermore, ATS' experiences highlight that a stronger association is needed between classroom knowledge and clinical application to help streamline the process of KT for ATS. Faculty and preceptors should aim to involve students in active learning opportunities during patient encounters, establish open lines of communication with students to discuss classroom knowledge and best approaches for implementation, and strive for collaboration on strategies to promote the translation of knowledge by students into clinical practice.

Free Communications, Poster Presentations: Post-Concussion Recovery: Considerations and Interventions

Saturday, June 24, 2023; authors present 11:45 AM-12:40 PM; Poster Hall

Well-Being and Performance Anxiety Following Sport-Related Concussion in Division I Female Gymnasts

Williams SM, Derrico D, Robinson H, Settle H, Jochimsen KN: West Virginia University, Morgantown, WV, and Boston University, Boston, MA

Context: Depressive symptoms can occur following a sport-related concussion, and are a known risk factor for the development of persistent concussion symptoms. However, less is known regarding the broader psychosocial response. Clinically, this is important to facilitate a well-rounded patient-centered rehabilitative approach. Therefore, we aimed to determine if well-being and performance anxiety changed from pre-season to the week following a sport-related concussion and if athletes who sustained a sport-related concussion differed in terms of pre-season well-being and performance anxiety from those who did not sustain a sport-related concussion in Division I college gymnasts. We hypothesized that following a sport-related concussion, well-being, and performance anxiety would decrease and that gymnasts who sustained a sport-related concussion would have higher pre-season performance anxiety. **Methods:** The first week

of pre-season (PRE), gymnasts completed the 5-item World Health Organization Well-Being Index (WHO-5; 0-100 with 0 indicating lowest and 100 indicating the highest well-being) and the performance anxiety section on the Athlete Psychological Strain Questionnaire (APSQ; 4-20 with 4 indicating lowest and 20 indicating highest performance anxiety). Surveys were completed weekly throughout the season (pre-season through post-season competition). For those who sustained a sport-related concussion, we analyzed their post-concussive WHO-5 and APSQ scores within 7 days of the injury (POST). Wilcoxon Signed Ranks Tests were used to compare PRE and POST scores on the WHO-5 and APSQ for gymnasts who sustained a sport-related concussion. Mann Whitney-U tests were used to examine the pre-season scores between gymnasts who did (CON) and did not (NON) sustain a sport-related concussion. **Results:** Of 17 female Division I college gymnasts, 6 (35.3%) sustained a sport-related concussion over the course of the season. For those athletes who sustained a sport-related concussion, WHO-5 and APSQ scores did not change from PRE to POST ($P = 0.07$ to 0.14). (Table 1) Gymnasts who sustained a sport-related concussion did not differ in pre-season WHO-5 or APSQ scores from those who did not sustain a concussion ($P=0.26$ to 0.80). However,

WHO-5 scores decreased 19 points from PRE to POST sport-related concussion, which exceeds the clinically significant change of 10 points.

Conclusions: We noted a 19-point decrease in student-athlete well-being following a sport-related concussion. Additionally, we noted gymnasts who sustained a sport-related concussion scored on average 2 points (12.5%) higher in performance anxiety at pre-season than those who did not sustain a sport-related concussion during the competitive season. These findings were not statistically significant, potentially due to our small sample (6 athletes with sport-related concussions), indicating the need for future studies to further examine well-being and performance anxiety following a sport-related concussion. However, these data may provide clinically meaningful information regarding the impact of sport-related concussion on student-athlete well-being.

Table 1. Psychosocial variables between pre- and post-concussion for gymnasts who sustained a sport-related concussion, and between pre-season psychosocial variables for gymnasts who did and did not sustain a sport-related concussion.

Measure	PRE (N=6)	POST (N=6)	Change Δ	P-value
WHO-5	73.6 \pm 7.3	54.4 \pm 24.6	19.2	0.14
APSQ*	10.6 \pm 4.0	9.2 \pm 3.6	1.4	0.07
	CON (N=6)	NON (N=11)	Difference	P-value
WHO-5	70.0 \pm 11.0	70.4 \pm 18.1	0.4	0.80
APSQ*	10.5 \pm 3.6	8.5 \pm 2.5	2.0	0.26

*Performance Anxiety subscale only

Health-Related Quality of Life in Adolescent Athletes Fully Returned Versus Those Not Fully Returned to School at One-Month Post-Concussion

Ingram BM, Chandler MC, Bloom J, Fonseca J, Ramsey K, De Maio VD, Register-Mihalik JK: Matthew Gfeller Center, The University of North Carolina at Chapel Hill, NC; STAR Heel Performance Laboratory, The University of North Carolina at Chapel Hill, NC; Human Movement Science Curriculum, Department of Allied Health Sciences, School of Medicine, The University of North Carolina at Chapel Hill, NC; Carolina Family Practice & Sports Medicine, Cary, NC; Department of Emergency Medicine, The University of North Carolina at Chapel Hill, Chapel Hill, NC; Injury Prevention Research Center, The University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: During initial recovery following sport-related concussion (SRC), athletes are often prescribed a brief period of cognitive and physical rest. Initial cognitive adjustments can include absence from school and a symptom-limited cognitive workload. Prolonged removal from school can lead to feelings of isolation and mood disturbances that impact health-related quality of life (HRQoL). Therefore, this study's objective was to determine differences in HRQoL between individuals fully returned versus those not fully returned to school at one-month post-concussion. **Methods:** This prospective cohort study included 226 adolescent athletes (133 female; 92 male; mean age 14.83±2.08) recruited from a convenience sample reporting to three community-health practice sites within three days of a SRC, who completed a one-month follow-up assessment. At an initial evaluation, participants provided informed consent/assent and completed a concussion evaluation. One month following initial evaluation, participants' legal guardians completed information about return to school and

sport, as well as the PedsQLTM, a valid and reliable assessment of pediatric HRQoL, and the Multi-Dimensional Fatigue Scale Module. Parent reports on the PedsQLTM were used to assess HRQoL. HRQoL is represented as the total score on the PedsQLTM. Psychosocial functioning and physical are sub-components of the total score. Multi-dimensional fatigue (MDF) is derived from the total score on the MDF Scale Module. Athletes were grouped based on whether they had returned to school full-time at the one-month follow-up (yes n=214; no n=12). Due to non-normally distributed data, Mann-Whitney U tests were used to determine group differences in the primary outcome variables of HRQoL total, psychosocial function, physical health, and MDF scores. Spearman's rank-order correlations investigated a potential relationship between days to return to school and the primary outcome variables in those returned to school full-time. **Results:** Individuals fully returned to school had higher (better) overall scores for HRQoL (median:86.95 [IQR:72.83-95.65] vs 72.82[IQR: 53.83-82.60], U=797.50, P=.011); physical function (median:87.50 [IQR:75.00-100.00] vs 56.25[IQR: 46.88-82.81], U=666.00, P=.002) and MDF (median:81.25 [IQR:60.29-95.83] vs 51.39 [IQR: 39.58-72.88], U=644.00, P=.001). While psychosocial scores were higher in the fully returned group, they were not statistically different (median:86.67 [IQR:73.33-96.67] vs. 74.17 [IQR: 56.67-89.17], U=931.00, P=.054). On average, individuals took 4.24±1.74 days to fully return to school (range=1-10). In those who had returned, days to return to school full-time was not correlated with HRQoL (rs=-0.14; P=.172), physical functioning (rs=-0.18; P=.097), psychosocial functioning (rs=-0.11; P=.280), or MDF (rs=-0.19; P=.072). **Conclusions:** Findings suggest adolescent athletes not fully returned to school one-month post-concussion had worse HRQoL outcomes than individuals fully returned. Families and clinicians should be aware that individuals with prolonged absence may have difficulties with physical functioning and fatigue. Future research should investigate factors impacting HRQoL in individuals with prolonged absence from school and strategies that may mitigate such effects.

JB, JF, and KR were employed at the study setting during the time of data collection. VDM is employed by 410 Medical Inc. for unrelated work. JRM reports grants from the National Football League, Department of Defense, NATA Foundation, and Centers for Disease Control and Prevention outside the submitted work and is a Member of USA Football's Football Development Council. Additionally, a family member of JRM, the principal investigator on this study, has received funding to her institution from NOCSAE for work that is not part of this current study. JRM's spouse has received a grant review panel stipend from NOCSAE unrelated to the current work. BI and MC have no conflicts of interest to disclose. This study was funded in part by the National Operating Committee on Standard for Athletic Equipment (NOCSAE).

Does Earlier Vestibular Rehabilitation After Sport-Related Concussion Lead to Faster Recovery?

Zargari M, Williams KL, Hill TM, Perry GM, Prosak OL, Amedy A, Anesi TJ, Jo J, Zuckerman SL, Terry DP: Vanderbilt University School of Medicine, Nashville, TN; Vanderbilt Sports Concussion Center, Vanderbilt University Medical Center, Nashville, TN; Department of Neurological Surgery, Vanderbilt University Medical Center, Nashville, TN

Context: Vestibular rehabilitation is often used to treat athletes after sport-related concussion (SRC). We sought to evaluate the association between time to vestibular rehabilitation referral and 1) initial clinic symptom burden, and 2) recovery, defined as time to return-to-learn (RTL), return-to-play (RTP), and symptom resolution. **Methods:** A retrospective, cohort study of adolescents (12-23 years old) who sustained a SRC from 10/2017-11/2021 treated at a regional sports concussion center was conducted. The exposure variable of interest was timing of vestibular rehabilitation referral. Outcomes were total initial symptoms, RTL, RTP, and symptom resolution. Pearson correlation was used to assess the relationship between timing of vestibular rehabilitation and total Post-Concussion Symptom Scale (PCSS) score and specific vestibular related symptoms (dizziness, blurred vision, and balance problems). A multiple variable linear regression examined the relationship between timing of vestibular

rehabilitation referral and the outcomes of RTL, RTP, and symptom resolution. **Results:** A total of 43 concussed athletes were referred for vestibular therapy; 24 (56%) were female, and the mean age was 16.8 ± 2.7 years. The mean time from injury to initial clinic visit was 19.3 ± 18.2 days and the mean time from injury to vestibular rehabilitation referral was 26.8 ± 19.8 days. There were no significant relationships between days to vestibular rehabilitation referral and initial PCSS ($r = -.11$, $p = .50$), balance problems ($r = -.03$, $p = .88$), blurred vision ($r = -0.14$, $p = .43$), and dizziness ($r = .06$, $p = .73$). Multivariable linear regression controlling for PCSS, age, and prior concussions found that longer days to vestibular rehabilitation referral was significantly associated with longer time to RTP ($\beta = 0.48$, $p = .02$) and symptom resolution ($\beta = 0.62$, $p = .003$), but not RTL ($\beta = 0.07$, $p = .69$). **Conclusions:** In a study of athletes with SRC referred for vestibular therapy, later vestibular rehabilitation referral was significantly associated with longer time to RTP and symptom resolution but not RTL. Future investigations should focus on identifying common post-concussive signs/symptoms that serve as indications for referral to vestibular rehabilitation.

