

American Academy of Sports Physical Therapy Poster Presentation Abstracts SPO1-SPO139

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SPO1

PHYSICAL THERAPISTS CHAMPIONING INCLUSION THROUGH ADAPTIVE SPORT

Adriana Saab, James Pierre-Glaude, Eric M. Lamberg

PURPOSE: This presentation will highlight the unique, vital role of physical therapists in increasing access and providing opportunities to adaptive sports; particularly for children with limb differences or limb loss through amputee soccer. Physical therapists (PT) have a deep understanding of the biopsychosocial demands associated with living with a physical disability, thus equipping them with the clinical skills to be servant leaders and advocates for the adaptive sports community. Physical Therapists practice with the intent to focus on the capabilities of individuals with disabilities that are masked by the stigmas society facilitates.

DESCRIPTION: American Amputee Soccer Association (AASA) has been a champion for increasing awareness and access to sports for individuals living with limb difference/limb loss. From the development of regional amputee soccer teams throughout the country that focus on grassroots play, to Men's and Women's national teams representing the United States in international tournaments, the AASA continues to aspire to its aforementioned mission.

Led by a dedicated team of physical therapists, a physical therapy student and other healthcare professionals such as athletic trainers, and social workers, the AASA created a youth amputee soccer program on Long Island, NY to provide greater access to adaptive sports for children with limb difference/limb loss. This youth amputee soccer program will serve as a template and catalyst for other regions and for physical therapists to increase access to the sport throughout the U.S. Through expertise in the biomechanics of adaptive athletes and a psychosocial mindset, this program not only promotes physical and mental well-being but also enhances camaraderie. Despite initial challenges in outreach and participation, the youth amputee soccer program created an enabling environment for young athletes to thrive.

SUMMARY OF USE: The success of the youth amputee soccer program on Long Island paves the way for the ultimate goal of expanding access to the rewarding outcomes of adaptive sports nationwide. With collaboration from regional amputee soccer teams and other adaptive sports communities, a thriving network will be created to ensure empowerment and inclusivity for all.

IMPORTANCE TO MEMBERS: The achievement of physical therapists creating the youth amputee soccer program and increasing awareness of adaptive

sports enhances the physical therapy profession. The initiative represents physical therapists as leaders in the sports medicine field demonstrating their expertise in biomechanics across diverse medical conditions. It demonstrates how physical therapists strive to create a more effective healthcare system where every individual is accepted, valued, and given high-quality care. Also, the program increases exposure, understanding, and insights into the physical therapy profession, emphasizing the essential role of physical therapists in community-based practice. The successes reflect an empowering profession that prioritizes advocacy and seeks equitable participation to foster an inclusive society.

SPO2

RETURN TO SPORT IN A PATIENT WITH CHOPART AMPUTATION AND MULTIPLE SCLEROSIS: A CASE REPORT

Paul Moreno Spano

BACKGROUND AND PURPOSE: Chopart and other partial foot amputations (PFAs) are performed to preserve a patient's hindfoot. By preserving as much of the anatomical foot as possible, long-term health outcomes are significantly better compared to those who undergo more proximal lower extremity (LE) amputation. Multiple sclerosis (MS) is a chronic disease that affects the central nervous system, leading to symptoms like fatigue, mobility issues, and cognitive difficulties. Individuals with PFAs or MS may experience significant impairments in performing activities of daily living (ADLs) - most notably those that require balance, ambulation, and stair negotiation. There is a dearth of research describing the return to higher level activities in patients with PFAs. This case study describes a patient with Chopart Amputation and MS who was able to return to functional independence, yoga and running.

CASE DESCRIPTION: Patient is a 34 y.o. female (she/her) referred to physical therapy due to pain in calcaneus and greater trochanter and strength imbalances through her right (R) residual limb (RL). She underwent PFA at age 7 secondary to a sarcoma and was diagnosed with MS at age 20. She ambulates without an assistive device and utilizes a prosthetic with carbon-fiber plate and an anterior block. Manual muscle test (MMT) for hip extensors and abductors (ABD) on RL were 3+/5, hip external rotation 4/5, and knee extension 4+/5. Left (L) LE had MMT of 5/5 throughout. Gait deviations include L Trendelenburg and R LE vaulting, limiting ambulation to 1 mile. Stair negotiation demonstrated heavy upper extremity (UE) reliance on the handrail and step-over-step (SOS) with R LE vaulting, circumduction, and reduced stance time compared to the L LE. Single

leg stance (SLS) was not assessed due to calcaneal and greater trochanter pain. Initial LEFS score were 64/80. The patient self-limited community fitness activities due to pain. Prescribed interventions included hip extension, hip ABD, knee extension, and anterior and lateral core strengthening. Static and dynamic balance activities that incorporated core stabilizing components were also performed. Exercise regimen was performed 4x per week at moderate intensity lasting 45 minutes each session.

OUTCOMES: The pt was seen for 6 visits over a 10-week span. MMT for RL increased to 4/5 hip extension, 4+/5 hip ABD and external rotators, and 5/5 knee extension. R LE vaulting during ambulation and stair negotiation were absent with symmetrical weight-bearing and stance time noted. Ambulatory endurance improved to >2 miles. SLS improved to 3 seconds on RL and 60 seconds on L LE. LEFS scoring improved to 68/80. Community participation improved to include yoga and running x4 times/week.

DISCUSSION: This is the first case study to describe return to yoga and running in a patient with Chopart amputation and MS using targeted physical therapy interventions.

SP03

ADAPTIVE CROSSFIT FOR A PERSON WITH POLIOMYELITIS: A CASE STUDY

Kaci Handlery, Reed Handlery, Dana Kahl

BACKGROUND AND PURPOSE: Poliomyelitis (PM) is a disease that causes paralysis, respiratory impairment, and autonomic dysfunction which leads to decreased function and physical activity. Traditional ideology discourages high-intensity (HI) exercise for people with PM with a fear of overloading musculature and causing irreparable harm. Adaptive CrossFit (aCF) involves varied functional aerobic and anaerobic exercises performed at HI. While aCF has led to health benefits for adults with spinal cord injury and Parkinson's, the effects of aCF for people with PM is unknown. The purpose of this study is to describe the feasibility and effects of aCF on a person with PM.

CASE DESCRIPTION: A 79-year-old community-dwelling White male diagnosed with PM at age five primarily used a manual wheelchair (wc) for mobility. He reported no significant past medical history and denied taking medications. He considered himself "much more active" than his peers. Physical therapists (PTs) provided 49 sessions of aCF over 25-weeks for the participant with PM and other wc users. The aCF program consisted of 108 exercises, the most common being ski ergometry, burpees, rope swings, medicine ball rotations, medicine ball wall balls, and wc U-turns. End of session Rate of Perceived Exertion (RPE) was captured with HI considered >5/10. Outcomes were assessed before, at the midpoint, and after the program.

Before the 10th session, the individual reported chest discomfort for three hours preceding the session. Palpation of the radial pulse by the PT revealed an irregularly irregular pulse and exercise was deferred. The participant was referred to the emergency department and subsequently diagnosed with chronic atrial fibrillation (aFib). The physician began medication treatment (Eliquis and metoprolol BID), and the individual was cleared to return to aCF exercise by the next session, 48 hours later. However, the individual often reported fear of exercising at HI despite medical clearance and supervision from a PT.

OUTCOMES: The participant attended 84% (41/49) of sessions and reported a median session RPE of 6/10, indicating exercise was performed at HI. Of interest, following the diagnosis of aFib, median session RPE increased 3.5 points. Post-program, he demonstrated increased cardiovascular endurance (3-point decrease in recovery RPE), increased muscular strength (bilateral shoulder flexors (average 8.4-lb increase), left elbow extensors (2.5-lb increase), left grip strength (3-lb increase)), and increased social support for exercise from friends (15-point increase). On a Global Rating of Change scale, he reported improvements in his ability to push his wc leisurely (5 points), fast (4 points), and for long durations (5 points) and in his physical activity levels (3 points).

DISCUSSION: Following 41 sessions of aCF, a person with PM demonstrated improved strength, cardiovascular endurance, social support for exercise,

and perceived physical ability and activity levels. aCF was safe and feasible, and led to improvements in health outcomes. Future studies may investigate aCF as a treatment option for people with PM living in the community.

SP04

POWER WHEELCHAIR ADAPTIVE SPORT PARTICIPATION BY ADULTS WITH DISABILITIES: A CASE STUDY MEASURING ENERGY EXPENDITURE

Lorna M. Hayward, Avery Melam, Lauren Raine, Aston McCullough

BACKGROUND AND PURPOSE: Adults with disabilities (AWD), including those with spinal cord injuries, and orthopedic impairments need opportunities for physical activity (PA). Wheelchair users report low levels of PA and are at risk for the consequences associated with inactivity including obesity, poor cardiovascular health, reduced strength, and flexibility. Few deliberate strategies exist for developing adapted team sports (ATS) programs for AWD. Documentation of the benefits of PA may support equity for active living and its inclusion as part of a complete health repertoire. However, lack of consensus exists for delineating and measuring PA in AWD who use wheelchairs, and limited research has explored energy expenditure during ATS for power wheelchair (PWC) users. Measuring energy expenditure during PA for PWC users is novel and studies involving women underrepresented. The research purpose was to test the feasibility and acceptability for using a portable, indirect calorimetry system and wireless heart rate (HR) monitor to examine energy expenditure during adaptive Volt PWC hockey.

CASE DESCRIPTION: A 24-year-old female participant, conveniently sampled, from a PWC hockey team. Participant was diagnosed with spinal muscular atrophy, weighed 79kg, with a height of 180cm. Data were collected on HR, oxygen uptake (VO₂), metabolic equivalent (METs), respiratory quotient (RQ), and Borg rate of perceived exertion (RPE) during a 30-minute hockey scrimmage. Breath-by-breath measures were recorded using the COSMED K-5, a portable, indirect calorimeter. During scrimmage, the K-5 was attached to the participant's PWC. A Polar A360 Smart watch was affixed to the patient's non-dominant wrist to collect real-time, second by second HR data. Simultaneous collection of VO₂ and HR data determined if the physiological responses to exercise were related. A 15-breath moving average filter was applied to VO₂ data. METs were correct by a factor of 0.992 to account for wheelchair use (METwc). HR, METwc, and RQ data were summarized using means and (standard deviations).

OUTCOMES: Pre-scrimmage HR mean was 96.4 (3.7) bpm (50.7% of HRmax) and (66.2% of HRmax) during scrimmage. METwc mean 2.2 (0.29), and RQ averaged 0.9 (0.06). As measured by HRmax, the participant spent 84.77% of the scrimmage at moderate intensity and 15.23% at vigorous intensity. RPE was recorded as 6 pre-scrimmage and 11 during scrimmage. These data suggest this protocol is feasible and well-tolerated by PWC users.

DISCUSSION: PA intensities reached moderate and vigorous levels for a PWC user as measured by HRmax. However, METwc data simultaneously reflected a light intensity. PA intensity may vary by measurement method and the characteristics of a disability. Equitable access to PA for AWD requires minimizing barriers and increasing knowledge about energy expenditure for PA. Increasing the diversity of PA options for PWC users may empower these individuals to exercise and reap the health benefits of exercise. More research is needed to document the health impacts and benefits of ATS participation in PWC users.

SP05

RELIABILITY OF USING HANDHELD DEVICES TO QUANTIFY HUMAN MOVEMENT: A SYSTEMATIC REVIEW

Seth A. Moore, Casey Base, Casady Downey, Rebecca R. Moreno, Tiffany Sissom, Mark P. Wilhelm, Mindy Nicole Brummett, Lee Tolbert Atkins

PURPOSE/HYPOTHESIS: Movement abnormalities have been identified as contributing factors to numerous musculoskeletal conditions. Thus, clinicians must be able to reliably and objectively assess their patients'

movements. Traditionally, quantitative movement analyses required costly equipment and extensive training, making them unsuitable for broad-based clinical use. However, recent technological advances have allowed clinicians to perform 2D quantitative movement analyses using handheld devices (e.g., tablets or smartphones). Therefore, this systematic review aimed to synthesize literature on the reliability of using a handheld device to quantify human movement.

NUMBER OF SUBJECTS: N/A

MATERIALS AND METHODS: CINAHL, Embase, PubMed, and SPORTDiscus database searches were completed using Medical Subject Heading terms, keywords, and text words related to reliability, handheld device, 2-dimensions, video analysis, application, kinematics, and functional movement. Three authors extracted data from the studies that included 1) study population, 2) rater information, 3) movement plane examined, 4) handheld device used, 5) application used, 6) movement analyzed, 7) number of trials assessed, 8) reliability statistics used, and 9) reliability outcomes. Intraclass correlation coefficients (ICC) were extracted and synthesized using a narrative approach.

RESULTS: Initially, 272 articles were identified and screened, resulting in nine articles being included in this review following screenings and study quality assessment. In these nine studies, the pooled sample consisted of 189 subjects (m=67, f=122; mean age = 24.35 yr; mean height = 1.697 m; mass = 69.99 kg; BMI = 24.3 kg/m²) and 23 raters. Raters included students, clinicians, and professors with varying experience levels using handheld devices to quantify human movement. Kinematics were measured with tablets in seven studies, while smartphones were used in the remaining two studies. The types of activities examined in these studies included drop vertical jump, single-leg drop landing, single-leg hop, 90° cut, overhead squat, and running. Interrater reliability ICC values ranged from 0.310 to 0.996. Similarly, intrarater reliability ICC values ranged from 0.450 to 0.998.

CONCLUSIONS: Handheld devices may be reliably used to quantify a patient's movements. However, the methodology used in these studies varied and appears to affect measurement reliability. Based on this systematic review's findings, we recommend utilizing skin markers, a tripod, and a stylus for measuring angles on handheld devices. A tripod or stable mounting base (versus holding the device in hand) may also increase reliability.

CLINICAL RELEVANCE: Handheld devices can be used reliably to quantify human movement in clinical settings. However, clinicians should be cautious of their methodological decisions as they can significantly impact measurement reliability.

SP06

IDENTIFYING THE RELATIONSHIP BETWEEN EXTERNAL LOAD, KNEE JOINT BIOMECHANICS, AND SELF-REPORTED SORENESS IN WOMEN'S VOLLEYBALL

London F. McDaniel, Frederick Holscher, Brett S. Peaa, Kevin R. Ford, Ashton Cook, Jeffrey B. Taylor

PURPOSE/HYPOTHESIS: Jump count is becoming a more widely recognized measure of external load in women's volleyball players. Prior research indicates that the variability in daily jump count may lead to future injury, yet there is limited evidence on how jump count impacts daily perceived levels of soreness. Further, there has been no reported relationship between an athlete's preferred movement strategy and internal and external load measures. The purpose of this study was to identify the relationship among jump count, biomechanics, and self-reported soreness in women's collegiate volleyball players. It was hypothesized that jump count would be a significant predictor of the subsequent day's self-reported soreness.

NUMBER OF SUBJECTS: 42 Division-1 women's collegiate volleyball player seasons.

MATERIALS AND METHODS: Participants were tracked over the course of their competitive season. Daily values of internal and external load were measured. Internal load was quantified as self-rated lower extremity soreness, captured by a daily electronic survey. Participants rated the intensity of soreness and

identified the location(s) of soreness on a body map. Soreness in the lower extremities was categorized into total soreness, joint soreness, and muscle soreness. External load was quantified as jump load (number of daily jumps * average jump height), captured by an accelerometer worn around the waist of each player for every practice and match. Jump landing biomechanics were measured in the pre-season using three-dimensional markerless motion capture techniques. Knee flexion range of motion and knee flexion and abduction moments during a drop vertical jump were the biomechanical variables of interest to act as a surrogate measure of biomechanics during volleyball specific landings. Linear mixed effect models were performed to identify predictors (i.e. external load, biomechanics) of soreness.

RESULTS: Daily jump count averaged 55.4±45.9 jumps with an average jump height (12.3±5.8 inches) over the course of the season. Analyses indicated that neither jump load nor the interaction of jump load and biomechanical measures predicted the following days total lower extremity, joint, or muscle soreness levels when controlling for position (p>0.05).

CONCLUSIONS: Jump count and biomechanical jump landing strategies were not related to self-reported soreness.

CLINICAL RELEVANCE: Jump counts did not predict soreness in this population of women's collegiate volleyball players; however, this could be due to the coaching staff's awareness of load management that may have limited large loading levels. Future study is necessary to elucidate predictors of soreness in women's volleyball players so that physical therapists can prioritize with primary prevention with interventions geared towards risk factors for soreness (e.g. biomechanical, external load, internal load, neuromuscular).

SP07

INTERJOINT COORDINATION OF THE KINETIC CHAIN IN COLLEGIATE BASEBALL PITCHERS: NOVEL INSIGHTS INTO BIOMECHANICAL ANALYSIS

Jeffrey Samuel Paskewitz, Philip J. Malloy, Andrew Stephen Babanee, Anne Leung, Ryan David Zaraycki

PURPOSE/HYPOTHESIS: Biomechanical analysis of baseball pitching motion has largely examined associations between joint torques and single joint angles at discrete time points within a pitching motion. Recent biomechanical analyses in other clinical populations have examined interjoint coordination by describing the kinematic relationship between multiple joints across time. Similar to walking, interjoint coordination may be associated with biomechanical variables that contribute to injury during baseball pitching. This study aimed to describe interjoint coordination of collegiate baseball pitchers using joint motions that have been previously implicated in pitching injuries: shoulder internal rotation (IR), contralateral trunk rotation (CTR), trunk flexion (TF), and elbow extension (EE). This study also examined whether pitchers with higher normalized shoulder and elbow torques demonstrate different joint interjoint coordination.

NUMBER OF SUBJECTS: 9 Division III collegiate baseball pitchers

MATERIALS AND METHODS: Participants underwent kinematic and kinetic analysis collected with a reliable and valid markerless system. Kinematic data was acquired at 240 Hz, and peak internal elbow varus and shoulder internal rotation torques were calculated using an inverse dynamics approach. Four ratios of joint movement (IR/CTR, IR/TF, EE/TF, EE/CTR) during the acceleration phase were calculated. T-tests examined differences in joint movement ratios between the 4 pitchers with highest shoulder and elbow torques and the 5 pitchers with lowest shoulder and elbow torques normalized to height, weight, and ball velocity.

RESULTS: During the acceleration phase, the shoulder internally rotated 7.0° (SEM=2.5°) for every degree of contralateral trunk rotation relative to the throwing arm. Pitchers demonstrated 2.3° of shoulder IR (SEM=0.5°) for every degree of TF, 6.4° of EE (SEM=1.2°) for every degree of TF, and 20° of EE (SEM=4.7°) for every degree of CTR. Pitchers with higher elbow and shoulder torques demonstrated higher IR/CTR ratios (mean difference = 9.71, p = 0.037). No other significant differences in joint movement ratios were observed between groups (p > 0.073).

CONCLUSIONS: Analysis of interjoint coordination during pitching provides new biomechanical insight. This preliminary data suggests that compared to pitchers with lower shoulder and elbow torques, pitchers with higher shoulder and elbow torques demonstrate significantly greater IR/CTR ratios during the acceleration phase, with nearly 10 more degrees of shoulder internal rotation for every degree of contralateral trunk rotation during the acceleration phase.

CLINICAL RELEVANCE: Our finding that higher shoulder IR/CTR ratios during the initial acceleration phase of pitching are associated with higher shoulder and elbow torques informs the development of treatment and cueing strategies to minimize shoulder and elbow torques during pitching. Interojoint coordination analyses may advance traditional biomechanical analysis of baseball pitching by more comprehensively characterizing this complex and variable movement. Future work should include larger samples and examine other phases of pitching and motions.

SP08

A COMPARISON OF KINEMATIC SEQUENCING IN PITCHERS & QUARTERBACKS

Phillip Page, Andre Labbe, Felix "Buddy" Savoie

PURPOSE/HYPOTHESIS: Overhead throwing involves a kinematic sequence of events from the contralateral foot to the throwing hand. After front foot contact, the pelvis and torso contribute to throwing velocity through rotation. "Hip-Shoulder separation" has been suggested as an important component of throwing velocity. While many researchers have evaluated biomechanics in baseball pitchers, few have evaluated football quarterbacks or compared both. The purpose of this study was to evaluate the kinematic sequencing in pitchers and quarterbacks during throwing, including hip-shoulder separation.

NUMBER OF SUBJECTS: 11 right-handed male overhead athletes including quarterbacks (n=6) and pitchers (n=5) between high school and college level participated in a biomechanical throwing analysis before their respective season.

MATERIALS AND METHODS: The Noraxon Utiium IMU system (Noraxon USA, Scottsdale AZ) was used to assess kinematic variables during the throwing motion. Athletes performed 9 targeted throws each; pitchers threw fastballs at 90 feet, while quarterbacks threw 20-yard passes. Noraxon MyoResearch 3.18 software was used to identify key events during the throwing motion: front foot contact, maximal shoulder external rotation, ball release, and maximal shoulder internal rotation. Kinematic data was extracted for shoulder external rotation ROM and internal rotation velocity, torso and pelvis ROM and velocity, and torso-pelvic axial angle (hip-shoulder separation). Spatial and temporal values were averaged for key events.

RESULTS: Pitchers demonstrated earlier ball release (30% vs 40% of throwing motion) and longer deceleration compared to quarterbacks. Pitchers also had greater peak external rotation (152o vs. 110o) and greater external rotation at ball release (71o vs. 30o). Hip-Shoulder separation was greater in pitchers (45.4o vs. 23.9o). Peak velocity was greater in pitchers and occurred earlier in the throwing motion (5102+808o/s at 40% vs. 2847.6+345o/s at 68%).

CONCLUSIONS: Pitchers demonstrated higher ROM, velocity, and hip-shoulder separation than football quarterbacks. Future research should include larger sample sizes, kinetic analysis, and different quarterback throws.

CLINICAL RELEVANCE: Compared to baseball pitching, more research is needed on the biomechanics of quarterback throwing. Understanding the different biomechanics of throwing athletes may assist in rehabilitation and performance.

SP09

EXPERIMENTALLY INDUCED INTRAARTICULAR EFFUSION DOES NOT RESULT IN BILATERAL SUSTAINED LIMB-LEVEL LOADING DURING OVERGROUND WALKING

Laura Stanley Pietrosimone, Katherine Collins, Timothy Lindsay, Heather Shannon Myers, Anthony Ceraulo, Brian C. Lau, Brian Pietrosimone

PURPOSE/HYPOTHESIS: Using an experimentally induced knee effusion (EIKE) model, previous research has identified lesser peak limb-level

loading (e.g., lesser peak vertical ground reaction force (vGRF)) similar to patterns of individuals who have undergone anterior cruciate ligament reconstruction (ACLR) and those with knee osteoarthritis (KOA). However, there are presently no studies that investigate bilateral limb-level loading following unilateral EIKE throughout stance. Therefore, the purpose of this study was to investigate bilateral differences in limb-level loading throughout stance following EIKE. We hypothesized that the EIKE-limb and non-EIKE limbs would exhibit sustained vGRF and anterior-posterior GRF (apGRF) waveforms following EIKE.

NUMBER OF SUBJECTS: Ten healthy participants (8M, 2F; 25.06±3.51yrs, 74.95±9.41kg, 173.55±8.83cm) were included in analysis.

MATERIALS AND METHODS: A crossover study design evaluated pre- and post-EIKE vGRF and apGRF throughout stance. GRFs were collected bilaterally at 1200 Hz throughout stance using 6 in-ground force platforms at a self-selected speed. GRFs were normalized to participant body weight (BW). A trained orthopedic physician performed all saline injections (60mL) to the dominant limb suprapatellar pouch under ultrasound guidance. Means and standard deviations were calculated for participant demographics. Four separate functional analyses of variance were used to compare time-normalized vGRF and apGRF pre- to post-EIKE on the EIKE and non-EIKE limbs and compute mean differences and 95% confidence intervals (CI) between GRFs pre- to post-EIKE using the functional data analysis package in R and RStudio software. Magnitude of the effects were characterized as significant at any point during stance in which the 95%CI did not cross zero. Cohen's d effect sizes (ES) and 95%CIs were calculated as the portion of stance with the largest difference between groups to determine the magnitude of group differences.

RESULTS: Participants walked at 1.42 ± 0.14 m/s pre-EIKE and 1.37 ± 0.17 m/s post-EIKE (change: -0.04 ± 0.05 m/s). EIKE-limb apGRF were significantly less post-EIKE as compared to pre-EIKE from 16-24% of stance (mean difference: 2%BW; ES: 0.432; 95%CI: 0.099, 0.765). The non-EIKE limb demonstrated significantly greater vGRF from 6-35% of stance (mean difference: 10%BW; ES: 0.437; 95%CI: 0.104, 0.770) and greater apGRF from 13-19% of stance (mean difference: -2%BW; ES: -0.327; 95%CI: -0.659, 0.004) post-EIKE as compared to pre-EIKE.

CONCLUSIONS: EIKE may not acutely result in the same bilateral limb-level loading profiles observed among individuals with ACLR and KOA. We can speculate that the greater vGRF and apGRF of the non-EIKE limb post-EIKE is likely due to an effort to offload the EIKE-limb.

CLINICAL RELEVANCE: The development of bilateral sustained limb-level loading post-ACLR may be due to other factors such as persistent knee impairments, biological changes, concomitant injury, and/or psychological response to injury, which are not simulated with an acute EIKE in healthy individuals.

SP010

LIMB DOMINANCE AND EXTERNAL WEIGHT DO NOT AFFECT BALANCE DURING THE SINGLE LEG ROMANIAN DEADLIFT

Zachary Hill, Vivianna Chang, Amber Johnson, Adam G. Hutchinson, Valerie Jane Williams Hogan

PURPOSE/HYPOTHESIS: The Romanian deadlift (RDL) on one or two legs are exercises utilized in the rehabilitation process to promote strength gains of the hamstrings and gluteal musculature. Single leg RDLs may be preferable in rehabilitation so that the patient cannot compensate with their uninjured limb. Moving from two legs to a single leg adds challenge to postural control. However, it is unknown if limb dominance or the addition of external weight changes balance once the patient is in single leg support. The purpose of the study is to examine balance during a single-leg RDL during weighted and unweighted conditions and on the dominant and non-dominant limbs. The hypothesis is there will be significant differences between the conditions, specifically the condition with the best postural control to be during the unweighted condition on the non-dominant leg.