Scott Zuckerman serves as an unaffiliated neurotrauma consultation for the U.S. National Football League. Douglas Terry receives honoraria from REACT Neuro, Inc as well as HitIQ and has a consulting practice in forensic neuropsychology. For remaining authors none were declared. None of the other authors have any disclosures.

Kinesiophobia Levels at Return-to-Sport Testing Between Collegiate Athletes With Sport Concussion and Anterior Cruciate Ligament Reconstruction

Rosenblum DJ, Donahue CC, Thompson XD, Hart JM, Resch JE: Exercise and Sport Injury Laboratory, University of Virginia, Charlottesville, VA, and University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Athletes with a history of sport concussion (SC) may be at an increased risk for sustaining a lower extremity injury (LEI). The underlying mechanism(s) for this association remains unclear. Heightened levels of kinesiophobia upon return to sport (RTS) is a known modifier of reinjury following an anterior cruciate ligament reconstruction (ACLR), and therefore may partially explain the relationship between SC and LEI. The levels of kinesiophobia upon RTS from ACLR and SC have not been compared. The purpose of this study was to compare kinesiophobia levels, upon RTS, between collegiate athletes with ACLR or SC. We hypothesized that athletes with ACLR would report higher levels of kinesiophobia at their RTS assessment compared to athletes with SC. **Methods:** This descriptive laboratory study included division 1 collegiate athletes (N=89[43.8% female]) who were on average 20.0±1.5 years of age who had either been diagnosed with a SC (n=62[40% female]) or had undergone ACLR (n=27[52% female]). Participants in each group were administered the Tampa Scale of Kinesiophobia (TSK), an accepted measure of kinesiophobia, prior to RTS with increased values being indicative of higher levels of kinesiophobia. Additionally,

we compared the proportion of participants in each group who scored above (high) or below (low) the clinically meaningful threshold of 37. Participants in each group completed the TSK in alignment with the Athletic Department's RTS protocol for SC and ACLR. Independent samples t-tests were used to compare days since injury and the total TSK score between groups. Effect size was calculated using Cohen's d with 95% confidence intervals. The proportion of each group with high versus low levels of kinesiophobia was compared using a chi-squared (χ^2) analysis. All analyses were performed with $\alpha=0.05$. **Results:** Participants in the ACLR and SC groups were similar in terms of height, weight, and age (all $p > 0.05$). The SC group was evaluated on an average (standard deviation) of 14.4(14.6) days following their date of injury while the ACLR group was evaluated on an average of 256(167.1) days following their date of surgery ($t(87)=-1.25, p<0.001, d=2.62, 95\% \text{ CI}=-3.21-[-2.02]$). No differences were observed in TSK scores between the SC (30.9±5.29) and ACLR (31.1±4.37) groups (mean difference -1.76, $t(87)=-0.151, p=0.88, d=-.035, 95\% \text{ CI}=-0.487-0.417$). Similarly, no differences were observed between athletes who had high or low levels of kinesiophobia between groups ($\chi^2[1, n=89]=0.08, p=0.31$) with 19%(5/27) of the ACLR group and 16%(10/62) of the SC groups scoring above the clinically meaningful threshold. **Conclusions:** Unexpectedly, participants in the ACLR and SC groups had similar levels of kinesiophobia upon RTS. Provided our results it is plausible that, as with ACLR, kinesiophobia may be a modifier of LEI following RTS in collegiate athletes with SC. Clinicians should consider adding a measure of kinesiophobia, such as the TSK, into their concussion management protocols.

The Influence of Race on Time to Symptom Resolution Following Sport Concussion in Collegiate Athletes

Domena A, Rosenblum DJ, Donahue CC, Resch JE: Department of Kinesiology, University of Virginia, Charlottesville, VA

Context: There are a variety of previously identified modifiers that can influence time to recovery from a sport concussion (SC). Race is an emerging modifier that has been previously shown to influence outcome scores of computerized neurocognitive tests, tests of motor function, and reported SC-related symptoms. However, there is a need to evaluate the effect that race may have on recovery time following a sport concussion (SC). Therefore, this study explored the influence of race on time to symptom-free from a SC. The primary objective of this study was to determine the influence of race on days until symptom free from SC in collegiate athletes. **Methods:** This prospective cohort study consisted of Black/African American participants ($n=53$, 20.2 ± 1.3 years of age) and White/Caucasian participants ($n=150$, 19.9 ± 1.2 years of age) from a large public urban university provided consent to participate in this study. Data was collected from the 2015-2016 to 2020-2021 collegiate sport seasons. Participants were included in the study if they had complete baseline and post-injury assessment data

following a diagnosed SC. Time, in days, until symptom free. Additional outcomes included the baseline and post-injury composite scores of the Immediate Post-Concussion Assessment and Cognitive Test (ImPACT), Sensory Organization Test (SOT), as well as symptom severity/duration measured via the Revised Head Injury Scale (HIS-r). ImPACT, SOT, and HIS-r values were analyzed using a 2(group) x 2(time) analysis of variance. A Mann-Whitney U Test was used to determine the difference between groups, in days, until symptom free.

Results: At baseline, there were statistically significant differences between races on average (standard deviation) for ImPACT's Verbal Memory (White/Caucasian [90.4 ± 8.3] vs. Black/African American [87.3 ± 10.07] $p<.05$) and on the SOT's Equilibrium score (White/Caucasian [82.9 ± 3.96], Black/African American [81.2 ± 4.18], $p<.05$). At the post-injury time-point, there were statistically significant differences on ImPACT's Visual Motor Speed (White/Caucasian [44.5 ± 5.62] vs. Black/African American [42.1 ± 5.95], $p<.05$). See Table 1. Results of the Mann-Whitney U Test indicated that White/Caucasian participants had a longer median recovery time (9 days) until symptom-free than Black/African American participants (6 days, $p=.04$) in our sample. No other significant differences were observed for any outcomes between groups at either time point. **Conclusions:** The primary finding of this study suggests that collegiate athletes who

identify as Black/African American may report symptom free sooner than athletes who identify as White/Caucasian. Given that the primary aim of this study was to determine whether there is a difference in time until symptom-free between races, we did not explore any underlying demographic variables including but not limited to socioeconomic status or previous concussion education which may have influenced our results. As such, future studies should explore other demographic variables that may provide rationale for the results of this study.

White/Caucasian					Black/African American	
Outcome Score	Baseline	Post-injury	Baseline	Post-injury		
ImPACT						
Verbal Memory	90.4 ± 8.31*	91.7 ± 7.89	87.3 ± 10.07*		89.8 ± 10.75	
Visual Memory	83.1 ± 10.97	81.9 ± 10.86	81.8 ± 10.17		80.6 ± 12.46	
Visual Motor Speed	43.6 ± 5.54	44.5 ± 5.62*	41.8 ± 6.11		42.1 ± 5.95*	
Reaction Time	0.50 ± 0.06	0.50 ± 0.07	0.6 ± 0.06		0.50 ± 0.06	
HIS-r						
Total Symptoms	2.9 ± 4.88	.77 ± 1.96	2.1 ± 4.04		0.33 ± 1.23	
SOT						
Equilibrium Score	82.9 ± 3.96*	84.3 ± 4.32	81.2 ± 4.18*		83.5 ± 5.04	

Table 1. Descriptive Statistics of Assessments Between Races at Baseline (BI) or Post-Injury (PI) * = p value <.05 which represents significant difference

Concussion Does Not Influence Total Sleep Time in Collegiate Athletes

Takata SC, Donahue CC, Statuta SM, Resch JE: University of Virginia, Charlottesville VA

Context: Sleep disturbances have been identified as a potential modifier of recovery following a sport concussion (SC). A reduction in total sleep time (TST) has been suggested to increase the number of days athletes may experience SC-related symptoms. However, it has yet to be established if TST deficits exist in college athletes after reporting being symptom free or even several months after diagnosis of SC. We compared these new TST values to pre-jury (baseline[BASE]) values. The purpose of this study was to investigate changes in TST as reported by collegiate athletes at their BASE assessment, upon reporting symptom free (SF) following a diagnosed SC, and at a new baseline assessment (NEWB) conducted prior to the start of the injured athlete's next sport season. We hypothesized that the TST of collegiate athletes with SC would be significantly decreased upon reporting SF, in comparison to BASE and NEWB values. **Methods:** A retrospective chart review was performed between the 2014-15 and 2021-22 sport seasons. Participants consisted of 87 (41.3% female) collegiate athletes who were on average 18.4 ± 0.90 years of age and diagnosed with a SC by an athletic trainer or physician. In alignment with the university's Athletic Department's concussion management protocol, athletes were

administered the Immediate Postconcussion and Cognitive Test (ImPACT) battery as part of their BASE, SF, and NEWB assessments. As part of the ImPACT, TST is reported by athletes, in relationship to the night prior to their assessment, during the medical history domain. TST was reported to the nearest half hour. A repeated measures analysis of variance was performed to compare TST across BASE, SF, and NEWB assessments. All analyses were performed with $P=0.05$. **Results:** On average, approximately 438.9 ± 318.77 days occurred between the BASE and SF assessments, and 262.4 ± 136.10 days elapsed between the SF and NEWB assessments. On average (standard deviation), participants reported a TST of 7.5 ± 1.22 , 7.4 ± 1.12 , and 7.4 ± 1.18 hours of sleep at the BASE, SF, and NEWB assessments, respectively. When examining TST across BASE, SF, and NEWB assessments, a significant main effect was not observed ($F(2,172)=0.29$, $p=0.75$, $\eta^2 = 0.003$). **Conclusions:** Our findings suggest that SCs do not influence TST at a clinically relevant time following a diagnosed SC and upon establishing a NEWB assessment in collegiate athletes compared to baseline values. Our methodological approach reflects a single time that reflected the TST the night prior to each athlete's assessment which may not be representative of an athlete's typical sleep habits. Future research is needed to examine TST more closely from the time of injury and until SF to more fully understand how sleep may influence recovery following a diagnosed SC and beyond.

Cervical Spine Range of Motion Pre-and-Post Concussion

Ottie K, Kontos A, Cappaert T, Martin M: Mars Hill University, Mars Hill, NC; University of Pittsburgh, Pittsburgh, PA; Rocky Mountain University of Health Professions, Provo, UT

Context: Cervical spine ROM may contribute to neurological deficiencies, deconditioning, atrophy, motor deficits, and joint restrictions post-concussion. Undetected or untreated, changes in cervical spine ROM may lead to uncontrolled gait patterns, reduced concentration, and reaction times, which may increase musculoskeletal injury risk post-concussion following return to play. The purpose of this study is to evaluate changes in cervical spine ROM from pre-to-post concussion. **Methods:** Baseline and post-concussion AROM measures for the cervical spine were collected from a heterogeneous group of 42 (21 concussed; 21 matched controls based on age, gender, and sport type) NCAA Division II University athletes in the Mid-Atlantic region using a prospective matched pairs design. MIO Micro-Electro-Mechanical Systems inertial measurement units were used to collect measurement data at 3-time intervals post-concussion, within 72 hours of injury, return to play, and within 3 weeks post-season. Comparisons between measurements were evaluated to determine: 1) if changes occur in the cervical spine ROM, 2) if cervical spine ROM measurements return to baseline levels at return to play, and 3) if post-season cervical spine ROM is equitable to baseline levels. **Results:** A repeated measures ANOVA revealed

significance from pre-to-post-concussion for left lateral flexion $F(3, 60) = 3.16, p=0.031$ and left rotation $F(3, 60) = 4.71, p=0.005$ between baseline, post-concussion, return to play, and post-season indicating a decrease occurred in ROM from baseline to post-concussion measures followed by an increase that equaled or exceeded baseline measures at post-season. A mixed model ANOVA demonstrated significance of the main effect for group from baseline to return to play for flexion $F(1, 40) = 4.23, p=0.046$. The main effect for the within-subjects factor from baseline to return to play for flexion $F(1, 40) = 0.12, p=0.731$, and the interaction effect for within-subjects for flexion $F(1, 40) = 0.01, p=0.925$ were not significant indicating cervical flexion measures were similar between groups. A repeated measures ANOVA revealed significance for left lateral flexion $F(2, 40) = 5.37, p=0.009$ and left rotation $F(2, 40) = 5.37, p=0.009$ between baseline, post-concussion, and post-season, indicating a decrease in ROM from baseline to post-concussion measures followed by an increase in ROM equal or exceeding baseline measures post-season. **Conclusions:** Cervical spine ROM pre-to-post-concussion decreased from baseline to post-concussion measures, followed by an increase equal to or exceeding baseline measures post-season, specifically left lateral flexion and left rotation. Cervical flexion increased across all groups between baseline and return to play. Cervical flexion for within-subjects groups was similar, non-significant, and represents a decrease in power due to the small sample size and uneven distribution of participants between sports groups.

Baseline Hours of Sleep Do Not Influence Recovery From Concussion in Collegiate Athletes

Bowling RO, Donahue CC, Rosenblum DJ, Resch JE: University of Virginia, Charlottesville, VA

Context: Following a sport concussion (SC), disturbances in sleep quality and quantity are commonly reported and have been suggested to be a modifier of recovery. Despite the association of poor sleep quality and quantity and prolonged recovery from SC; limited research has examined the relationship between pre-injury (baseline) hours of sleep, which may be indicative of pre-morbid sleep hygiene, and recovery from a SC. The purpose of this study was to explore the relationship between self-reported hours of sleep collected during a concussion baseline assessment and the number of days until a collegiate athlete reported symptom free (SF) following a diagnosed SC. We hypothesized that a significant negative correlation would exist between self-reported hours of sleep and days until SF following a diagnosed SC. **Methods:** Data for this cross-sectional study were collected between the 2015-16 and 2021-22 sport seasons. Participants consisted of 301 Division I collegiate athletes (41.2% female) who were on average 17.2 ± 1.34 years old and who were diagnosed with a SC by an

athletic trainer or physician. Prior to the start of each athlete's respective sport season, they were administered the Immediate Postconcussion and Cognitive Test (ImPACT) battery. The ImPACT includes a medical history domain in which athletes are asked to report their number of hours of sleep the night prior to their assessment. Following a diagnosed SC, the number of days until athletes reported symptom free (SF) were recorded. As days until SF were non-normally distributed, Spearman's correlation coefficient (ρ) was calculated between the number of hours of sleep prior to the athlete's baseline assessment and the number of days until SF. All analyses were performed with an alpha value of 0.05. **Results:** Participants self-reported a median of 7.5 (interquartile range [IQR]=1.5) hours of sleep prior to their baseline assessment. Following a diagnosed SC, participants took a median of 7.0 days (IQR=287 days) to report SF. A weak, non-significant, correlation was observed between the number of hours of sleep prior to an athlete's baseline ImPACT assessment and days until SF following a diagnosed SC ($\rho=0.015$, $p=0.80$). **Conclusions:** Our results suggest that baseline hours of sleep may not be a modifier of recovery from a diagnosed SC in collegiate athletes. As our findings suggest baseline hours of sleep are not prognostic in terms of recovery from SC, future research is needed to better understand the relationship between sleep and recovery from SC.

Academic Adjustments and Concussion Recoveries in NCAA Student-Athletes: A LIMBIC MATARS Investigation
Helm TC, Bowman TG, Beidler E, Kelshaw PM, Cifu DX, Resch JE: University of Lynchburg, Lynchburg, VA; Duquesne University, Pittsburgh, PA; University of New Hampshire, Durham, NH; Virginia Commonwealth University, Richmond, VA; University of Virginia, Charlottesville, VA

Context: Difficulties returning to the classroom are commonly reported following a sport concussion (SC) in collegiate athletes. Academic adjustments have been recognized as a key component of a return-to-learn protocol for collegiate athletes diagnosed with SCs and have been suggested to facilitate recovery. However, the evidence remains limited on the influence of academic adjustments on recovery following SC in collegiate athletes. The purpose of this study was to investigate the association between academic adjustments and recovery from SC (in days) in collegiate athletes. Our hypothesis was that those with academic adjustments would recover faster than those without academic adjustments. **Methods:** A retrospective chart review was performed between 2015 and 2020 at 11 universities who were members of the LIMBIC Military and Tactical Athlete Research Study consortium. Participants consisted of 304 (34.9% female) athletes who were on average 20.0±1.37 years of age. Participants were divided into groups based on if they did (n=179

[33.5% female]) or did not (n=126 [36.5% female]) receive academic adjustments. Mann-Whitney U tests were used to compare time (in days) from the date of each participant's concussion until (i) participant symptom resolution and (ii) return to sport between groups. All analyses were performed with $\alpha=0.05$. Nonparametric effect sizes were calculated with $r=Z/\sqrt{n}$. **Results:** The number of days between participant injury and self-reported symptom-free between those who had (median=7 (IQR=11)) and did not have (median= 5 (IQR=8)) academic adjustments were similar ($Z= -1.580$, $p=.114$, $r= -0.09$; Table). Similarly, no differences were observed between days to return to sport from the date of injury among those who were (median=12 (IQR=11)) or were not (median = 12.5 (IQR=12)) assigned academic adjustments ($Z= -0.86$, $p=.931$, $r= -.01$; Table). **Conclusions:** Our data suggest that the prescription of academic adjustments did not influence the recovery trajectories of collegiate athletes diagnosed with SC. Though this finding may appear contrary to guiding documents related to SC management, academic adjustments are typically prescribed to collegiate athletes with a higher symptom burden which is associated with a prolonged recovery from SC. Our data may reflect the benefit of academic adjustments in that each group had similar recovery trajectories. Clinicians and healthcare professionals should assist and support collegiate athletes after SCs on an individual basis, including academic adjustments when appropriate based on patient presentation.

Table. Descriptive statistics and statistical test results.

	Return to Learn Adjustments	Median (IQR)	<i>p</i>	<i>Z</i>	<i>r</i>
Days of Diagnosis until Sx free	Yes	7 (11)	.114	-1.580	-0.09
	No	5 (8)	.114	-1.580	-0.09
Days until RTP from Dx	Yes	12 (11)	.931	-0.86	-.01
	No	12.5 (12)	.931	-0.86	-.01

Acute Symptom Reporting is Not Associated with Post-Concussion Physical Activity Participation

Petit KM, Kuenze C, Pfeiffer KA, Fitton N, Saffarian M, Covassin T: University of Wisconsin Oshkosh, Oshkosh, WI; University of Virginia, Charlottesville, VA; Michigan State University, East Lansing, MI

Context: Exercise during concussion recovery has been found to promote healing and potentially speed up recovery. With these benefits in mind, researchers have begun evaluating other modes of activity such as habitual physical activity (PA) (i.e., walking) and its potential to improve concussion recovery outcomes. Despite these early studies, little is known about the habitual PA profiles of patients with a concussion. Additionally, research is needed to evaluate the potential factors that may influence the amount of daily PA someone with a concussion participates in. Thus, the purpose of the study was to evaluate the influence of acute symptom reporting on habitual PA participation in college-aged adults. **Methods:** A sample of 33 college-aged adults (68.8% female, age: 19.8 ± 1.4 yrs, 53.1% with concussion history) completed their initial visit within 72 hours of concussion occurrence. Post-concussion symptom total and severity were assessed utilizing the symptom checklist from the Sport Concussion Assessment Tool-5 (SCAT5). Participants were then given an Actigraph GT9X Link Physical Activity Monitor (Actigraph Corp, Pensacola, FL) to wear on their non-dominant wrist for seven consecutive days. Data were collected at 30Hz and processed over 60 second epochs. Wear time validation was

done using the Choi et al. algorithm, and had to be worn for at least eight hours per day and a minimum of four days. Wrist specific cut points were provided by Montoye et al. to determine activity intensity. Physical activity monitoring started no earlier than 48 hours post-concussion due to the consensus recommendation of strict rest. Post-concussion PA participation was expressed as Vector Magnitude (VM) counts per minute, while PA intensity was percent time spent in moderate-to-vigorous PA (%MVPA). Separate univariate linear regression analyses assessed the relationship between acute symptom reporting (total and severity) and each of the PA outcomes. Alpha was set a priori to .05. **Results:** Participants completed 2446 ± 441 VM counts per minute of PA, and spent $11.8\% \pm 3.7\%$ of time in MVPA. Acute concussion symptoms had no association with PA participation (total: $R^2 = .008$, $p = .622$, severity: $R^2 = .007$, $p = .637$) or intensity (total: $R^2 = .000$, $p = .923$, severity: $R^2 = .002$, $p = .800$). **Conclusions:** These findings suggest that habitual PA participation decisions may not be influenced by acute concussion symptomology. With consensus recommendations encouraging patients to perform habitual activities after a brief resting period, understanding factors that may impede habitual PA decisions is imperative. Thus, further research is needed to explore not only the use of habitual PA as a treatment method, but also the factors that may deter patients from being physically active after a concussion.