NUMBER OF SUBJECTS: Eighty-three subjects (43 females and 40 males) were included in this study (age 23 ± 1.99 years, height 172.62 ± 9.73cm,

mass 75.04 ± 16.17kg) who had no reports of injury to the lower extremities in the last 3 months, concussion or known balance impairments.

MATERIALS AND METHODS: Sway was measured using a Bertec Force Plate AM6800 to capture the center of pressure velocity (COPV) in mm/sec. All subjects performed four repetitions to a metronome beat of 60 beats per minute in each condition in a randomized order: non-dominant unweighted (NDUW), nondominant weighted (NDW), dominant unweighted (DUW), dominant weight (DW). Subjects under 68kg (150lbs) used a 10lb kettle bell and those greater than 68kg used a 20lb kettle bell. Researchers were blinded to the dominant limb, defined as the leg used to kick a ball, until after data collection was complete. A 2x2 repeated measures ANOVA was used to assess for main and interaction effects ($\alpha=0.05$).

RESULTS: COPV mean ± standard deviation in mm/sec for each condition were: NDUW 88.91 ± 17.24, NDW 85.23 ± 18.74, DUW 90.16 ± 21.03, DW 90.16 ± 19.02. There were no significant main effects for limb ($p=0.349$), weight ($p=0.837$), or interaction of limb and weight ($p=0.821$).

CONCLUSIONS: Limb dominance and the addition of an external weight do not affect postural control during the single leg RDL in young healthy subjects.

CLINICAL RELEVANCE: Although this finding should be confirmed in patients with pathology, it appears that clinicians can add a small external load during the single leg RDL without adding a significant challenge to balance. This is useful as clinicians may want to add weight to challenge strength in unilateral stance to avoid potential compensation from the uninjured limb and could do so without simultaneously adding challenge to balance. The subject's limb dominance should not affect their balance either.

SP011 SMARTPHONE-BASED GAIT ASSESSMENT OF NORMAL WALKING IN LABORATORY AND FREE-LIVING ENVIRONMENTS

*Joshua Ray Kniss, Samantha N. Magliato,
Katherine Smulligan, Mathew J. Wingerson, Vipul Lugade,
Julie C. Wilson, David R. Howell*

PURPOSE/HYPOTHESIS: Gait metrics provide crucial information in the evaluation and prognosis of many disease states. Gait evaluations historically require expensive equipment and professional expertise, but smartphone-based tri-axial accelerometers have helped make gait assessment more accessible. This study aimed to assess the reliability and level of agreement of gait metrics assessed by a novel smartphone application in a laboratory (lab) and free-living environment (FLE). We hypothesized that gait velocity (GV) in the lab would be faster than GV in a FLE due to Hawthorne effects and the ideal environment for gait assessment. Furthermore, we hypothesized that gait metrics measured in the lab and FLE would be positively correlated.

NUMBER OF SUBJECTS: We enrolled 28 subjects in a longitudinal study comparing gait temporal-distance metrics in two environments.

MATERIALS AND METHODS: In the lab, participants completed four gait assessment trials. During each trial, a smartphone was attached to the participant's lower back at L2-L4 using a jogging belt, and the participant walked 10 meters down and back along a marked, straight-line pathway free from obstructions or distractions. During FLE testing, the participant was instructed to walk in the same manner along an approximate 10-meter path, within one week of completing the initial laboratory visit. For all lab and FLE gait trials, we collected and recorded accelerometer data using a smartphone application (IMPROVE, Control One LLC), which generated GV, cadence, step length (SL), and SL asymmetry values for each trial. Paired t-tests assessed mean differences in each metric between testing environments ($\alpha=.05$). Reliability and agreeability of gait measures in different testing environments were assessed using Pearson's correlation and Bland-Altman analysis.

RESULTS: We enrolled 28 participants (26.1 ± 2.6 years, 71% female). The average time between lab and FLE gait trials was 8 days. Participants

walked significantly faster, with a higher average GV (mean diff.=0.14 m/s; 95% CI=0.09-0.19 m/s; $p<0.001$), higher cadence (mean diff.=8 steps/min; 95% CI=3-13 steps/min; $p=0.002$), increased SL (mean diff.=3.5%; 95% CI=1.5-5.5%; $p=0.001$), and increased SL asymmetry (mean diff.=3 cm; 95% CI=1-5 cm; $p=0.007$) in the lab, compared to FLE conditions. GV measures were not significantly correlated between lab and FLE trials ($r=.174$, $p=.375$), but they did show good agreement. 97% of the data points were contained within the 95% limits of agreement (-0.141 to 0.412). In both environments, cadence and GV were strongly correlated (lab: $r=.833$, $p<.001$; FLE: $r=.819$, $p<.001$).

CONCLUSIONS: Although the relationships between GV, cadence, SL, and SL asymmetry remained constant within testing environments, these metrics were influenced by different testing environments (lab vs FLE). These differences may result from a Hawthorne effect in the lab environment, increased complexity of the FLE, or differences in testing procedures.

CLINICAL RELEVANCE: Our results support the use of smartphones as field-based devices for gait evaluation and provide key information for interpreting gait measures obtained in different testing environments.

SP012 ASSOCIATION BETWEEN MUSCULOSKELETAL IMPAIRMENTS AND NON-CONTACT LOWER EXTREMITY INJURY IN COLLEGIATE ATHLETES. DOES GENDER MATTER?

*Amanda E. Waltz, Kevin W. Sears, Kevin Cuervo,
Daniel Martin, Kanika Bansal, Jake Clark, Megan E. Ball,
Kristen N. Bartlebaugh*

PURPOSE/HYPOTHESIS: More than half of all collegiate athletic injuries are related to the lower extremities. Pre-season musculoskeletal screens are performed to assess the collegiate athletes' current health status, establish a medical baseline, and optimize safe participation in sports. While injury prevention is emphasized, it is not known whether these musculoskeletal screens identify predisposing factors that increase the risk for injury. The purpose of this cross-sectional study was to test the hypothesis that altered joint mobility and/or flexibility deficits are associated with the incidence of non-contact lower extremity injury in male and female college athletes.

NUMBER OF SUBJECTS: A total of 707 adult collegiate athletes participated in the study (465 males and 242 females). Subjects participated in the following sports: football, soccer, basketball, volleyball, track and field, dance and cheerleading, wrestling, softball, baseball, lacrosse, swimming and diving, and golf.

MATERIALS AND METHODS: All athletes underwent a preseason musculoskeletal screen, which assessed lower limb function, joint mobility, flexibility, and joint stability. Tests in the screen included the Functional Squat test, the 90/90 test, the FABER test (Flexion, Abduction, External Rotation), and the duck walk. Injuries were tracked throughout one academic year. Spearman's Rho correlational analysis tested the hypothesis separately for males and females.

RESULTS: The average musculoskeletal screen score was significantly higher for males (2.5 ± 1.2) than for females (2.1 ± 1.07) ($p < 0.001$). The number of non-contact injuries was significantly greater for male collegiate athletes (0.39 ± 0.65) than for female collegiate athletes (0.3 ± 0.55). However, the correlational analysis revealed a significant association between musculoskeletal screen outcome and the number of injuries sustained for females ($r = 0.13$, $p = 0.04$) but not for males ($r = -0.035$, $p = 0.455$).

CONCLUSIONS: The number of non-contact musculoskeletal injuries was significant in the female population of Division III collegiate athletes. However, factors impacting the number of non-contact injuries in males are unknown. Further research is needed to identify appropriate tests to predict non-contact injuries in male collegiate athletes, as well as to confirm the clinical utility of the tests and how they generalize to the collegiate population.

CLINICAL RELEVANCE: The implementation of a pre-season musculoskeletal screen can help identify a predisposition for non-contact lower extremity

injuries in female collegiate athletes. Physical therapists and athletic trainers should consider gender when screening an athlete for potential injuries.

SP013

DROP JUMP LANDINGS VARY BASED ON HISTORY OF SINGLE OR MULTIPLE CONCUSSIONS COMPARED TO CONTROLS

Paige Burrell, Caitlin Anne Nadolny, Shiho Goto, Kalyssa Creed, Bobby Jean Sanders Lee

PURPOSE/HYPOTHESIS: Athletes post-concussion exhibit neurocognitive changes that may lead to altered movement patterns, increasing the risk of lower extremity (LE) injuries. If athletes experience multiple concussions, their risk for LE injury may be higher. The purpose of this study was to determine the kinetic and kinematic differences between healthy controls, athletes with a history of a single, and athletes with a history of multiple concussions.

NUMBER OF SUBJECTS: 66 participants were enrolled in the study. 33 subjects with no history of concussion were included in the control group (CG). 22 subjects with a history of one and 11 subjects with a history of 2 or more concussions were included in the single (SG) and multiple (MG) groups, respectively. All subjects were matched for weight, height, age, gender, limb dominance and IKDC.

MATERIALS AND METHODS: Performance during three double-limb jump landing was assessed using a motion-capture system and force plates. One-way independent ANOVAs were performed to determine differences between groups in demographic data, ground reaction forces (GRF), and velocity at initial contact (Vel) for hip, knee, and ankle of the dominant limb (DL) and non-dominant limb (NDL). Alpha level was set at 0.05 for all statistical analyses.

RESULTS: When looking at anterior-posterior (AP) GRF in the DL, MG (0.23 ± 0.009 N/kg) group was significantly lower than CG (0.92 ± 0.17 N/kg, $p = .019$), but no difference was found between CG and SG (0.56 ± 0.08 N/kg, $p = .019$), nor SG and MG ($p = .019$). When looking at medial-lateral (ML) GRF in the NDL a significant difference was found between CG (0.078 ± 0.010 N/kg) and MG (0.022 ± 0.007 N/kg, $p = .015$). No difference was found between CG and SG (0.059 ± 0.012 N/kg, $p = .015$), nor SG and MG ($p = .015$). No differences in vertical GRF were found between groups for either limb. Frontal plane Vel of the DL revealed a difference between CG (-19.38 ± 8.01 m/s) and SG (24.70 ± 12.53 m/s, $p = .012$) at the hip and between MG (-49.63 ± 27.21 m/s) and SG (-159.55 ± 29.12 m/s, $p = .034$) at the ankle. At the hip in the NDL a difference was found between CG (-44.06 ± 11.93 m/s) and SG (8.69 ± 9.81 m/s, $p = .006$). Sagittal plane Vel at the ankle demonstrated a difference in the DL between MG (-189.98 ± 120.68 m/s) and SG (-397.86 ± 30.36 m/s, $p = .039$). Similarly, a significant difference was found in the NDL at the ankle between MG (-82.90 ± 110.60 m/s) and CG (-374.23 ± 30.86 m/s, $p < .001$) and MG and SG (-452.00 ± 43.45 m/s, $p < .001$).

CONCLUSIONS: Participants with multiple concussions demonstrate less AP GRF in the DL and less ML GRF in the NDL during a double-limb jump landing task compared to controls. Vel in the frontal plane shows that the DL ankle moves slower into abduction in the MG versus the SG. Sagittal plane Vel shows that the ankle of the DL and NDL move slower into dorsiflexion in the MG compared to those with a history of zero or one concussion.

CLINICAL RELEVANCE: Athletes with a history of multiple concussions move differently compared to those with a history of one or none. Kinematic parameters at the hip and ankle may play a role in injury risk after multiple concussions.

SP014

SMARTPHONE APPS AND STROBOSCOPIC GLASSES AS A FEASIBLE AND AFFORDABLE ALTERNATIVES TO ASSESS STATIC-AND-DYNAMIC MOVEMENTS

Brent Alfred Harper, Christopher Kim, Tom Murray, Jorge Orozco, Julia Polanco, Sarah Tritz, Ivy Xie, Michael Shiraishi, Rohan Soangra

PURPOSE/HYPOTHESIS: Sensory organization test (SOT) is the gold standard for assessing sensory dependence using sway-referenced conditions

while force plate technology (FPT) provides precise measurements of postural control. Both methods are expensive. An alternative cost-effective option for tracking postural sway is through Smartphone Apps (SPA). Additionally, Stroboscopic vision (SBV) can induce postural instability similar to sway-referenced vision in the SOT. Purpose was twofold: First, to determine agreement between FPT and SPA across three static and two dynamic postural control tasks using SBV. Second, to establish agreement between SPA and manual stopwatch (MSW) during a figure-eight walking task under SBV conditions.

NUMBER OF SUBJECTS: Healthy individuals ($n = 12$, 42% female; age 26.3 ± 1.2 (years); height 168.3 ± 3.5 (cm); mass 74.0 ± 3.4 (kg); BMI 26.1 ± 2.7).