Dr. Petit received a Student Research Grant from the Blue Cross and Blue Shield of Michigan Foundation as well as internal fellowship funding from the Department of Kinesiology at Michigan State University.

Relationship Between Golf-Specific Low Back Pain Questionnaire Scores, Demographics and Pain

Skibski A, Goetschius J, Ingersoll CD, Mangum LC: University of Central Florida, Orlando, FL, and James Madison University, Harrisonburg, VA

Context: Low back pain (LBP) is a leading cause of disability in the general population, and it is the most common injury in golf. Traditional outcome measures, such as the Oswestry Disability Index, may not adequately represent pain in this population. The Golf-specific Low Back Pain questionnaire (GLBP) is a patient-reported outcome measure to quantify LBP-related disability in golfers. However, since limited evidence exists regarding this questionnaire, relationships between the GLBP and other factors have not yet been established. The purpose of this study was to evaluate relationships between GLBP score, demographics, and pain (current, average, and worst) in adult golfers with a history of LBP. **Methods:** This was a cross-sectional study design utilizing an online questionnaire. Only complete responses were included for analysis. Participants were a convenience sample of 52 adult golfers with a self-reported history of LBP (age: 30.0 ± 14.5 years, height: 176.6 ± 9.5 cm, weight: 81.3 ± 19.0 kg, average 18-hole score 83.6 ± 10.2). Survey instruments included demographics, pain level via 3 visual analog scales (current, average, and worst pain), the Godin Leisure-Time Exercise Questionnaire

(Godin), and the GLBP. The GLBP consists of 22 items related to LBP in golfers, scored from 0 to 100%, where higher scores indicate greater function. Pearson's r correlations were calculated to determine relationships between GLBP score, pain scales, and demographics (height, weight, average 18-hole score, days of golf played per week, Godin score) at $p \leq .05$.

Results: There were significant negative relationships between GLBP score and average 18-hole score ($r = -.33$, $p = .02$), current pain ($r = -.47$, $p < .001$), average pain ($r = -.32$, $p = .02$), and worst pain ($r = -.39$, $p = .004$). There were significant positive relationships between GLBP score and days of golf played per week ($r = .42$, $p = .002$) and Godin score ($r = .44$, $p = .001$). No significant relationships existed between GLBP score and height ($r = -.03$, $p = .81$) or weight ($r = -.17$, $p = .23$).

Conclusions: Higher levels of golf-related LBP disability were associated with higher pain levels and worse average 18-hole scores in adult golfers. Higher levels of golf-related LBP disability were associated with lower levels of physical activity. Height and weight were not associated with golf-related LBP. Decreasing severity of pain may relate to decreased golf-related disability, increased physical activity, and improved golf performance. The GLBP is a valuable patient-reported outcome measure for this population and relates to factors such as demographics and pain. Reducing LBP symptoms is important to decrease disability and increase physical activity, which may ultimately allow more frequent sport participation and may improve performance.

**Gender Differences in NeuroCom®
VSR Sport System Limits of Stability
Protocol in Division I Intercollegiate
Athletics**

Stiltner S, Cripps AE, Toonstra JL:
Bowling Green State University,
Bowling Green, OH

Context: Limits of stability (LOS) is a patient's ability to voluntarily move their center of gravity (COG) without losing their balance. Within the LOS assessment, movement reaction time (RT), movement velocity (MVL), endpoint excursion (EPE), maximum excursion (MXE) and directional control (DC) are assessed. These LOS assessments have not been utilized in an athletic population as part of routine baseline testing, however it is known that LOS is fundamental to mobility tasks required in athletics, and it has been suggested that there may be impairments in function without appropriate postural stability. Postural stability impairments leading to injury disproportionately affect females over males, but females have shown superior dynamic postural stability over males. LOS has been established as a reliable assessment of postural stability and dynamic control but, no normative data exists for a healthy, collegiate athletic population. Additionally, data to establish difference in dynamic postural stability between healthy, elite athlete male and females does not

exist. With that, it was the purpose of this study to identify male vs. female normative data for a LOS protocol. **Methods:** Participants were 499 healthy intercollegiate athletes participating at a Division I institution (269 male, 230 female). Participants completed the LOS testing protocol as outlined by the NeuroCom® company, as part of their routine baseline testing. Participants were asked to move their COG as quickly and accurately as they could to 8 specific targets. Outcomes for the LOS were composite scores for RT, MVL, EPE, MXE, and DC. A one-way ANOVA was calculated comparing gender differences for each of the LOS outcomes. **Results:** Significant between group differences were noted in RT ($F_{1,497}=37.58$, $p < .01$) and MV ($F_{1,497}=10.98$, $p = < .01$). Males have a faster reaction time ($0.71, \pm 0.16$) than females ($0.81, \pm 0.18$). Males also have a greater movement velocity ($5.22, \pm 1.41$) than females ($4.80, \pm 1.41$). Table 1 identifies gender differences for remaining variable between male and female participants. **Conclusions:** This study provides normative data of the LOS protocol for intercollegiate athletes, stratified by gender. Limits of stability assessments have been used to assess the voluntary motor control within their COG. Results of the study will provide clinicians working with this population baseline values. This data gives clinicians access to normative data for comparison purposes.

**Movement Assessment Battery
Performance of Singles Figure Skaters**
Mangum LC, Garcia G, Gilbert M,
Munoz B, Sanchez-Torres M, Ingersoll
CD, Slater L: University of Central
Florida, Orlando, FL; University of
Illinois, Chicago, IL; US Figure Skat-
ing, Colorado Springs, CO

Context: Incorporating functional assessments can be beneficial for a variety of sports; notably when using power, balance, and endurance tests to aid clinicians in decision-making. Figure skating incorporates specific movement assessments through combine and developmental screenings. Females have better balance and endurance in the elite level skater, although developmental skaters may exhibit other sex differences. The purpose of this study was to assess performance differences in male and female singles figure skaters in a battery of movement assessments. **Methods:** Fifty-five singles skaters from the US Figure Skating Development Camp were included in this study (Age: 13.6±1.9 years; Leg length: 81.8±6.9 cm; 26 males; 29 females). All athletes completed the following

tests: bilateral squat, vertical jump, 4-jump, and lateral bound. Evaluators were trained by a single investigator and used the same scoring procedures and rubric. Testing instructions and scoring were based on established testing procedures in the literature. Two trials were performed for the bilateral squat, and lateral bound, which were scored on a 0-2 scale. Hip/knee/ankle alignment, balance/control, and landing position were evaluated on the 0-2 scale. A score of 2 indicated optimal performance and 0 was poor performance. Vertical jump height, 4-jump height and ground contact time were recorded for two trials using an instrumented mat. The scores from each trial were averaged. Mann-Whitney U tests were used to determine sex differences for non-normally distributed data from the 0-2 rubric-scored variables (bilateral squat, lateral bound). Independent t-tests were used to evaluate sex differences in continuous and normally distributed vertical jump height (cm), 4-jump height (cm), and 4-jump ground contact time (s). Cohen's d effect sizes were calculated for significant findings to determine magnitude of difference. **Results:** Males exhibited a 0.05s longer ground contact time on the right with a moderate effect ($p=.03$, $d=.59$) and 0.09s on

the left ($p=.007$, $d=.76$) during the 4-jump test with a large effect (Table 1). Males had a deeper bilateral squat depth with 65.4% scoring a 2, while 20.7% of females scored a 2 ($p=.01$). There were no significant sex differences in the lateral bound, vertical jump and 4-jump height. **Conclusions:** Movement assessments revealed deeper squat depth and longer ground contact time in jump tests for developmental male singles figure skaters. Power-based assessments showed an increased frequency of optimal test performance in males, which is contrary to improved balance and control in female skaters in prior testing. The use of a battery of jump, squat, and bounding tests can be useful in a developmental population whose sport requires power and control to progress sport-specific skills.

Table 1. Average movement assessment scoring for all skaters and sex comparison for each test

	All (n=55)	Males (n=26)	Females (n=29)	Sex comparison p-value	Cohen's d effect size (95% confidence interval)
Vertical jump (cm)	15.89±1.99	16.27±2.11	15.54±1.86	.18	0.37 (-0.17, 0.90)
4-jump GCT right (s)	0.48±0.13	0.52±0.12	0.45±0.12	.03*	0.59 (0.05, 1.13)
4-jump height right (cm)	8.38±1.29	8.44±1.37	8.33±1.23	.75	0.09 (-0.44, 0.62)
4-jump GCT left (s)	0.49±0.13	0.54±0.15	0.45±0.08	.007*	0.76 (0.21, 1.30)
4-jump height left (cm)	8.07±1.24	8.04±1.16	8.09±1.33	.89	-0.04 (-0.57, 0.49)

*, $p \leq .05$

Cm, centimeters; GCT, ground contact time; s, seconds.