MATERIALS AND METHODS: Observational cohort study. Randomly performed test conditions with randomized order on a foam pad. Static testing of FPT and SPA included Eyes Open (EO), SBV, and Eyes Closed (EC) with Dynamic testing of FPT and SPA of visual motor sensitivity (VMS) of EO and SBV. Figure-eight walking task (F8-WT) with EO and SBV comparing MSW and SPA. Parametric analysis was performed (Shapiro-Wilk test). Static-and-Dynamic (FPT and SPA during EO, Strobe, EC and VMS EO & Strobe) analyzed using mixed factorial ANOVAs with homogeneity of variance (Levene's $p > .05$) and post hoc analysis (Tukey HSD). F8-WT comparing MSW and SPA (EO & Strobe) analyzed using paired sample t -tests including Bland-Altman plots, and intraclass correlation coefficients (ICC).

RESULTS: Sway anterior-posterior, medial-lateral, velocity, and area for each condition (e.g., EO, SBV, EC) and VMS (e.g., EO, SBV) were significant ($p < .001$) using each device. F8-WT showed differences between equipment. EO was not significant ($p = .051$) between devices while SBV was ($p = 0.016$) with small effect size ($d = 0.016$) (17.6 ± 2.4 & SPA 18.9 ± 2.6 seconds). Bland-Altman Plots showed agreement between devices during both conditions (EO & SBV). Intraclass correlation coefficient showed excellent agreement between devices for each condition, EO ($p < .001$, $ICC_{2,1} = 0.988$; 95%CI[0.948, 0.997]) and SBV ($p < .001$, $ICC_{2,1} = .986$; 95%CI[0.906, 0.997]).

CONCLUSIONS: Combining Smartphone App with Stroboscopic glasses appears to be a feasible alternative to capture postural sway metrics and during a walking course with multiple turn angles. App data should not be used interchangeably with FPT, as they use different measurements to calculate findings, nor with MSW. The App appears to be an excellent alternative to collect consistent data by which to assess postural control and timed gait movements.

CLINICAL RELEVANCE: Standard static-and-dynamic postural control tasks using Stroboscopic glasses can be feasibly assessed using Smartphone Applications, which is a more affordable option to the more expensive SOT and FPT. App appears to be agreeable to the standard stopwatch but can be leveraged during other postural-control conditions. SPA with SBV may provide more objective information for clinical decisions in musculoskeletal conditions (e.g., concussion).

SP015

HEALTHY YOUNG ADULTS AND RECITING MONTHS OF THE YEAR IN REVERSE A COGNITIVE ASSESSMENT STUDY

Melanie Kwok, Tamara Valovich McLeod

PURPOSE/HYPOTHESIS: The Months of the Year in Reverse (MOTYR) is a brief cognitive task aimed to assess attention, concentration, working memory, executive function, and central processing speed. It is a component of assessments used to evaluate patients following sport-related concussion. Previous iterations of this task only recorded errors; however, the most recent version of the Sport Concussion Assessment Tool (SCAT) and the Sport Concussion Office Assessment Tool (SCOAT) includes the time to complete the task as a second outcome variable. There is limited normative data for the MOTYR in healthy active individuals. Furthermore, it is unclear whether there are differences among individuals with and without a prior concussion history. Therefore, our purpose was to evaluate the

MOTYR time across trials and between individuals with and without a prior concussion history.

NUMBER OF SUBJECTS: 80

MATERIALS AND METHODS: Eighty adults from a convenience sample participated in this pilot study. Participants were initially screened with a demographic and health questionnaire via Google Forms. Inclusion criteria consisted of being between 18-30 years old, English literacy, and a self-reported "healthy" status from the questionnaire. Exclusion criteria was a history of moderate or severe TBI. The study consisted of three timed trials of recalling the MOTYR starting from a different month. Each trial was separated by two minutes. Descriptive data was analyzed to provide representative data. Group (concussion history vs no concussion history) was the independent variable and time to complete MOTYR was the dependent variable. A repeated measures ANOVA was used to assess differences across trials between groups.

RESULTS: Time to complete the MOTYR for each trial: trial 1 -15.3±7.6s (range 6.4-46.8s), trial 2 - 17.14±8.49s (range 7.2-40.8s), trial 3 - 15.13±7.42s (range 6.3-48.6s). There was no group by time interaction ($p=.814$) or main effect for group ($p=.826$). There was a main effect for time ($p=.025$) with trial 2 being significantly slower than trial 1 or trial 3. There were no significant differences between trials 1 and 3.

CONCLUSIONS: While the mean times were between 15-18 seconds, there was variability in the time to complete the MOTYR among this healthy sample. Concussion history did not influence the timing of the MOTYR task among healthy young adults. The data collected could serve as an initial set of representative data for this task to be used in comparison with future patients assessed following a concussion.

CLINICAL RELEVANCE: As the timing of the MOTYR is a new addition to common concussion assessment tools, little data exists regarding normative values or factors that may influence scoring of this task. This study hopes to present an initial set of data that may further guide a potential study to gain normative values to compare to when administering the MOTYR in concussion evaluations.

SP016

DYNAMIC MULTI-PLANAR NEUROMUSCULAR NECK TRAINING REDUCES HEADACHE AND NECK PAIN ASSOCIATED WITH POST-CONCUSSION SYNDROME

Theo Versteegh

PURPOSE/HYPOTHESIS: The incidence of post-concussion syndrome (PCS) after mild traumatic brain injury (mTBI) ranges from 11% to 82%, posing a significant healthcare challenge. Two of the most common complaints of PCS are headaches and neck pain. This study investigates the effect of dynamic multi-planar neuromuscular neck training (TopSpin360) on headache and neck pain associated with PCS.

NUMBER OF SUBJECTS: 58

MATERIALS AND METHODS: This feasibility randomized controlled trial explored the implementation of TopSpin360 on PCS symptoms. Subjects suffering from PCS for more than four weeks were recruited (average days post injury = 72) and randomized into either a standard of care group - referral to physical therapy (CON, $n=29$, 21 female) or a standard of care plus TopSpin360 (INT, $n=29$, 21 female). INT received a TopSpin360 training device to take home and asked to perform 3 sets of 30 revolutions twice per week for 8 weeks (16 sessions, ~2 minutes each). Headache Disability Index (HDI), Neck Disability Index (NDI), and SCAT5 total symptom score (SCAT5) were collected at baseline and after 8 weeks, along with program adherence from the INT group. Statistical analyses were performed using independent samples t-tests (Bonferroni correction for multiple comparisons) of the change scores from pre- to post-testing between groups and Cohen's d to assess effect size.

RESULTS: There were no adverse events reported for the duration of the study, each subject in the INT group completed an average of 15.14/16 (94.6%) training sessions. The INT group showed statistically significant

improvements compared to the CON group in all measures with large effect sizes for changes in SCAT5 (INT(SD) pre 37.2 (12), post 10.7 (4.7), change -26.5 (13.1), 71.2% reduction, vs CON pre 24.8 (9.1), post 27.4 (12.9), change 2.6 (1.9), increase 10.4%, Cohen's $d = 1.08$, $p=.0129$) and HDI (INT pre 58.4 (12.8), post 37.5 (14.8), change -20.9 (11.5), -35.8% reduction, vs CON pre 37 (15.7), post 41.7 (11.5), change 4.7 (3.7), 10.3% increase, Cohen's $d = 1.01$, $p=.0098$) and medium effect sizes for change in NDI (INT pre 18.5 (3.9), post 11 (6.1), change -7.5 (4.8), 40.5% reduction, vs CON pre 14.2 (5.7), post 14.9 (5.4), change .7 (.5), 4.9% increase, Cohen's $d = .65$, $p=.0161$).

CONCLUSIONS: TopSpin360 significantly reduces headaches and neck pain associated with PCS. With high adherence and no adverse events, this approach appears feasible and warrants further investigation and consideration for a broader clinical application.

CLINICAL RELEVANCE: The findings from this study highlight the potential benefits of incorporating dynamic multi-planar neuromuscular neck training using the TopSpin360 device into the rehabilitation protocol for patients suffering from post-concussion syndrome (PCS). Given the high incidence of PCS following mild traumatic brain injury and the prevalence of headaches and neck pain among these patients, effective treatment options are critically needed. These results suggest that TopSpin360 is not only a feasible intervention but also a potentially impactful one for managing PCS symptoms.

SP017

ADHERENCE TO THE CONCUSSION CPG RECOMMENDATIONS FOR EXAMINATION AND TREATMENT OF CONCUSSION: A CASE SERIES

Steven Busby, Austin Hemenway, Tori Marie Smith VanBelle, Amanda Megan Murray

PURPOSE/HYPOTHESIS: The purpose of this study was to 1) Describe current physical therapy (PT) treatment for patients with a diagnosis of concussion undergoing PT in an outpatient clinic and 2) Evaluate the frequency of use of concussion clinical practice guidelines (CPG) following training for physical therapists in implementing CPG recommendations for management of patients with concussion.

NUMBER OF SUBJECTS: 20 patients with concussion undergoing PT (age: 35 years; sex: 65% female; length of stay: range of 1-161 days; number of visits: 8, range of 1-21 sessions).

MATERIALS AND METHODS: A retrospective chart review was utilized to analyze data regarding PT examination and treatment for patients who have undergone PT for concussion following a 6-month training and competency assessment for physical therapists in this setting. From the identified charts, outcome measure usage categorized by the domains identified in the CPG (cervical musculoskeletal (CMSK), vestibulo-oculomotor (VOM), exertional tolerance (ET), and motor impairment (MI)), were extracted to assess recommended domains evaluated. Billing codes from subsequent treatment sessions were extracted to determine the utilization of recommended treatment from the concussion CPG within the plan of care.

RESULTS: For examination, 22 different assessment tools were performed at initial evaluation. VOM (43%) and CMSK (29%) were the most frequently assessed CPG categories, while MI (18%) and ET (11%) were the least commonly assessed categories during initial evaluation. Within the VOM category, the Vestibular/Ocular-Motor Screening (VOMS), and Post Concussion Symptom Scale (PCSS) were the most used outcome measures. Throughout the course of care, therapeutic exercise (36%), neuromuscular re-education (36%), and manual therapy (12%), were the most frequently used billing codes.

CONCLUSIONS: Based on retrospective chart review, current concussion CPG recommendations are being used in this clinic setting after an educational training program for physical therapists. The CMSK and VOM domains were the most readily utilized in the examination and subsequent treatment sessions. This is supported with therapeutic exercise,

manual therapy, and neuromuscular re-education being the most common billing codes. A limitation with this study was variations in documentation across therapists and inferring the use of the domains of the CPG during examination and treatment sessions.

CLINICAL RELEVANCE: This retrospective case series describes current usage of concussion CPG guidelines in an outpatient clinic. Two of the four domains in the CPG comprise most usage for examination and treatment sessions, possibly due to clinician specialization and confidence. Additionally, some assessments, such as ET, may have been assessed during later sessions other than initial evaluation, which was not extracted for this analysis. Further investigation is needed to identify how the other domains can be better implemented. Investigations may include interviewing clinicians to identify current barriers to use of the concussion CPG and uniformity of documentation.

SP018

CONCUSSION EDUCATION IMPROVES AWARENESS IN YOUTH SOCCER ATHLETES

Cassandra Johnson, Cheyenne Fox, Stephanie Michelle Garrison, Tarang Kumar Jain

PURPOSE/HYPOTHESIS: Concussions in youth athletes are a significant health concern, especially in contact sports like soccer, where heading the ball increases the risk of head injuries. There is a gap in knowledge and utilization of concussion education among young athletes, notably under the typical concussion screening age of 14. The purpose of this study is to investigate the current level of concussion awareness among youth soccer athletes and the effectiveness of a targeted educational intervention in improving their understanding and prevention of concussions.

NUMBER OF SUBJECTS: Eighteen male soccer players from a 12U team participated in this study. The sample consisted of athletes aged 11-12 years, with varying levels of prior concussion knowledge and history.

MATERIALS AND METHODS: This cohort study was conducted over six weeks, involving three key sessions. The first session included a pre-survey to assess baseline knowledge. The second session provided a 20-minute educational lesson on concussions, using interactive activities and handouts. The final session involved a post-survey to measure changes in knowledge. Surveys were based on a 5-point Likert scale, and data analysis included calculating mean scores, conducting dependent t-tests, and performing a post-hoc power analysis using G*Power software.

RESULTS: The pre-survey revealed a moderate understanding of concussions, with an average score of 3.77 for knowledge about concussions and 2.39 for the ability to identify a teammate's concussion. Post-survey results showed a significant improvement in knowledge, with scores increasing to 4.43 for understanding concussions and 3.64 for identifying a concussion. The most notable improvements were in recognizing the increased risk of future concussions (from 2.72 to 4.14, $p = 0.007$) and identifying concussion symptoms (from 2.43 to 3.64, $p = 0.002$). The least improvement was seen in understanding the need to avoid video games post-concussion (from 3.21 to 3.50, $p = 0.566$). The study's post-hoc power analysis indicated a power of 0.41, suggesting the need for a larger sample size in future studies.

CONCLUSIONS: This educational intervention significantly improved concussion awareness among 12U male soccer players. This study emphasizes the importance of incorporating concussion education into youth sports programs to enhance knowledge and promote safer practices. Participant feedback revealed group engagement, reward, and visual examples may be effective approaches for conveying important health information to youth soccer players. Targeting parent/guardian and coach comprehension may help address the lack of exposure to concussion education and baseline testing in those younger than 14 years of age.

CLINICAL RELEVANCE: The findings of this study highlight the critical role of concussion education in youth sports. Improved knowledge about concussion symptoms, risks, and prevention strategies can lead to better

recognition and management, potentially reducing the incidence and severity of concussions in young athletes. By addressing these educational gaps, physical therapists and coaches can foster a safer sporting environment and promote long-term athlete health.

SP019

SINGLE AND DUAL TASK SINGLE LEG DROP JUMP STRATEGY DIFFERS IN ATHLETES WITH CONCUSSION HISTORY

Bobby Jean Sanders Lee, Mark Weber, Josh Carr

PURPOSE/HYPOTHESIS: Athletes who return to play (RTP) after sport-related concussion (SRC) are at increased risk for subsequent lower extremity injury. Athletes with a history of SRC exhibit persistent differences in biomechanics and neurocognitive performance compared to their non-concussed counterparts even after symptom resolution. Research using dual-task paradigms during sport-specific tasks such as jumping remains largely unexplored after SRC. Therefore, this study aimed to compare movement differences between athletes with and without a history of SRC during a single leg drop jump (SLDJ) and a SLDJ with a dual task challenge.

NUMBER OF SUBJECTS: One hundred forty-eight healthy NCAA Division I collegiate athletes participated in the study. Of these, 115 (age: 20.3 ± 1.55 years, sex: 50 male/65 female) had no history of concussion (noSRC) while 33 had a history of concussion within the last 5 years (+SRC) (age: 20.7 ± 1.71 years, sex: 14 male/19 female, time since last concussion 1.99 ± 1.48 years).

MATERIALS AND METHODS: Participants performed two SLDJs per limb onto a force plate box with (COG) and without (SLDJbase) a cognitive task. The COG consisted of a serial subtraction task, where participants subtracted 7 repeatedly from a random starting number. Results across both repetitions for SLDJbase and COG trials were averaged for each limb and the limb for analysis was randomized. Separate two-way mixed factorial ANOVA tests assessed differences in eccentric impulse, countermovement depth, and concentric impulse between groups (+SRC, noSRC) and tasks (COG, SLDJbase). Post-hoc testing with Bonferroni corrections and alpha level set at $p < .05$ for all analyses.

RESULTS: Significant group \times task interactions were found for eccentric impulse, $F(1,146) = 5.404$, $p = 0.021$, countermovement depth, $F(1,146) = 4.371$, $p = 0.038$ and concentric impulse, $F(1,145) = 3.982$, $p = 0.048$. The +SRC group demonstrated less eccentric impulse compared to the noSRC group under both COG ($p = 0.007$) and SLDJbase ($p < 0.001$) conditions. Countermovement depth was decreased in the +SRC group compared to the noSRC group during the SLDJbase ($p = 0.002$). Concentric impulse was higher for the +SRC group during COG ($p = 0.007$) and SLDJbase ($p < 0.001$) tasks compared to the noSRC group.

CONCLUSIONS: SRC-history athletes exhibit distinctly different movement strategies compared to non-SRC athletes during the SLDJ. Specifically, decreased eccentric impulse under cognitive dual-task and SLDJ conditions, suggesting reduced force absorption capacity. Further, SRC-history athletes utilize decreased countermovement depth in the transition phase of the SLDJ. These findings indicate increased stiffness in SRC-history athletes compared to athletes with no history of SRC. To achieve comparable performance, SRC-history athletes likely compensate by producing greater force and/or increasing concentric duration during the push off phase of SLDJ tasks.

CLINICAL RELEVANCE: Increased stiffness and differences under dual-task conditions with SLDJs may have implications in the identified relationship between concussion and subsequent injury risk after RTP.

SP020

COMPARISON OF AUTONOMIC RESPONSE TO AEROBIC EXERCISE WITH AND WITHOUT BLOOD FLOW RESTRICTION

Ashley M. Fox, Lori Bolgla

PURPOSE/HYPOTHESIS: Despite the established benefit of sub-threshold aerobic activity after a concussion, exercise intolerance is a common post-concussion symptom that can make rehabilitation efforts challenging. The literature suggests exercise intolerance is due to autonomic nervous

system (ANS) dysregulation. Exercise with blood flow restriction (BFR) may offer a way to increase exercise tolerance post-concussion. However, the ANS response to exercise with BFR is unknown. The pupillary light reflex (PLR) is a means for measuring ANS response, though its use has not been examined with exercise using BFR. This study aimed to compare the autonomic nervous system response during aerobic exercise with and without blood flow restriction using pupillometry. The hypothesis was that the ANS response would be similar in both cases.

NUMBER OF SUBJECTS: 30 subjects between 18-40 years old.

MATERIALS AND METHODS: Initially, subjects had their blood pressure taken and wore a Polar H-10 chest strap to monitor heart rate. Using Karvonen's formula, we calculated 40% of the heart rate reserve (HRR). The Delphi Personalized Tourniquet System (PTS) was donned to the proximal aspect of both thighs, and a 60% limb occlusion pressure (LOP) was established. The PLR of each eye was examined using the NeuroOptics PLR-3000 handheld pupillometer and measured the following variables: average constriction velocity (ACV), maximum constriction velocity (MCV), and the time from peak pupil constriction size to 75% of its baseline size (T75). Subjects then walked on a treadmill for 10 minutes at 40% of HRR without BFR and then immediately had their PLR assessed. Next, subjects rested in supine for up to 20 minutes until their HR returned to baseline. The Delphi PTS was applied to the bilateral proximal thighs, and a 60% LOP was applied. PLR was measured before and after subjects completed the same treadmill exercise with BFR. Separate 2 X 2 AVOVA with repeated measures were used to compare the effect of BFR on PLR.

RESULTS: All subjects, regardless of exercise condition, demonstrated lower ACV ($P=.013$) and MCV ($P<.001$) following treadmill exercise. T75 values were not significantly different concerning time or the exercise condition.

CONCLUSIONS: Aerobic exercise resulted in a significant decrease in pupil ACV and MCV, irrespective of BFR, which aligns with the expected physiologic response. There was no significant difference in T75 between exercise conditions with or without BFR. The findings suggest that in healthy individuals the ANS response to aerobic exercise is not significantly affected by using BFR.

CLINICAL RELEVANCE: Aerobic exercise below the symptom threshold is recommended after a concussion to reduce symptoms and shorten the recovery period. BFR leads to improvements in aerobic capacity that are typically only achieved with high intensities when performed at lower exercise loads. Adding BFR to aerobic exercise below the symptom threshold after a concussion could improve aerobic capacity without impacting ANS activity. Pupillometry could be valuable to evaluate ANS response to aerobic exercise with BFR in subjects following a concussion.

SP021

JOINT DISPLACEMENT CHANGES DURING JUMP LANDING IN ATHLETES WITH HISTORY OF SINGLE AND MULTIPLE CONCUSSION

Chad Hanson, Caitlin Anne Nadolny, Shiho Goto, Kalyssa Creed, Bobby Jean Sanders Lee

PURPOSE/HYPOTHESIS: The relationship between a history of sport-related concussion (SRC) and lower extremity (LE) injury has been established previously in the literature. Few studies have explored biomechanical data beyond the knee, limiting the amount of ankle and hip kinematic information. The purpose of this study was to determine if biomechanical differences exist during a double limb drop jump-landing (DJL) between healthy matched controls (CG) and athletes with a history of single (SG) and multiple (MG) SRC.

NUMBER OF SUBJECTS: Sixty-six participants were enrolled in the study and divided into three groups: 33 subjects with no history of concussion in CG, 22 subjects with a history of one concussion in SG, and 11 subjects with a history of two concussions in MG. All subjects were matched for age, gender, height, weight, limb dominance and IDKC.

MATERIALS AND METHODS: 3-Dimensional Motion Capture and force plates were used to measure joint displacement in the frontal and sagittal planes

for the dominant (DOM) and nondominant (NON) hip, knee, and ankle during 3 DJL. Results for each variable were averaged across the 3 trials for each limb. One-way independent ANOVAs were utilized to analyze differences between CG, SG, and MG. Alpha was set at .05 for all analyses and Bonferroni corrections were utilized for post-hoc testing.

RESULTS: In the DOM hip, SG had significantly less abduction than CG ($MD=-58.87$, $SE=17.06$, $p=.003$). For hip extension, MG had significantly less than CG ($MD=14.94$, $SE=5.18$, $p=.016$). In the NON hip, SG ($MD=15.66$, $SE=6.12$, $p=.039$) and MG ($MD=41.34$, $SE=7.74$, $p<.001$) had significantly more abduction than CG. Also, MG ($MD=32.85$, $SE=5.41$, $p<.001$) had significantly less extension than SG and SG had significantly less than CG ($MD=14.78$, $SE=4.28$, $p=.003$). The DOM knee revealed significantly less knee adduction in SG ($MD=16.13$, $SE=4.08$, $p<.001$) and MG ($MD=16.60$, $SE=5.16$, $p=.006$) compared to CG. Less knee flexion was found in SG than CG ($MD=14.48$, $SE=5.29$, $p=.024$). No differences were identified in either plane for the NON knee for any of the groups. At the DOM ankle, SG had significantly less adduction than CG ($MD=16.24$, $SE=6.15$, $p=.031$); while at the NON ankle, MG had significantly more adduction than SG ($MD=-13.59$, $SE=4.41$, $p=.009$) and CG ($MD=-20.62$, $SE=4.16$, $p<.001$). MG NON ankle had significantly more plantarflexion than CG ($MD=-28.75$, $SE=5.70$, $p<.001$).

CONCLUSIONS: Differences in displacement exist based on history of concussion(s) and limb dominance during a DJL. SG DOM hip had less abduction than CG, contrarily SG and MG NON hip had more abduction than CG. There was a trend of progressively less hip extension as the number of concussions increased in both the DOM and NON LEs. There were no significant differences at the knee in either plane in the NON LE, but there were significant differences at the knee in both planes in the DOM LE. At the ankle, SG DOM had less adduction than CG, contrarily MG NON had more adduction than SG and SG more than CG.

CLINICAL RELEVANCE: Clinicians should consider using interventions to address the hip, knee, and ankle following SRC to mitigate LE injury risk after single and multiple concussions.

SP022

EFFICACY OF NECK STRENGTHENING FOR PREVENTING CONCUSSIONS FROM HEADING INJURIES IN SOCCER ATHLETES: SYSTEMATIC REVIEW

Ashley Michelle Boles, Amber C. Fleer

PURPOSE/HYPOTHESIS: Concussions for female athletes are a prevalent outcome for those playing competitive soccer. As a result, aspects of prevention are of importance in the sphere of research. One area in particular is the effectiveness of cervical neck strengthening programs. The purpose of this review was to determine the effectiveness of these cervical neck strengthening programs on concussion prevention for female soccer athletes.

NUMBER OF SUBJECTS: 675

MATERIALS AND METHODS: Databases that were used in this study included CINAHL Ultimate, CINAHL Complete, and SPORTDiscus with Full Text. Studies were limited to Full Text and Peer Reviewed from 2019-2023. The Modified Downs and Black was used to assess the qualities of the study and a score of 14 or higher was needed to be included.

RESULTS: After screening 83 studies, only 5 met our criteria for inclusion. The average Modified Downs and Black score was 20.2, with a range of 16 (fair) to 23 (good). The studies used various outcome measures to appraise the benefits of neck strengthening and structured strengthening programs for female soccer athletes. The average Modified Downs and Black score was 20.2, with a range of 16 (fair) to 23 (good). The studies used various outcome measures to appraise the benefits of neck strengthening and structured strengthening programs for female soccer athletes.

CONCLUSIONS: The current literature shows inconclusive evidence in the use of structured neck strengthening programs to prevent concussions in female soccer players. Further research on this topic is necessary to make supported determinations.

CLINICAL RELEVANCE: Although neck strengthening is good for the cervical spine, literature doesn't definitively support it for the prevention of concussions in female soccer athletes. Clinically it should be noted that although neck strengthening is not a bad thing, choosing this intervention in hopes of concussion prevention may not lead to the desired outcomes; however, it will not hurt the athlete and may benefit the stability of the cervical spine.

SP023

ASSOCIATION OF HEART RATE VARIABILITY AND ANXIETY SCORING ON THE CONCUSSION CLINICAL PROFILE SCREENING TOOL

Caitlin Fields

PURPOSE/HYPOTHESIS: Heart rate variability (HRV) is the variation in time between heart beats measured in milliseconds that can be used as a non-invasive method to analyze the autonomic nervous system (ANS). Low HRV has been shown to be an indicator of psychological distress such as anxiety while higher HRV is associated with a better ability to adapt to stress. Lowered HRV has potential to manifest after concussion indicating ANS dysfunction. The Concussion Clinical Profile Screening Tool (CCPST) is a relatively new patient reported outcome measure that takes symptom inventory of 5 clinical trajectory profiles including: anxiety/mood, cognitive/fatigue, migraine, ocular, vestibular, and 2 modifying factors including sleep and neck. Recently published cut-off scores of for each clinical trajectory highlight contributing symptomology post-concussion. This pilot cohort study aims to determine if there is an association between HRV and CCPST anxiety/mood scoring.