**Accuracy of Diagnostic Imaging of
Triangular Fibrocartilage Complex
Injuries: A Critically Appraised Topic**
Brewin DO, Jutte LS: Xavier
University, Cincinnati, OH

Context: Arthroscopy is the gold standard for diagnosing triangular fibrocartilage complex (TFCC) injuries. Because it is costly and invasive, diagnostic imaging is a preferred method. MRI is most commonly used, but reports from the literature demonstrate some inconsistencies in detecting TFCC injuries. Magnetic resonance arthrography (MRA) is an alternative diagnostic imaging technique that can detect these tears, therefore clinicians should consider which imaging technique is superior. In patients with wrist injuries, is MRA more accurate, sensitive, and specific, than MRI in detecting TFCC injuries? **Methods:** CINAHL, Medline, and SPORT Discus databases were searched in October 2022, followed by a hand search through references. Search terms included: “MR arthrography OR arthrography”, AND “triangular fibrocartilage complex tear OR injury,” AND “MRI OR magnetic resonance imaging,” AND “diagnostics OR diagnosis” AND “wrist injuries”. Only articles written in English in the last 5 years, where MRA was compared to MRI for the diagnosis of TFCC injuries were included. Any study on overall wrist pain and/or CT comparisons to MRA or MRI, but not both, were excluded.

Articles were either scored with the QUADAS or PRISMA-NMA. Outcome measure gathered included diagnostic accuracy, sensitivity, and specificity. In studies where outcome measures were reported separately by location of injury, the values were averaged. **Results:** The initial search produced 328 articles. Five diagnostic studies and a meta-analysis remained after exclusion criteria were applied. Two diagnostic studies were removed since they were included within the meta-analysis. The 3 diagnostic studies scored in the high-range using the QUADAS. The meta-analysis scored 21/27 on the PRISMA. All studies were rated as a level 1 study on the SORT scale. All 4 studies found that MRA was more accurate (range across all studies 0.84 to 0.98), sensitive (range across all studies 0.77 to 1.0), and specific (range across all studies 0.85 to 1.0) than the MRI [accuracy (range across all studies 0.72 to 0.86), sensitive (range across all studies 0.63 to 0.79), specificity (range across all studies 0.71 to 0.91)] when detecting all TFCC tears. **Conclusions:** MRA should be utilized more than MRI when a TFCC injury or tear is suspected as the evidence supports that MRA is more sensitive, specific, and accurate. The strength of this recommendation is grade A on the SORT scale based on consistent diagnostic evidence. Clinicians will more accurately diagnose TFCC injuries when using MRA, thus leading to more efficiency in treatment, time, and costs.

Ultrasound-Detected Knee Effusion Does Not Affect Lower Limb Loading During Drop-Vertical Jumps in Division I Colligate Female Athletes

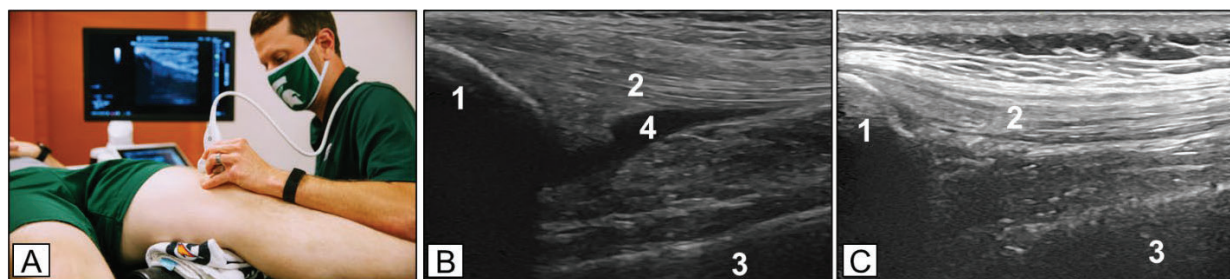
Grozier CG, Tolzman JE, Fajardo R, Collins K, Fox B, Kuenze C, Harkey MS: Michigan State University, East Lansing, MI; Lansing Radiology Associates, Lansing, MI; University of Virginia, Charlottesville, VA

Context: The presence of knee effusion can be detected with ultrasound and may be an early sign of underlying structural pathology or a natural inflammatory response to athletic activity. Experimental effusions have been shown to result in an immediate decrease in quadriceps activation and changes in lower limb loading during stair descent. However, naturally occurring effusion, in the absence of acute pathology, have not been studied among young active people, and it is unclear if the presence of effusion affects lower limb loading during a drop-vertical jump. Therefore, the purpose of this study was to determine the bilateral prevalence of knee effusion in Division I female athletes, as well as if lower extremity loading differ between athletes with and without effusion during a drop-vertical jump. **Methods:** Forty-two female Division I athletes (Height: 170.2 ± 7.5 cm, Mass: 67.0 ± 10.0 kg, age: 19.9 ± 1.4 years) participated in an ongoing study that included a knee ultrasound assessment and a drop-vertical jump biomechanics assessment in a research laboratory. In this cross-sectional sub-analysis, effusion was assessed bilaterally by a single investigator with a sagittal suprapatellar ultrasound scan (Figure A). Participants were positioned supine with a bolster under their knee. The

presence of effusion was defined as an abnormal hypoechoic (i.e., dark) area deep to the quadriceps tendon (Figure B/C). Participants were then categorized into three groups based on the bilateral presence of effusion (i.e., no effusion in either limb, effusion in one limb, effusion in both limbs). Participants then completed three drop-vertical jumps from a 30 cm box that was positioned half of their height away from two force plates. Lower extremity loading was quantified bilaterally as the peak vertical ground reaction force normalized to body weight (vGRF in body weights [BW]) averaged across each trial in both limbs. We used frequencies to characterize the bilateral prevalence of knee effusion. Separately for the right and left limbs, we used a t-test to compare the peak vGRF during drop-vertical jumps between athletes with and without knee effusion within the respective knees. **Results:** Of the 42 participants evaluated, 14 (33%) had unilateral knee effusion and 14 (33%) had bilateral knee effusion. There were no significant differences in the peak vGRF for the right (2.17 ± 0.5 BWs, $t_{40} = 0.09$, $p = 0.93$) and left (1.93 ± 0.4 BWs, $t_{40} = -1.07$, $p = 0.29$) limbs between athletes with and without effusion within the respective knees. **Conclusions:** Two-thirds of these Division I female athlete participants evaluated had effusion in at least one of their knees. However, the presence of effusion did not appear to affect lower limb loading during a dynamic drop-landing task in these athletes. Since the prevalence of effusion is so high in these individuals, future research is needed to determine if the presence of effusion affects any other clinically relevant outcomes or performance.

Dr. Harkey was funded on a NIH Grant (K01AR081389).

Figure. Assessing Knee Effusion with Ultrasound. A) Suprapatellar longitudinal scan: probe position = distal femur and proximal patella, participant position = supine 30° knee flexion. B) Example image of suprapatellar longitudinal scan with effusion. C) Example image of suprapatellar scan without effusion. Key landmarks: 1. Proximal pole of the Patella; 2. Quadriceps tendon; 3. Superficial femur; 4. Effusion



Resilience and Grit in the Professional Firefighter

Tinsley JE, Uhl TL, Heebner NR, Abel MG, Hoch JM: University of Kentucky, Lexington, KY

Context: Recent evidence suggests career firefighters experience job stress, depression, burnout, and post-traumatic stress disorder (PTSD). Previous investigations support a relationship between musculoskeletal disorders and psychosocial factors, with suggestions that factors relating to tenacity and the ability to handle these stressors may be pertinent. Therefore, our purpose was to identify factors predictive of grit and resilience in career firefighters. We hypothesized that years of experience, injury history and status, current assignment, and professional quality of life questionnaire (ProQOL) scores would predict resilience and grit scores. This understanding can begin elucidating the direction of the relationship between personal and psychosocial factors and musculoskeletal disorders in a population seeing increased engagement with athletic trainers. **Methods:** We collected demographic, occupational, and injury history information from a convenience sample (n=97, 92 male) of career firefighters in this cross-sectional survey study. Occupational information obtained included rank (e.g., lieutenant, captain, etc.), years of service, and current assignment (ambulance, fire engine, etc.). Participants completed the Brief Resilience

Scale (BRS) to measure resilience, the Short Grit Scale (Grit-S) to measure grit, and the ProQOL to assess compassion satisfaction (ProQOL-CS) and compassion fatigue which included two subscales: burnout (ProQOL-Burnout) and secondary traumatic stress (ProQOL-STSS), which assesses fear and work-related stress. Separate linear regression analyses were used to examine the relationship between resilience and grit with sex, participant rank, years of service, primary assignment, injury history and current injury status, ProQOL-CS, ProQOL-Burnout, and ProQOL-STSS. Pearson's correlations were used to select variables that progressed into each model ($r \geq 0.20$) to minimize model overfitting, as well as identify collinearity between predictors ($r \leq 0.70$). **Results:** Descriptive data are presented in Table 1. Pearson's correlations indicated that only ProQOL-CS ($r=0.382$), ProQOL-STSS ($r=-0.302$), and sex ($r=-0.263$) would progress into the model predicting BRS scores, and ProQOL-CS ($r=0.223$) and ProQOL-STSS ($r=-0.372$) would progress into the model predicting Grit-S scores. No collinearity was indicated between variables. Sex ($\beta: -0.568$), ProQOL-CS ($\beta: 0.028$), and ProQOL-STSS ($\beta: -0.016$) were predictive of BRS scores, accounting for 24% of variance ($p < 0.001$). ProQOL-STSS ($\beta: -0.026$) predicted Grit-S scores, accounting for 14.6% of the variance ($p < 0.001$). **Conclusions:** Sex, compassion satisfaction, and secondary stress predicted psychosocial constructs in career firefighters. Specifically, male participants with

moderate ProQOL-CS and moderate ProQOL-STSS displayed higher BRS scores. Additionally, participants with moderate ProQOL-STSS presented higher Grit-S scores. While the male to female ratio is representative of the firefighting population, sex as a predictor should be interpreted with caution. While injury history was not predictive of resilience and/or grit, many previous cross-sectional studies support that these psychosocial constructs relate to occurrence of injury. To expand on these previous findings and identify holistic prevention and treatment strategies, future prospective studies should investigate personal and psychosocial factors in prediction of firefighter musculoskeletal disorders.