NUMBER OF SUBJECTS: 5

MATERIALS AND METHODS: This study included 5 total participants that were recruited from an outpatient neurological physical therapy clinic. Inclusion criteria: previous history of concussion, ages 18-65. Exclusion criteria: not currently on beta blockers, no other history of major neurological or musculoskeletal injury. Heart rate variability was acquired on initial evaluation while the patient is at rest for six minutes, in a quiet area, using a Scosche heart rate band. CCPST scores were acquired shortly after by the evaluating physical therapist. Data on heart rate variability was extracted from a larger multi-institutional study. Statistical analysis included Spearman's coefficient using bivariate correlations with an alpha level set at 0.05.

RESULTS: The analysis revealed a strong inverse relationship between heart rate variability (HRV) and anxiety scores as measured by the CCPST. Participants with higher HRV demonstrated significantly lower anxiety scores, indicating a robust correlation between ANS regulation and anxiety levels post-concussion. Specifically, Spearman's rank correlation coefficient was calculated to be -0.667 ($p < 0.05$), indicating a significant negative correlation. These findings suggest that HRV could serve as a reliable biomarker for anxiety in concussion patients, offering potential for improved assessment and management strategies in clinical settings.

CONCLUSIONS: HRV norms vary in the literature, however there is evidence that suggests that age, sex, and fitness level are influential to HRV. This study did not include physical activity level which may influence HRV scoring. In conjunction with various contributors to HRV, the small sample size of this study was due to practice patterns in the healthcare setting of patients who were frequently prescribed beta blockers post-concussion. **CLINICAL RELEVANCE:** This study highlights a potential benefit to monitoring HRV during active physical therapy intervention when patients have higher anxiety scoring on the CCPST.

SP024

INJURIES IN PICKLEBALL PLAYERS: A PRELIMINARY REPORT FROM THE NATIONWIDE SPIN SURVEY

Oluwatoyosi Owoeye, Timothy Howell, Ted Yemm, Dawn Laura Kennedy, Ryan Blechle, Wassim Mourad, Chris Anne Sebeliski, Katie Stamatakis

PURPOSE/HYPOTHESIS: Pickleball is the fastest growing sport in the United States. In this preliminary analysis of an ongoing study, the Surveillance

in Pickleball players to reduce Injury burden (SPIN), we present the prevalence and characteristics of injuries in pickleball players across the United States.

NUMBER OF SUBJECTS: Projected 3,000 pickleball players across all levels of play.

MATERIALS AND METHODS: A cross-sectional survey involving a hybrid observational-implementation approach was executed. Pickleball players who engage in any form of play at least once a month and 18+ years old were invited to participate in the survey. An injury was defined as any physical complaint (all complaints) experienced while playing pickleball, including pain/physical discomfort not resulting in loss of pickleball participation and traumatic injuries resulting in loss of pickleball participation. Descriptive statistics of means and proportions with 95% CI were used to describe participant characteristics and injury outcomes, as applicable.

RESULTS: Based on a preliminary sample of 660 pickleball players (54% female, age range: 18-81 years), 98% (647/660) of the respondents identified as either a recreational (70%, 453/647) or an amateur (28%, 181/647) player. 65% (421/647) played pickleball $\geq 3x$ weekly. The 12-month prevalence of injuries was 68% (95%CI: 63% to 73%) for all-complaint injuries, 49% (95%CI: 44% to 54%) for pain and 39% (95%CI: 35% to 44%) for traumatic time-loss injuries. The knee, thigh/lower/leg/feet, shoulder and elbow were the most injured body parts, and the wrist/arm/hand/fingers were the least injured body parts, similar for pain and traumatic time-loss injuries. The most frequent "most serious" all-complaint injury types, as perceived by the players, were overuse/tendinitis/chronic conditions (34%), muscle strains (24%), joint/ligament sprains/conditions (20%), altogether accounting for 78% of all injuries. Majority (82%) of the time-loss injuries occurred during pick-up recreational games. The point prevalence of all-complaint injury was 45% (95%CI: 39%-51%); 86% of which were indicated as non-time-loss (ongoing) discomforting pain. Ongoing pain affected the knee (23%), feet (15%), shoulder (11%) and elbow (10%).

CONCLUSIONS: All-complaint injuries appear prevalent in pickleball players with 2 in 3 players expected to have a discomforting pain or traumatic time-loss injury over a 1-year period. 2 out of 5 players may experience an injury that will stop them from continued participation in pickleball. About 1 in 2 players play with pain. This preliminary analysis suggests that the knee joint is the most affected body region and overuse conditions are the most frequent injury type among players.

CLINICAL RELEVANCE: With the explosion of participation in pickleball in the United States, physical therapists have seen an increase in patients in their facilities with pickleball related injuries. Information about the location, frequency and types of these injuries will help inform effective treatments for these patients and allow physical therapists to educate these clients to avoid future injury and maintain their physical activity.

SP025

ECCENTRIC HAMSTRING STRENGTHENING FOR LOWER EXTREMITY INJURY PREVENTION IN PROFESSIONAL SOCCER PLAYERS: A SYSTEMATIC REVIEW

Ashley Michelle Boles, Amber C. Fleer

PURPOSE/HYPOTHESIS: Professional soccer players are susceptible to a high prevalence of musculotendinous hamstring injuries that result in missed match time throughout the season. With the high incidence rate of hamstring injuries within this population, researchers have recently determined several common risk factors for sustaining a hamstring injury, including decreased eccentric strength and previous injury to the area. This study examines the effectiveness of increasing eccentric hamstring strength through various techniques of exercise and its relationship to injury prevention.

NUMBER OF SUBJECTS: 709

MATERIALS AND METHODS: The databases searched for finding the studies included in this review were CINAHL Complete, Cochrane, Cochrane Central Register of Randomized Controlled Trials, Cochrane Database of

Systematic Reviews, Medline, and SportsDiscus. The Kennelly Checklist, including the Modified Downs and Black Scale was used to assess the quality of the three cohort studies and one meta-analysis selected for review.

RESULTS: The researchers independently assessed 76 articles and collectively narrowed them to the 4 articles included in this systematic review. The average score between articles using the Modified Downs and Black Scale was 17, with a range of 14 (poor) to 19 (fair). A variety of outcome measures were used by the studies to determine the efficacy of implementing eccentric hamstring exercise for strength gains and injury prevention in professional soccer players.

CONCLUSIONS: This systematic review supports the use of eccentric hamstring strengthening for lower extremity injury prevention in professional soccer players. Implementation of eccentric exercise into training showed increased strength gains and lower injury rates within the professional soccer population. Further research should focus on higher-quality studies that include more specific protocols for applying the injury prevention plan of care. Further research should focus on higher-quality studies that include more specific protocols for applying the injury prevention plan of care.

CLINICAL RELEVANCE: The main focus in implementing eccentric exercise is as a preventative measure, rather than a method of rehabilitation. Physical therapists should educate professional organizations and their athletes on the importance of prevention programs and their effect on injury rates and lost playtime

SP026

PATTERNS OF SELF-REPORTED SORENESS IN COLLEGIATE SOCCER: SEX DIFFERENCES, LIMB DOMINANCE, AND ACL INJURY HISTORY

Natalie Massa, Katie Oatman, Brett S. Pexa, Kevin R. Ford, Jeffrey B. Taylor

PURPOSE/HYPOTHESIS: While rehabilitation is often the focus for sports physical therapists, the primary prevention of an injury may be most impactful to athletes' long-term health. Self-reported soreness may serve as a warning sign of future injury; however, there is not great current evidence to understand this variable. The purpose of this study was to investigate self-reported daily soreness in collegiate soccer athletes throughout a competitive season to help inform preventative and rehabilitative care for these athletes. It was hypothesized that there would be differences in sex-specific reporting trends of soreness, and higher levels of soreness in the dominant limb (kicking limb), and in athletes with previous knee injury.

NUMBER OF SUBJECTS: Fifty-six Division-1 soccer players (27 male, 29 female) participated in the study during their competitive season.

MATERIALS AND METHODS: All participants completed pre-season past medical history questionnaires and daily soreness monitoring throughout the season. Soreness was collected via a daily self-report electronic survey that asked participants to identify anatomical regions of pain and the associated soreness intensities on a scale from 0-10. Anatomical regions of interest included both joints (hip, knee, ankle) and musculature (quadriceps, hamstrings, calf). Descriptive statistics were run on the whole sample. Independent t-tests was performed to identify sex differences in soreness reporting and a repeated measures ANOVA was used to identify differences in dominant and non-dominant limbs ($\alpha=0.05$).

RESULTS: Athletes on the men's team demonstrated higher survey compliance (98.6%) than the women's (72.3%) team. Soreness was reported on 32.8% of daily surveys, with no significant difference in frequency of reporting soreness between males and females ($p=0.58$). Males reported muscle soreness at a greater frequency than females (quadriceps: 31.9% higher, hamstrings: 50.4% higher, calf: 41.1% higher), while females reported 77.6% greater frequencies of knee joint soreness than males. There were no significant differences in average soreness intensities between dominant and nondominant limbs ($p=0.13$) nor a side x sex interaction ($p=0.78$). Participants with a history of ACL injury ($n=8$) trended towards larger frequencies of reporting quadriceps soreness than those with no previous history ($p=0.07$).

CONCLUSIONS: Males reported muscle soreness more frequently than females, who more commonly reported knee joint soreness. There were no reporting asymmetries dependent on limb dominance.

CLINICAL RELEVANCE: Collegiate soccer athletes reported high levels of daily soreness throughout the season. Though there were minimal differences in the frequency of soreness reporting, these data indicate that male and female soccer players have different reporting habits and/or soreness concerns. Preventative interventions should focus towards muscle injury in male athletes and joint injury in female athletes. Other data, including psychological and other internal load measures may also affect the care of these athletes.

SP027

RETURN TO HOCKEY CONSIDERATIONS FOLLOWING A TALUS FRACTURE AND DISLOCATION

Nathan Dixon McClain

BACKGROUND AND PURPOSE: Talus fractures compose of only 0.5% of fractures. Research shows that only 53% of patient's return to sport at their previous level after injury. Minimal research exists on return to sport after talus fracture and dislocation. Following ankle injuries, restoration of ankle dorsiflexion (DF) range of motion (ROM) is a mainstay of treatment. The nature of the injury sustained in this case prevented restoration of ankle ROM, thus to achieve set goal of return to sport, modifications were necessary. This case study uses data-driven decision making around ROM and muscle performance to guide treatment of athletes back to highest level of performance.

CASE DESCRIPTION: Patient is a semi-professional female hockey player looking to try out for the emerging Professional Women's Hockey League. During a game, she was illegal boarded and suffered a talar head and body fracture, calcaneal fracture and dislocation of the talocrural, talonavicular and subtalar joints. Following relocation and surgical stabilization of talus fracture, she was immobilized for 12 weeks prior to presenting to physical therapy. Patient verbalized goals to return to hockey by a year. At evaluation, Weightbearing Dorsiflexion Lunge Test (WDLT) was 0 centimeters (cm) compared to 12.5 cm on her contralateral side. Additionally, she was unable to complete a Single Leg Heel Raise, and had 4/5 manual muscle test (MMT) strength with hip and ankle testing.

OUTCOMES: After 9 months in physical therapy, at discharge the patient never achieved greater than 7 cm with the WDLT, despite consistent targeted interventions. After consecutive months of limited ankle DF ROM, focus shifted towards kinetic chain strengthening, which was monitored via handheld dynamometry (HHD). At discharge, the patient achieved force normalized to body weight in her quad at 2.87 Nm/kg and hip abductors at 2.57 Nm/kg, with limb symmetries of 96% and 104% respectively. Additionally, ankle inversion and eversion HHD progressed from 77% and 69% limb symmetry to 95% and 98%. Upon achieving set criteria, the patient returned to skating at 6 months post-operatively. The lead therapist utilized a criteria based protocol on progression of movements on ice to an eventual full return to game play at 10 months post-operative. During follow up survey at 1 year post-discharge, the patient noted no pain and full, unrestricted participation in sport.

DISCUSSION: Standard return to play criteria often consider ROM restoration as a primary goal of care. However, intrinsic factors existed in this case that prevented full restoration of ankle DF ROM. In order to achieve the patient's goal, a strict criteria was utilized to return to skating from current literature from other body regions. While limited evidence supports use of HHD with the ankle, assessment of ankle strength was paramount to the patient's successful return to sport. Despite minimal research to support clinical care or return to sport standards, use of clinical decision making supported by current research, paired with use of high standards with innovative assessment tools lead to a successful return to sport.

SP028**EFFECTIVE PREVENTION STRATEGIES FOLLOWING ACUTE LATERAL ANKLE SPRAIN IN YOUNG ADULTS: A SYSTEMATIC REVIEW**

Ashraf Elazzazi, Ryan Lambert, Brenna Stanton, Michael Mangi, Coby S. Cover, Deanna M. Errico

PURPOSE/HYPOTHESIS: Lateral ankle injuries are prevalent in the young adult athletic population, predisposing athletes to recurrent injuries and osteoarthritis if proper rehabilitation strategies are not utilized. This study investigated the most effective rehabilitation strategies for preventing recurrent lateral ankle sprains after an initial injury.