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Table 1: Descriptive Data

Outcome Measure	Means \pm SD	Interpretation of Score
BRS	4.03 \pm 0.50	
Grit-S	3.61 \pm 0.39	
ProQOL: Compassion Satisfaction	39.47 \pm 5.57	Moderate
ProQOL: Compassion Fatigue Burnout Subscale	21.96 \pm 5.67	Low
ProQOL: Compassion Fatigue Secondary Traumatic Stress Subscale	29.73 \pm 3.63	Moderate

Relationships Between Three Neuromuscular-Cognitive Assessments in Collegiate Women's Tennis Athletes

Porter KH, Torp DM, Ochoa L, Hoch MC: University of Kentucky, Lexington, KY

Context: Integrating neuromuscular and cognitive assessments may provide a more clinically relevant strategy for assessing injury recovery and human performance. Developing neuromuscular-cognitive assessments that mimic the dynamic nature of athletics (i.e., multidirectional cutting and jumping) may enhance contextual relevance. Currently, it is unknown how individuals perform on neuromuscular-cognitive assessments that vary in physical and cognitive demand. Therefore, the purpose of this research was to investigate the relationship between a spectrum of neuromuscular-cognitive assessments in healthy collegiate tennis athletes. **Methods:** Ten collegiate female tennis athletes (20.10 ± 1.20 y; 170.26 ± 6.58 cm; 59.86 ± 5.59 kg) volunteered for this cross-sectional study. During a single visit, participants completed 3 neuromuscular-cognitive assessments: reactive agility (RA), single-leg memory hop (SLMH), and lower extremity reaction task (LERT). For RA, participants stood in the center of a 4mx4m square with light sensors on tripods at each corner. Each light illuminated with a unique color and as quickly as possible, the participant identified the dark blue sensor, extinguished it with their hand, then returned to the center marker. This process was repeated 10 times for 2 trials (Figure 1A). For the SLMH, participant stood on their dominant leg as a light sensor in front of them flashed various colors. When the sensor

turned dark blue, the participant completed one single limb hop as quickly and far as possible, landing and stabilizing on the same leg. A second sensor to the side of the participant captured reaction time during each of the 3 trials (Figure 1B). For the LERT, 5 sensors were positioned around a 180° semicircle in increments of 45°. The distance of the lights from the participant was normalized to shank length. Participants stood on their dominant limb and deactivated the sensors with the opposing foot as quickly as possible for 3 trials of 60s (Figure 1C). The average reaction time (seconds) from each assessment was used for analysis. RA reaction time was normalized to height (seconds/centimeter). The relationship between assessments was examined with Pearson correlation coefficients ($\alpha=0.05$). **Results:** No significant relationships were identified between assessments. The normalized RA (0.012 ± 0.001 s/cm) had a moderate positive correlation to the SLMH (1.28 ± 0.19 s, $r=0.46$, $p=0.18$) and a weak negative relationship to the LERT (0.65 ± 0.11 s, $r=-0.218$, $p=0.55$). Additionally, the SLMH had a weak relationship to the LERT ($r=0.06$, $p=0.88$). **Conclusions:** This study determined that RA had a moderate relationship to the SLMH and LERT had weak relationships to RA and SLMH. These results suggest that each assessment possessed unique attributes, particularly the LERT, which focused on reacting while maintaining static balance. The moderate relationship between the RA and SLMH may signify these dynamic assessments required more comparable levels of cognitive demand and motor planning. Overall, strong correlations were not identified between any tests suggesting each may provide unique insights for neuromuscular-cognitive function.



Figure 1. A: Reactive Agility; B: Single Leg Memory Hop; C: Lower Extremity Reaction Task

The Relationship Between Patient-Generated Outcome Measure Severity Ratings and the Modified-Disablement in the Physically Active Scale

Howard JS, Tinsley JE: Appalachian State University, Boone, NC, and University of Kentucky, Lexington, KY

Context: A recent investigation demonstrated that the use of a patient-generated outcome measure (PGOM) may qualitatively identify areas of primary concern for highly active patients, such as collegiate student-athletes, that are not encompassed in those patient-reported outcome measures (PROMs) most commonly used in athletic training. However, a quantitative comparison of PGOM and PROM ratings has not been reported in this patient population. Therefore, the purpose of this report is to describe the relationship between self-reported severity ratings on a PGOM, the Measure Your Medical Outcomes Profile-2 (MYMOP-2), and PROM scores on a commonly used global disability measure, the modified-Disablement in the Physically Active Scale (mDPA). **Methods:** For this cross-sectional study, injured collegiate-athletes (n=150, 72 females, age=19.6±1.4) completed a PGOM, the MYMOP-2. Any athlete experiencing an injury that altered participation in their competitive sport was eligible to participate. The MYMOP-2 has previously been validated for use in active populations and instructs the patient to identify up to two symptoms and one activity that bother them most. Patients also

provide a severity rating for these patient-generated responses (Symptom 1, Symptom 2, and Activity) and their “general well-being over the last week” from 0 (“as good as it could be”) to 6 (“as bad as it could be”). Spearman rho correlations were used to compare MYMOP-2 severity ratings to mDPA mental and physical summary component scores. **Results:** Median(range) values were Symptom 1= 4(0-6), Symptom 2=3.5 (0-6), Activity=4(0-6), Well-being=3(0-6), mDPA Physical=23(0-48), and mDPA Mental=3.5(0-16). Low to fair correlations ($\rho=0.195$ to $\rho=0.479$, $p<0.05$; Table) were observed between MYMOP-2 severity ratings and mDPA scores. The highest relationship was between the patient-generated Activity severity rating and the mDPA physical summary component, while the lowest correlation was between Symptom 2 and the mDPA mental summary component. **Conclusions:** All MYMOP-2 severity ratings and mDPA component scores were positively correlated with one another suggesting that all are associated with the patients’ underlying state of overall disability. However, these correlations were limited, with, at most, 23% of the variation in one instrument explained by variation in the other. These results are in agreement with previous research proposing that PGOMs identify unique patient-concerns. These results indicate that self-reported disability severity, focused on patient-identified concerns, cannot be fully quantified in the mDPA despite it being considered a global measure. Furthermore, even within the MYMOP-2,

only fair correlations were observed between the severity ratings for Symptom 1, Symptom 2, and the Activity patient-generated items, suggesting these items also may largely vary independently from one another. In order to achieve patient-centered care, the patient’s priorities and concerns must be identified and quantified in order to evaluate treatment success. The addition of a PGOM, such as the MYMOP-2 provides unique qualitative and quantitative information towards achieving this goal.

Table. Spearman's Rho Correlation Coefficients

	MYMOP2 [†] Symptom 1 Severity	MYMOP2 Symptom 2 Severity	MYMOP2 Activity Limitation Severity	How would you rate your general feeling of well-being during the last week?	mDPA [‡] Physical Component	mDPA Mental Component
MYMOP2 Symptom 1 Severity (n=150)	-	0.431** (p<0.001)	0.480** (p<0.001)	0.334** (p<0.001)	0.311** (p<0.001)	0.274** (p=0.001)
MYMOP2 Symptom 2 Severity (n=110)	0.431** (p<0.001)	-	0.380** (p<0.001)	0.339** (p<0.001)	0.223* (p<0.021)	0.195* (p=0.043)
MYMOP2 Activity Limitation Severity (n=146)	0.480** (p<0.001)	0.380** (p<0.001)	-	0.496** (p<0.001)	0.479** (p<0.001)	0.361** (p<0.001)
How would you rate your general feeling of well- being during the last week? (n=148)	0.334** (p<0.001)	0.339** (p<0.001)	0.496** (p<0.001)	-	0.442** (p<0.001)	0.428** (p<0.001)
mDPA Physical Component(n=148)	0.311** (p<0.001)	0.223* (p=0.021)	0.479** (p<0.001)	0.442** (p<0.001)	-	0.561** (p<0.001)
mDPA Mental Component (n=148)	0.274** (p<0.001)	0.195* (p=0.043)	0.361** (p<0.001)	0.428** (p<0.001)	0.561** (p<0.001)	-

[†]Measure Your Medical Outcomes Profile - 2, [‡]modified-Disablement in the Physically Active scale, *p,0.05,

Body Dysmorphic Disorder Screening Tool Usage in Athletic Training

Hughes JI, Drescher MJ, Eberman LE:
Indiana State University, Terre Haute,
IN

Context: Current studies have stated that body dysmorphic disorder is often misdiagnosed or underdiagnosed. Recognition of body dysmorphic disorder is critical due to marked impairment in psychosocial functioning, notably a poorer quality of life, and high suicidality rates associated with the disorder. As body dysmorphic disorder typically begins during childhood or adolescence, athletic trainers working within the collegiate setting may benefit from the knowledgeable of the criteria associated with the disorder and effective screening tools that can be implemented to measure symptoms and severity. A substantial gap in knowledge exists as no studies have been conducted regarding body dysmorphic disorder screening tools within Athletic Training. Body dysmorphic disorder screening tool education is needed now more than ever. **Methods:** A cross-sectional mixed methods, web-based survey was used to explore the usage of body dysmorphic disorder screening tools in athletic training. The survey was comprised of 7 open and 26 closed-ended questions examining demographics, knowledge of BDD, and screening tools used to mitigate BDD. The tool was validated using a CVI process with a scale-CVI/Average of .98. Data were analyzed using measures of central tendency

and frequency counts. Open-ended questions were analyzed following the guidelines for thematic analysis, and data was identified, analyzed, organized, described, and reported into themes found within our data set by the primary investigator. **Results:** The survey was distributed to 5,422 certified athletic trainers in good standing with the NATA and working in the collegiate setting. 505 people accessed the survey (Access rate=9.3%), and 498 responded to the survey (Response rate=9.2%). Overall, 306 participants ($M = 10.7 \pm 9.1$ -year, range = 1-46 years) completed the entire instrument (61.8% completion rate). Of participants, 78 identified as man (25.3%), 224 identified as woman (72.7%), 3 preferred not to identify (1.0%), and one person did not answer the question (0.33%). When asked about body dysmorphic disorder screening tool usage within the profession of Athletic Training, 94.4% ($n=289$) did not use any screening tools. Participant reasons for not using BDD screening measures included lack of knowledge (25.5%, $n = 78$), belief that BDD is not prevalent in their patient population (19.3%, $n = 59$), belief that identifying BDD is not in their scope of practice (15.4%, $n = 47$), lack of control or resources in their clinical practice (14.4%, $n = 44$), or a perceived lack of time (1.3%, $n = 4$). **Conclusions:** The majority of athletic trainers do not use any tool to screen for BDD in their patient populations. Future research should explore future strategies that can be used to increase implementation of BDD screening tools within athletic training.

An Explorative Analysis of the Relationship Among the Lower Y-Balance Test, Upper Y-Balance Test and the Bunkie Test

Anderson EM, Young JP, Eberman LE, Games KE: Indiana State University, Terre Haute, IN

Context: The Bunkie Test (BT) uses 5 trunk-bridging positions to assess static endurance of core musculature. The Upper-Quarter Y-Balance Test (UQYBT) assesses dynamic shoulder stability in a closed-kinetic-chain position, while the Lower-Quarter Y-Balance Test (LQYBT) assesses dynamic, single-leg lower extremity mobility and stability. The purpose of this study was to investigate the relationships among the LQYBT, Upper-Quarter Y-Balance Test UQYBT, and BT. A knowledge of the potential relationships between these different functional tests could provide valuable information for clinicians to consider as they evaluate and deliver interventions for musculoskeletal injury, function, or performance. **Methods:** We used a lab-based, crossover study to explore the relationships between the LQYBT, UQYBT, and BT. Twenty (6 males, 14 females) individuals participated in the study (age=23.1 ± 1.51 years, mass=75.22 ± 13.23 kg, height=166.88 ± 8.06 cm, leggedness=20 right, handedness=20 right, exercise participation=9.55 ± 5.85 hours/week). The testing session consisted

of demographic characteristics, anthropometric and limb-length measurements, handedness, leggedness, and functional test performance. Participants were randomly assigned a testing order and provided 30-60 second, and 5-minute, rest periods between each individual test direction or position, or functional tests, respectively. The BT has five positions; anterior power line (BT-APL), lateral stabilizing line (BT-LSL), posterior power line (BT-PPL), posterior stabilizing line (BT-PSL), and medial stabilizing line (BT-MSL), which were measured bilaterally. BT performance was measured by position-hold for time, in seconds. LQYBT and UQYBT performance was measured by reach distance in 3 directions, over 3 trials for each direction. We calculated composite reach distance, consisting of the sum of the means for each distance, divided by 3 times the limb-length, for both Y-Balance Tests (YBT) and used that calculation for analyses. Descriptive statistical analyses were used for demographic and functional test variables. Inferential comparisons and correlations were used to explore differences and relationships between composite reaches for the LQYBT and UQYBT, and performance on BT positions. **Results:** No significant differences ($p=0.586$) between right ($M=92.0\pm7.9$) and left ($M=91.5\pm6.6$) composite reaches were present for the LQYBT. Significant differences were present ($p=.007$) between right ($M=85.0\pm11.5$) and left ($M=82.9\pm11.3$) composite reaches for

the UQYBT. Mean BT scores were largely normative (Table 1). We identified 11 relationships between the BT positions and YBT that were statistically significant ($p < 0.05$) with moderately positive relationships (Table 1). **Conclusions:** Significant relationships most commonly occurred between YBTs and the BT-LSL and the BT-APL test positions. The BT-LSL and BT-APL positions are believed to assess the rectus abdominus, rectus femoris, internal obliques, external, and latissimus dorsi. The static endurance performance of these muscles may be related to performance on the YBTs in active and healthy individuals and should be considered during functional movement screening and evaluation to provide a holistic representation of movement-related patient function.

Table 1. Bunkie Test Scores and Pearson Correlations Between Bunkie Test Positions and Lower and Upper Y-Balance Test Composite Reach Distance

BT Test Position (M±SD)	Left LQYBT	Right LQYBT	Left UQYBT	Right UQYBT
Right BT-APL (39.0±14.5)	.31	.32	.51*	.60**
Left BT-APL (37.7±13.6)	.50*	.48*	.59**	.62**
Right BT-LSL (35.4±15.3)	.39	.46	.63**	.64**
Left BT-LSL (36.1±15.3)	.57**	.62**	.58**	.61**
Right BT-PPL (30.7±18.1)	.39	.25	.12	.16
Left BT-PPL (29.4±19.0)	.36	.19	.09	.11
Right BT-PSL (22.3±16.2)	-.03	.07	.20	.27
Left BT-PSL (22.9.0±15.8)	.26	.19	.24	.29
Right BT-MSL (20.0±15.8)	.27	.36	.16	.28
Left BT-MSL (18.8±15.2)	.27	.39	.23	.29

* r significant at $p < .05$, ** r significant at $p < .001$

BT mean scores reported in seconds

The Intra-Rater and Inter-Rater Reliability of a Novel Handheld Toe Strength Dynamometer

Xu J, Goss DD, Saliba SA: University of Virginia, Charlottesville, VA

Context: Patients with plantar fasciitis, patellofemoral pain syndrome, and chronic ankle instability demonstrate reduced intrinsic foot muscle (IFM) size and strength. It is vital for clinicians to have a method to track IFM strength changes in populations like these. However, IFM strength assessment has primarily been laboratory-based. Previous methods to obtain surrogate strength measures have included ultrasound or MRI to assess size and EMG to assess muscle activity, while custom-built dynamometers, pressure platforms, and force plates have been used to quantify force output. The purpose of this study was to assess the reliability of a clinically useful novel toe strength dynamometer (Human Locomotion, Newton, MA) in assessing IFM strength of healthy adults. We hypothesized that the toe dynamometer would have good reliability (ICC=.75). **Methods:** Twenty-five healthy individuals (4 males, 21 females; age: 21.6 ± 3 , mass: 65.14 ± 12.44 kg, height: 164.92 ± 8.45 cm) participated in this laboratory-based reliability study. Two novice assessors measured participants' toe strength on two occasions 6.7 \pm 0.8 days apart. The commercially available toe dynamometer consisted of a plastic card attached to a hanging scale (American Weigh Scales, Georgia, USA). Participants were placed in a hook-lying position on low-pile carpet for the entire test, and

the card was placed under their toe(s) according to the toe condition chosen. The 4 toe conditions were randomized in a Latin square scheme: 1) great toe (GT) dominant foot, 2) lesser toes (LT) dominant foot, 3) GT non-dominant foot, 4) LT non-dominant foot. They were instructed to press down with the toe(s) to resist the assessor pulling the card out over a period of 3 seconds. Peak force was recorded for 3 trials under each condition. Means and standard deviations (SD) per assessor and session were calculated, along with standard error of measurement (SEM) to indicate absolute reliability, or variation in individuals' measurements. Intra-class correlation coefficients (ICC) were calculated per condition using SPSS (Version 28, Chicago, IL), where ICC(3,1) indicates intra-rater reliability for each assessor and ICC(2,1) indicates inter-rater reliability between assessors. ICC values were interpreted as poor (< 0.5), moderate (0.5-0.75), good (0.75-0.9), and excellent (> 0.9). **Results:** Condition means, SD, and SEM across time-points were reported (Table 1). Intra-rater and inter-rater reliability of the toe strength dynamometer was good to excellent across all conditions (Table 1). **Conclusions:** This novel toe dynamometer is a budget-friendly (\$75), compact tool that has been shown to be reliable both within raters and between raters when applied to a healthy population. Future research should assess the validity of this device compared to other previously used IFM assessments to determine its feasibility in tracking strength changes in rehabilitation processes in pathological populations, or potentially identifying individuals at risk for injuries.

Intersession Reliability of Quadriceps Corticospinal Excitability: A Functional Transcranial Magnetic Stimulation Study

Young KM, Rush JL, Lepley AS, Norte GE: University of Toledo, Toledo, OH, and University of Michigan, Ann Arbor, MI

Context: Transcranial magnetic stimulation (TMS) derived measures of quadriceps corticospinal excitability have demonstrated acceptable reliability when assessed during open-chain knee extension tasks. However, very few studies have explored the reliability of corticospinal excitability during more functional closed-chain tasks, which may better reflect brain-to-muscle dynamics during daily activities, such as gait and stair negotiation. Therefore, our objective was to investigate the intersession reliability of TMS-derived measures of quadriceps corticospinal excitability during a single-leg squat in uninjured, physically active females. On the basis of previous literature, we hypothesized that the active motor threshold (AMT) would demonstrate strong intersession reliability, and that motor evoked potential (MEP) amplitudes would demonstrate moderate intersession reliability due to having

inherently higher variability. **Methods:** We used a descriptive laboratory study with test-retest design to investigate the reliability of TMS-derived outcomes during a single-leg squat. 20 uninjured, physically active females (22.05 ± 2.54 years, 1.68 ± 0.73 m, 66.34 ± 13.62 kg, 5.90 ± 1.12 Tegner Activity Scale) were assessed in a research laboratory at the same time of day on two separate visits using an identical single-pulse TMS protocol. The independent variables were time (day 1, day 14) and limb (dominant, non-dominant). The dependent variables were AMT (%) and background EMG-normalized MEP (unit-less ratio) amplitudes at 120% of the AMT. Each outcome was assessed via surface EMG on the vastus medialis of each limb. Participants performed a series of single-leg squats to a depth that induced 10-15% of their maximum EMG amplitude with the aid of visual feedback, before a single TMS pulse was delivered. Two-way mixed effects intraclass correlation coefficients were used to assess the intersession reliability for internal consistency (ICCConsistency) and absolute agreement (ICCAbsolute). Minimal detectable changes with 95% confidence intervals (MDC95) were calculated to aid in interpretation. **Results:** The dominant limb AMT demonstrated moderate reliability (ICCAbsolute = 0.771, $p < .001$, MDC95 = 6.46%). However, the non-dominant

limb AMT (ICCAbsolute = 0.364, MDC95 = 12.67%), and normalized MEPs of the dominant (ICCAbsolute = 0.192, MDC95=17.87) and non-dominant (ICCAbsolute = 0.272, MDC95 = 14.77) limbs demonstrated poor reliability. **Conclusions:** AMT was moderately reliable and demonstrated a low MDC95 in the dominant limb over a two-week period, suggesting it may be an adequately sensitive measure to investigate corticospinal excitability in uninjured, physically active females during functional activities. The poor intersession reliability observed in the non-dominant limb may be attributed to limb dominance, which is known to influence neuromuscular control and motor behavior during single-leg, dynamic tasks. Future research is likely warranted to improve the standardization of this technique prior to incorporating in outcomes research.

This study was funded by the Gordy Graham Research Assistance Award from the Great Lakes Athletic Trainers' Association.