NUMBER OF SUBJECTS: Eight electronic databases and manual searches of systematic reviews were completed using keywords related to ankle sprain or injury, conservative management, and recurrence of injuries. Only peer-reviewed, experimental, or quasi-experimental studies published in English-language academic journals between Jan. 1990 and Feb. 2024 were included.

MATERIALS AND METHODS: Covidence software was used to screen titles and abstracts, full-text reviews, quality appraisal, and data extraction by four independent, blinded, and randomly assigned reviewers using the established inclusion and exclusion criteria. The Cochrane Risk of Bias Tool was used to assess the risk of bias, and a standardized data extraction tool was adapted for Covidence. Meta-analysis was performed to synthesize data from grouped studies using SPSS Version 29.1 software (IBM Corp., 2021). A random effects model for binary outcomes with risk differences to measure effect size was used. Egger's regression model and I² were used to examine publication bias and heterogeneity, respectively. A certainty assessment was performed using the GRADE approach to evaluate the risk of bias, inconsistency, indirectness, imprecision, and publication bias domains.

RESULTS: After removing 20 duplicates, 438 studies were screened, and 415 were excluded using the inclusion and exclusion criteria. Of the 23 full-text studies that were assessed for eligibility 10 were excluded. This systematic review included 12 randomized control trials and one cohort study. Studies addressed two types of interventions: exercise vs usual care (n=9) or bracing vs usual care (n=5). Three of the four arms in one study (Mohammadi et al., 2007) were used in both meta-analyses as they compared exercise vs usual care vs bracing. A separate meta-analysis was used to synthesize the results for each intervention. Overall, the risk of bias for both treatments was rated as "some risk of bias." Meta-analysis findings revealed a small but significant effect size of risk difference for both treatments with 11% risk reduction (95%CI: 0.06, 0.17; *p*<0.001; I²=0.41) for exercise vs. usual care and 0.08 or 8% risk reduction (95%CI: 0.00, 0.16; *p*=0.04; I²=0.60) for bracing vs. usual care.

CONCLUSIONS: There is level 1A evidence that proprioceptive and bracing interventions have a low but statistically significant risk reduction for ankle sprain recurrence. The certainty of evidence using proprioceptive training is rated as moderate, indicating the true effect is probably close to the estimated effect of 11%. Contrarily, bracing vs usual care has very low certainty, meaning the true effect is probably markedly different from the estimated effect of 8%.

CLINICAL RELEVANCE: Balance/proprioceptive training is recommended to prevent the recurrence of ankle sprains after an initial injury.

SP029**THE EFFECTIVENESS OF CONSERVATIVE INTERVENTIONS FOR CALCANEAL APOPHYSITIS: A SYSTEMATIC REVIEW**

Mitchell C. Selhorst, Katie Lullo, Joshua Allen Kempton, Alexander William Rospert

PURPOSE/HYPOTHESIS: Calcaneal apophysitis, also known as Sever's Disease, is a common condition in the pediatric population and can cause severe pain and disability. The purpose of this systematic review was to assess the effectiveness of conservative interventions for calcaneal apophysitis.

NUMBER OF SUBJECTS: 1591 abstracts were screened, with 132 full-text articles reviewed. This systematic review included ten full-text articles (8 randomized trials, 2 case series).

MATERIALS AND METHODS: Studies were included in this systematic review if they assessed the effectiveness of conservative interventions for calcaneal apophysitis in the pediatric population (birth-18 years) in > 2 patients. Two reviewers evaluated all articles independently in this review. A third reviewer served as a tiebreaker if there was a disagreement about the article. There were eight randomized controlled trials assessing the effectiveness of shoe inserts (orthoses, heel lifts, and heel cups), braces (x-brace and cheetah cups), taping (kinesiology, arch taping), physical therapy (PT), and wait-and-see for calcaneal apophysitis. One case series assessed arch taping. Another case series assessed the effectiveness of custom orthoses.

RESULTS: *Inserts:* Six randomized controlled trials and one case series assessed the effectiveness of shoe inserts. All of these studies agreed that using shoe inserts (orthoses, heel lifts, and heel cups) was beneficial for pain and functional ability in this population. Results are mixed on which insert type was most effective. *Bracing:* One randomized controlled trial found bracing beneficial for pain relief in barefoot athletes who could not wear inserts. *Taping:* There was no benefit in using kinesiology taping over sham taping for calcaneal apophysitis, while immediate pain relief was observed in arch taping. *PT vs. Wait-and-See:* In one randomized controlled trial, PT was more beneficial than a wait-and-see approach at a 6-week follow-up for pain and function.

CONCLUSIONS: The results of this systematic review demonstrate that shoe inserts are a beneficial conservative intervention for calcaneal apophysitis. It is unclear which type of insert is most beneficial. Bracing may be a beneficial alternative to shoe inserts for athletes who participate in barefoot sports. Limited evidence on taping suggests that kinesiology taping was not beneficial, while arch taping may have limited short benefits for pain relief. While most studies included PT as a standard part of care in all groups, limited evidence exists assessing the effectiveness of PT for calcaneal apophysitis, suggesting that PT may be more effective than a wait-and-see approach. More research is necessary to determine the true effectiveness of physical therapy for this population.

CLINICAL RELEVANCE: Clinicians should provide shoe inserts in combination with PT exercises for patients with calcaneal apophysitis. For barefoot athletes, clinicians may consider using bracing (x-brace or cheetah cups) as an alternative to shoe inserts during sport.

SP030**TENDON STIFFNESS AND JUMP PERFORMANCE OF A HEALED ACHILLES TENDON RUPTURE: A CASE STUDY**

Matthew Lee Dewald, Abigail (Abby) Ripperda, Tiegen Lindner, Kaylee Freitag, Kino Dunkley

BACKGROUND AND PURPOSE: Achilles tendon (AT) ruptures are among the most common tendon injuries in adults, with an incidence of 7-40 ruptures per 100,000 individuals. The majority of evidence indicates no difference between operative and non-operative management in complication rates, functional outcomes, and return to activity. This case investigates acute effects of ankle hops, heel raises, and knee to wall mobility exercises on the AT stiffness and drop jump performance of a 23-year-old female with a healed AT rupture treated non-operatively five years ago.

CASE DESCRIPTION: The subject is a 23-year-old female who tore her Achilles tendon and was treated non-operatively 5 years ago. She continues to have weakness and atrophy. The subject participated in a randomized cross over trial for two weeks for a total of three different sessions; three different interventions were implemented with one week's rest between each session. Interventions included a plyometric double leg wall hop, a dynamic knee to wall stretch, and a body weight loading heel raise. Pre- and Post- intervention measures each week include tendon stiffness assessed using the MyotonPRO and single leg drop jump performance from a 4 inch box assessed using the *MyJump2* app. Variables assessed

from the drop jump included: single leg hop height, reactive strength index (RSI), and ground contact time.

OUTCOMES: The involved side had detectably slower ground contact time (24.44 ms, MDC: 13.62) and more tendon stiffness (66.2 N/m, MDC: 25.89 N/m) than the uninvolved. The involved side jump height and RSI decreased with heel raises and knee to wall mobility exercises. The contact time improved with heel raises. The tendon stiffness increased with heel raises and decreased with ankle hops and knee to wall mobility.

DISCUSSION: The tendon properties and jump performance of the healed AT demonstrated deficits and diminished acute responses to interventions compared to the uninvolved side. All three exercises had unique acute improvements. The knee to wall exercise normalized ground contact time and tendon stiffness on the uninvolved side; however, it did have undesirable acute effects on jump height and RSI. This demonstrates the need for a multimodal exercise approach.

SP031

INTRA-RATER RELIABILITY OF THE MOBIL-AIDER® DEVICE FOR MEASUREMENT OF ANTERIOR LINEAR TRANSLATION OF THE TALUS

Penny Lanette Head, Lauren Batten, Nadine H. Langsdorf, Jaclynn N. Whiting

PURPOSE/HYPOTHESIS: Approximately 2 million ankle sprains occur in the US each year, with the anterior talofibular ligament (ATFL) being the most commonly injured ligament. The anterior drawer test (ADT) is commonly used to assess ligamentous laxity of the ATFL following injury. This test involves moving the calcaneus anteriorly to create an anterior translation of the talus relative to the distal tibia/fibula. The intra-rater reliability of this test has been found to have a large variance ranging from 46% to 92% agreement. The use of a joint arthrometer to measure linear translation may be a valuable clinical tool to improve reliability of the ADT. The Mobil-Aider® device is a lightweight portable joint arthrometer designed to quantify linear translation of a joint. The purpose of this study was to determine the intra-rater reliability of the Mobil-Aider® in measuring anterior translation of the talus during the performance of an ADT.

NUMBER OF SUBJECTS: 28 healthy adults (14 M; 14 F) with a mean age of 23.4 years (range 21-25 years). Exclusion criteria included no history of ankle surgery and no previous history of ankle injury within the past 3 months.

MATERIALS AND METHODS: Each subject was tested in a supine position with the knee of the dominant leg flexed 20° over a bolster and the ankle hanging freely off the edge of the table. The Mobil-Aider® was aligned with the talocrural joint and the digital display was covered to blind the rater to all measures. An expert clinician with 34 years' experience in orthopedic/sports physical therapy served as the rater and performed the ADT with the Mobil-Aider® in place to measure the amount of talar translation. A co-investigator recorded all measures from the device. A total of 3 trials were performed for each subject during a single session. Intra-rater reliability was estimated using the intraclass correlation coefficient (ICC 3,1) with 95% CIs based on a single rating, 2-way mixed effects model. Measurement error was also estimated by calculating the standard error of measurement (SEM) and the minimal detectable change (MDC).

RESULTS: The Mobil-Aider® demonstrated good to excellent intra-rater reliability with an ICC (3,1) of 0.87 (95%CI=0.77 to 0.93). The SEM was determined to be 0.81 mm and the MDC was calculated to be 2.2 mm.

CONCLUSIONS: When used by an experienced clinician, the Mobil-Aider® appears to be a reliable tool for assessing anterior translation of the talus during performance of the ADT in healthy, young adults. The SEM suggests good measurement precision for this device and the MDC indicates a change of 2.2 mm is needed to demonstrate a true change. Further research is needed to determine the reliability of the Mobil-Aider® in subjects following ATFL injury.

CLINICAL RELEVANCE: The ability to quantify joint translation using the Mobil-Aider® device during the ADT may improve the reliability for assessment of ATFL ligamentous laxity following ankle sprain injury.

SP032

BIOMECHANICS LAB TO CLINIC: ACHILLES TENDON REPAIR WITH SPEEDBRIDGE: A CASE REPORT

Gabe Haberly, Tess Treinen Swake

BACKGROUND AND PURPOSE: In the U.S., Achilles Tendon (AT) ruptures have increased 39% during 2012-2016. The Speedbridge AT repair has gained publicity following use of this surgical technique to expedite speed of return to play timeline and allow early weight bearing. Within assessment, peak torque and rate of torque development (RTD) have been used both in athletic and rehabilitation populations as measures of sports performance or biomarkers for progression of orthopedic conditions. As such, peak torque and RTD asymmetry may be helpful for return to sport following injury. The purpose of this case report was to explore plantarflexion (PF) peak torque and RTD along with kinematics and kinetics measured using a markerless motion capture system with PT after a Speedbridge AT repair.

CASE DESCRIPTION: The patient was a 38-year-old male recreational athlete with a Speedbridge AT repair. Along with PT treatment, beginning at 2.5 months post-operative (post-op), bilateral PF peak torque was measured monthly using a Biodex isokinetic dynamometer. RTD was calculated over three separate windows following onset of contraction. Monthly markerless gait and force plate analyses were also performed.

OUTCOMES: Over 4 months, symmetry improved for peak PF torque (16%), RTD 0-50 ms (68%), 0-100 ms (49%), and 0-200 ms (29%). Single heel raise symmetry improved for ankle range of motion (ROM) (5%), peak ankle PF moment (7%), and peak ankle power generation (6%). Jogging and double leg jumping began at 4.5 months post-op. For jogging, symmetry improved for ankle ROM (7%), peak PF moment (42%), peak ankle power generation (44%) and absorption (53%). Double leg jumping ankle symmetry improved for ROM (10%), peak PF moment (23%), peak ankle power generation (18%) and absorption (37%). Single leg jumping began 5.5 months post-op. Symmetry improved for ankle ROM (16%) and peak power absorption (23%). Comparing peak PF torque calculated by the Biodex to peak PF moments measured during movement, the involved limb displayed a greater peak moment to torque ratio compared to the uninvolved limb. Most recently, discrepancies between involved and uninvolved limbs were observed for the single leg heel rise (44%), jogging (35%), double leg jump (20%), and single leg jump (14%).