Table 1. Intersession reliability of TMS-derived outcomes over 2 weeks

Measure	n	ICC ^a (Consistency)	95% CI		ICC ^a (Absolute)	95% CI		P value	SEM	MDC ₉₅
			Lower	Upper		Lower	Upper			
Dom AMT	20	0.769	0.50	0.90	0.771	0.51	0.90	<.001*	2.33%	6.46%
Dom MEP	18	0.184	0.00	0.70	0.192	0.00	0.71	.340	6.45	17.87
Non AMT	20	0.375	0.00	0.70	0.364	0.00	0.68	.047*	4.57%	12.67%
Non MEP	19	0.292	0.00	0.73	0.272	0.00	0.71	.235	5.33	14.77

Abbreviations: ICC, Interclass Correlation Coefficient; CI, confidence interval; SEM, standard error of measure; MDC, minimal detectable change; Dom, dominant limb; AMT, active motor threshold; MEP, motor evoked potential; Non, non-dominant limb

^a Strength of intersession reliability: moderate (yellow), poor (red)

* Statistically significant at $P \leq .05$

Use Of Diagnostic Ultrasound In Evaluating Rotator Cuff Tears: A Critically Appraised Topic

Legan J, Mansell JL, Tierney RT, Russ AC: Temple University, Philadelphia, PA

Context: Shoulder injuries, including rotator cuff tears, can be complex and difficult to diagnose. While MRIs are often sought to gain objective clarity, they can be time-consuming and expensive. Diagnostic ultrasound is becoming a more readily available evaluation technique that can offer an inexpensive way to objectively evaluate an injury. Is diagnostic ultrasound an accurate way of identifying patients with rotator cuff tears? **Methods:** PubMed was searched in June of 2022 using a PICO (Patient, Intervention, Comparison, Outcome) format to generate a search strategy using Boolean search phrases. Boolean search phrases included: Diagnostic Ultrasound AND Shoulder, Diagnostic Ultrasound AND Rotator Cuff, Diagnostic Ultrasound AND MRI AND Shoulder, Musculoskeletal Ultrasound AND Shoulder. Only studies from the last five years were considered. Outcome measures of sensitivity, specificity, positive likelihood ratios (LR+) and negative likelihood ratios (LR-) were used to determine if diagnostic ultrasound is effective in detecting rotator cuff tears. The QUADAS-2/QUADAS-C were used to critically appraise each article. The assessment has four domains which are used to assess risk for bias and applicability judgement of the study. **Results:**

The search returned 20 articles and 3 met all inclusionary criteria. In one cohort study full thickness tears reported a sensitivity of 93.7% and specificity of 100% (LR+=93.7, LR-=.06). Partial-thickness tears reported a sensitivity of 52.9% and specificity of 96.7% (LR+=16.03, LR-=.489). The second cohort study reported a sensitivity of 94.7% and specificity of 100% (LR+=94.7, LR-=.54) for full-thickness tears, while reporting a sensitivity of 80.8% and specificity of 100% (LR+=80.8, LR-=.19) for partial-thickness tears. The third cohort study did not differentiate between full-thickness and partial-thickness tears but reported a sensitivity of 87.5% and a specificity of 63.6% (LR+=2.4, LR-=.197). All studies presented with a low concern of risk of bias and a low concern regarding applicability, according to the QUADAS-2/QUADAS-C. Patient selection, index test and reference standards presented with good applicability and showed good evidence to support the question. **Conclusions:** Results support the use of diagnostic ultrasound as a means of identifying rotator cuff tears, in particular full-thickness tears. While partial-thickness tears showed overall satisfactory results, MRIs may still be valuable in providing more clarity of structures involved and severity of injury. Diagnostic ultrasound can provide a quality first step in helping determine if the MRI is needed, hopefully minimizing the need for unnecessary and costly advanced imaging. As diagnostic ultrasound instrumentation becomes more accessible, athletic trainers should learn how to incorporate this skill into their evaluation procedures. SORT B

The Impact of Patient-Reported Outcome Measure Terminology on the Reporting of Post-Injury Deficits
Marshall AN, McKeon PO: Appalachian State University, Boone, NC, and Ithaca College, Ithaca, NY

Context: Patient-reported outcome measures (PROMs) have been used to routinely capture the patient's perception of disability; however, the specific wording of a question has been shown to influence the patient's interpretation of that question. Region-specific PROMs often use the term "difficulty", but this may not be the most meaningful disability descriptor to the patient. The purpose of this study was to determine the impact of PROM word choice ("difficulty", "fear", "uncertainty") on the identification of injury-related disability in patients with a foot or ankle injury. **Methods:** We used a cross-sectional research design to collect responses from a convenience sample of recreationally active adults who self-reported foot/ankle injury. The survey was delivered through a web-based research service (Qualtrics LLC, Provo, UT) in May 2022. Participants provided demographic information (age, gender, activity level). Participants were asked to complete three versions of the Foot and Ankle Ability Measure Sport Subscale (FAAM-Sport), with each using a different perceptual descriptor ("difficulty", "fear", or "uncertainty") with activities due to their injury. A total of 145 individuals completed the survey (response rate = 24.69%). Respondents were 50.3% female (n=73) and were 43.33±15.45 years old (median=40.50, IQR=31-57, range=18-76). Summary statistics were used to describe demographics (gender, age, activity level, severity), PROM responses, and the most meaningful descriptor ("difficulty",

"fear", "uncertainty") for the individual. Two-way random effects intraclass correlation coefficients [ICCs] for consistency were used to assess the level of agreement and explained variance between total scores. **Results:** A majority of individuals reported that they were recreationally active (75.2%, n=109), with fewer participants reporting participation in college/university (15.2%, n=22), high school (4.8%, n=7), or semi-professional/professional (4.8%, n=7) athletics. Participants more frequently reported a previous injury (53.1%, n=77) as compared to a current injury (46.9%, n=68) and had a self-reported severity of 5.48±2.22 (median=5, IQR=4-7, range=0-10). The scores for each version of the FAAM-Sport were as follows: "Difficulty"=16.62±6.15 (median=17.00, IQR=13-22, range=0-28), "Fear"=17.94±6.36 (median=18.00, IQR=13-23, range=2-28), "Uncertainty"=17.11±6.03 (median=17.00, IQR=12-21, range=5-28). Agreement between the different versions of the FAAM-sport was similar: "Difficulty" and "Fear" ICC=0.78 (p<0.01, r²=0.60), "Fear" and "Uncertainty" ICC=0.86 (p<0.01, r²=0.74), "Difficulty" and "Uncertainty" ICC=0.77 (p<0.01, r²=0.59). "Difficulty" was identified as the most meaningful descriptor (43.1%, n=66), followed by "uncertainty" (32.0%, n=49) and "fear" (24.8%, n=38). **Conclusions:** Our findings indicate that "difficulty" is a commonly-selected PROM descriptor of post-injury disability in the recreationally active population, but may not be the most consistently meaningful PROM descriptor. Approximately half of the sample selected uncertainty or fear as more meaningful. In light of these findings, there is a need to further examine the constructs of fear and uncertainty as they relate to a patient's perception of disability.





The Prevalence of Symmetry in General Populations Using the Deadlift Movement

Davis PE, Elsbree ME, Coffman MM, Wieck SM, Hetzler TM, Hetzler BS, Christian ME: Missouri State University, Springfield, MO

Context: Functional movement requires an individual to maintain a balance between mobility and stability while performing fundamental patterns with accuracy and efficiency. Currently, the research looks at asymmetry negatively within athletics and daily life. We are aiming to utilize bottom of deadlift and offset bottom of deadlift as a tool to assess the way one moves. This study aims to look at whether symmetry is present while someone is in an asymmetrical stance. **Methods:** A cross-sectional study conducted on a university campus consisted of 19 voluntary participants who completed a health questionnaire consisting of age (22.47 ± 1.18 years), gender (male= 5; female=12), height (67.56 ± 3.67 in), weight (167.71 ± 32.72 lbs), previous medical and neurological conditions, and activity level. Seventeen of the 19 participants qualified and were then taken through a movement assessment consisting of the bottom of deadlift shape and the offset bottom of

deadlift shape for both the right and left sides. An established criterion (Figure 1) for the bottom of deadlift shape and offset bottom of deadlift shape was employed to consider a pass or fail for each participant. The statistical analysis employed to answer the primary research question included percentages, Pearson r correlation, and chi-squared. Data collection is currently in progress and will have approximately 150 participants at the time of completion. **Results:** In preliminary data analysis, the majority passed the offset deadlift expectations on the right (pass = 11 [64.7%], fail = 6 [35.3%], and left (pass = 9 [52.9%], fail = 8 [47.1%]). The chi-square showed a statistically significant relationship between left and right offset deadlifts ($\chi^2(1) = 10.43$, $p = .001$) with a positive, significant correlation between both sides ($r = .783$, $p < 0.001$). The association between the left and right sides was moderately strong, $\phi_c = .78$. **Conclusions:** The study shows while a person is in an asymmetrical stance, they can still show symmetry across the axis; however, conclusions may change due to ongoing data. The extent to which symmetry, or lack thereof, exists in the general population and its effect on musculoskeletal injuries requires further investigation.

Funding from Missouri State University Graduate College.

BoDL		OBoDL	
		Right	Left
			
0	1	0	1
Pn		Pn	Pn
Feet hip width		Feet hip width, tripod, forward	
Feet forward		Elbows on knees	
Tripod		Shoulders above hips	
Elbows on knees		Shoulders level	
			
0	1	0	1
Pn		Pn	Pn
A/P		A/P	
Vertical midline		Foot tripod, forward	
Hips within knee window		Patella aligned with foot; over toes 3-5	
		Shoulders level	
PSIS level		Vertical midline (pelvis up)	
Shoulders level		Lat	
Patella over foot; patella oriented with feet; vertical tibia		Hands behind calves*	
		GT above scored leg tibial tuberosity	
		Natural spine -or- slight extension	
Lat		Neutral to retracted scapulae	
Order: ankles, knees, hips, shoulder, chin, ear		Chin "up"	
Feet Tripod, flat		Order: Ankle, knee, hip, shoulder, chin, ear	
Knees over mid foot or toes; tibias inclined slightly forward			
Neutral/slightly retracted scapulas			
Neutral/uniform spinal extension; slightly extended cervical spine			
Chin up			

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