DISCUSSION: From 2.5 to 6.5 months post-op, RTD symmetry from 0-50 ms and 0-100 ms improved to a greater extent compared to peak torque and RTD symmetry from 0-200 ms, suggesting greater restoration of neuromuscular control in early rehabilitation. Peak ankle PF moment and power generation symmetry improved in all movements except the single leg jump, with the greatest improvement observed with jogging. This is expected, considering the high demand of the ankle PF's during locomotion. Peak ankle power absorption improved in all movements except the single heel rise. This result most likely reflects the static versus dynamic nature of the movements. The greater peak moment to torque ratio of the involved limb may be a result of changes in neuromuscular control following injury. The nervous system may be compensating for differences in musculotendon properties between limbs.

SP033

INVESTIGATION OF LANDING MECHANICS AND VERTICAL JUMP FOLLOWING ANKLE TAPING IN ATHLETES: A CLINICAL TRIAL

Boriko Rodic, Michael Edward Lehr, Scott Kieffer, Matthew Lewis, Lincoln Stormer, Micaiah Sidell, Paul Asper, Ethan Brady Phillips

PURPOSE/HYPOTHESIS: Chronic Ankle Instability (CAI) is one of the most common ankle pathologies managed by sports medicine professionals among collegiate athletes. Injury prevention and management strategies for CAI commonly includes taping interventions to the ankle complex that can include both traditional methods, as well as contemporary strategies

that involve fibular repositioning. Limited research exists comparing these two taping techniques on human performance measures, such as landing mechanics utilizing the landing error scoring system (LESS) and lower extremity power measured by the vertical jump. The primary aim of the study is to investigate how specific taping strategies impact scores on the LESS and vertical jump performance.

NUMBER OF SUBJECTS: The randomized repeated measures control study design was conducted on 21 collegiate athletes from four different collegiate men's and women's sports teams.

MATERIALS AND METHODS: The subjects were randomly assigned into three groups: control, traditional taping, and fibular taping based on inclusion criteria. A board-certified orthopedic specialist (OCS)/core faculty member performed all fibular taping procedures using leukotape, while a licensed athletic trainer/professor performed all traditional taping. Pre and post-test measures were collected for landing mechanics utilizing the Landing Error Scoring System (LESS) and vertical jump performance. Central tendency measures, descriptive, and comparative analyses (Mixed ANOVA) were conducted between groups to determine mean differences and changes in pre and post-test measures.

RESULTS: With Vertical jump as the dependent variable, both a main effect of time (pretest, posttest), $F(1, 18) = 4.984, p = .039, R^2 = .217$, and the groups x time interaction, $F(2, 18) = 4.691, p = .023, R^2 = .343$, were significant. The main effect of groups, $F(2, 18) = 1.290, p = .300, R^2 = .125$, was not significant. The main effect of time showed that scores significantly decreased from the pretest ($M = 116.15$) to posttest ($M = 115.42$).

With LESS as the dependent variable, no effects were significant. The main effect of time (pretest, posttest), $F(1, 18) = 0.023, p = .881, R^2 = .001$, the main effect of groups, $F(2, 18) = 0.621, p = .549, R^2 = .064$, and the groups x time interaction, $F(2, 18) = 0.230, p = .797, R^2 = .025$, were not significant.

CONCLUSIONS: Traditional ankle taping or fibular taping techniques do not impact landing mechanics as measured by the LESS or vertical jump performance in collegiate athletes.

CLINICAL RELEVANCE: Research consistently demonstrates neuromuscular changes not only isolated to the ankle but within the entire kinetic chain in CAI pathology. Return to sport decision making can be enhanced with objective clinical information on landing mechanics and lower extremity power in the collegiate athlete. Ankle-taping techniques are rarely used in isolation when addressing CAI, and future research should incorporate a multimodal approach to rehabilitation to explore the impact on human performance measures that are meaningful to the collegiate athlete's sport.

SP034

POSTERIOR HIP DISLOCATION WITH SUBSEQUENT SUBLUXATIONS IN PROFESSIONAL FOOTBALL PLAYER

Adison Cook, Paul Hartman, Misha Bradford, Jake Magel

BACKGROUND AND PURPOSE: Hip injuries make up 7.4% of lower extremity injuries in the National Football League (NFL). Hip instability with a dislocation or subluxation event is a rare injury, with an incidence of 16 occurrences in the NFL over 17 seasons. Complications of hip dislocation include osteonecrosis and post-traumatic osteoarthritis leading to long-term morbidity. There is little evidence on treatment efficacy and return to sport prognosis, only suggestions to "progressive activity in a gradual manner". The purpose of this case is to describe the postoperative rehab of a professional football player after hip dislocation.

CASE DESCRIPTION: The patient is a 25-year-old male complaining of left hip instability, with self-reported subluxations occurring bi-weekly and anterior hip pain (3/10). Past medical history includes a left hip posterior dislocation in 2021 with surgical fixation. The patient completed rehab and returned to play professionally in March of 2023. In May of 2023, the involved hip subluxed. He continues to have instability and pain in tripod stance, deep hip flexion, and during daily activity. On exam he reports instability with squat below 70°, painful and limited internal rotation (IR)

range of motion (ROM), positive FABER and FADIR, and strength below 22% body weight (BW) in the following positions: IR, ER, abduction, and extension. Recent imaging shows decreased femoral head and increased size of osseous excrescence at femoral head/neck junction, significant signal in the posterior hip joint, thin hip capsule, and severe atrophy of deep hip ER musculature.

OUTCOMES: Current rehab guidelines following dislocation recommend 6 weeks of protected weight bearing with early ROM and progressive return to activity. Physical therapy (PT) began 23 weeks after re-injury and included banded hip strengthening and grade 3 global hip distraction, resulting in decreased hip instability and pain. Rehab progressed with increased loading through deeper, pain-free ROM in weight bearing. After an increase in symptom irritability, exercise intensity was regressed to isolated hip strengthening with bands. He returned to PT with decreased pain intensity (2/10) and improved strength, albeit did not reach age matched norms. Due to duration of symptoms and imaging findings, he decided to pursue explorative arthroscopic hip surgery to aide in symptom management and promote return to play.

DISCUSSION: This patient demonstrated an average of 4.6% BW increase in hip strength measurements after 6 weeks, however, failed to reach 2.6 Nm/Kg (1.83Nm/Kg) with abductor strength norms studied in professional football players. He continued to have significant hip pain and reports of instability following recommended conservative interventions. In addition to strength, anatomical variations likely impact hip instability and need to be considered. Ultimately, this patient did not return to sport after conservative management in PT and surgical consultation was warranted.

SP035

ARE PRIOR FOOT/ANKLE OR KNEE INJURIES IN YOUTH SPORTS ASSOCIATED WITH YOUNG ADULT HIP PAIN?

Christa M. Nelson, Craig P. Hensley, Alison H. Chang, Amanda Acosta, Urte Barauskas, Caroline Case, Grace Chaw, Chris Grecco, John Goetschius

PURPOSE/HYPOTHESIS: Hip pain is a common musculoskeletal concern affecting 10% of the general population, significantly impacting the quality of life in both younger and older age groups. Studies have observed a link between prior injuries to the knee and ankle and the subsequent development of site-specific pain in these joints. The concept of regional interdependence is often used in clinical reasoning when assessing and managing lower limb dysfunction. However, it is unclear whether previous injury to the foot/ankle and/or knee increases the likelihood of developing hip symptoms. This study aims to investigate the association between youth non-hip lower extremity injuries and subsequent hip pain.

NUMBER OF SUBJECTS: 424

MATERIALS AND METHODS: This is a secondary analysis of a cohort of students at a large university in the U.S. who participated in an electronic survey conducted from Dec. 2019 to Jan. 2020. The sample included adults aged 18-24 who had participated in a primary sport during their youth. Participants reported if they had any history (yes/no for each joint) of foot/ankle, knee, or hip injuries during youth sports prior to grade 9 that had impacted their ability to play their sport for at least 1 week. Joint pain at the time of the survey was rated using separate VAS scales (0-10 cm) for each region (foot/ankle, knee, hip).

Individuals with a history of hip injury (N=49) were excluded from the analysis to minimize effects of a prior hip injury on current hip pain. A cumulative odds ordinal logistic regression with proportional odds model determined the association of youth injury history (0: no injury history, 1: knee ONLY, 2: foot/ankle ONLY, or 3: BOTH foot/ankle and knee) on current hip pain (none: =0, mild: >0 but <2, and at least moderate: ≥2) adjusting for age, sex, and BMI.

RESULTS: The final analysis included 375 participants. More severe current hip pain was associated with a prior injury to both the foot/ankle AND

knee [odds ratio (OR)=4.9; 95% CI: 2.8-8.6, $p<0.001$] or with foot/ankle injury ONLY [OR=2.7; 95% CI: 1.7-4.4, $p<0.001$], but not with knee injury ONLY [OR=1.2; 95% CI: 0.6-2.2, $p=0.6$]. Sex was also a significant factor; females had greater odds of more severe current hip pain than males regardless of injury history [OR=2.2; 95% CI: 1.5-3.4, $p<0.001$]. Sensitivity analysis using 4 pain categories (none, mild, moderate, severe) for the dependent variable yielded similar results.

Sex-stratified analyses adjusting for age and BMI showed similar patterns of significant associations for both males and females.

CONCLUSIONS: These results suggest that in young adults with no history of hip injuries, current hip pain may be associated with a prior injury to the foot/ankle and/or knee. Those with a history of injuries to BOTH the foot/ankle and knee were nearly 5 times more likely to experience more severe hip pain. To our knowledge, this is the first larger scale study reporting the adverse impact of prior foot/ankle and knee injuries on hip pain.

CLINICAL RELEVANCE: When designing a comprehensive rehabilitation program, clinicians should be mindful that patients or athletes with foot/ankle and knee injuries may be at risk of developing hip pain.

SP036

PERSISTENT CARTILAGE ALTERATIONS IN FEMALE DIVISION I ATHLETES WITH PREVIOUS KNEE INJURIES

Karen Thatcher VanEtten, Lucas Allen VanEtten, Smrithi Ajit, Fabrice Mowbray, Dola Pathak, Corey Grozier, Arjun Parmar, Matthew Harkey

PURPOSE/HYPOTHESIS: Young female athletes face an elevated risk of knee injury, a significant precursor to osteoarthritis development. While cartilage alterations are a hallmark sign of osteoarthritis, the progression of these changes in athletes post-knee injury remains poorly understood. This study aimed to assess differences in femoral cartilage using musculoskeletal ultrasound between female Division I athletes with previous knee injuries and those with no history of knee injury.

NUMBER OF SUBJECTS: 31 Division I female soccer, field hockey, and volleyball athletes. 13 participants had a history of knee injury (PKI group), while 18 did not have a history of knee injury (NKI group).

MATERIALS AND METHODS: History of knee injury was determined with a pre-season self-reported injury history screening form. A single investigator performed pre-season transverse suprapatellar ultrasound assessments of femoral cartilage on all participants, positioned supine with knees flexed to 140 degrees. A custom semi-automated segmentation tool, requiring minimal user input, calculated mean thickness (cross-sectional area/cartilage-bone interface length) and mean echo intensity—key indicators of cartilage morphology and composition. Bilateral cartilage assessments were conducted, with asymmetries calculated using the formula: $\text{abs}(R-L)/[(R+L)/2]*100$. This formula yields the percent difference between limbs, interpreted as asymmetry. Given the uncertainty of which knee was previously injured, absolute values were used when assessing inter-knee differences to ensure any discrepancy was accounted for as asymmetry. Cartilage asymmetry was compared between athletes with a PKI and NKI with the Wilcoxon rank sum test due to non-normally distributed data.

RESULTS: The NKI group (age=18.9±0.9 yrs) was statistically younger than the PKI group (age=20.5±1.6 yrs; $p<0.01$), with no significant between group differences in height ($p=0.23$) or weight ($p=0.29$). The PKI group exhibited greater echo intensity asymmetry than the NKI group (NKI median = 3.5%, IQR = 8.2%; PKI median = 7.1%, IQR = 10.3%; $W=83.5$; $p=0.039$), while cartilage thickness asymmetry did not differ significantly between groups (NKI median = 6.1%, IQR = 11.3%; PKI median = 11.6%, IQR = 11.1%; $W=189.5$; $p=0.16$).

CONCLUSIONS: The PKI group showed greater cartilage echo intensity asymmetry, suggesting more pronounced alterations in cartilage composition following previous knee injury compared to athletes with no known

knee injury history. These findings suggest that cartilage alterations persist after rehabilitation and can be detected non-invasively long before osteoarthritis development. Understanding the time course of cartilage changes post-knee injury may help elucidate early treatment options, mitigating future disability due to joint tissue degradation.

CLINICAL RELEVANCE: Continuous monitoring and targeted rehabilitation strategies are crucial for young female athletes with a history of knee injury. Future research should explore the progression of these asymmetries and potential interventions to prevent long-term joint deterioration.

SP037

RELIABILITY OF THE REACTIVE 5-10-5 SHUTTLE FOR RETURN TO SPORT TESTING

Jeremy Shakouri Wydra, Ava Schwartz, Grant Norte, Randi Moak Richardson, Moein Koohestani, Kylie McGlone, Gaston Dudley, Matt S. Stock, Meredith Chaput

PURPOSE/HYPOTHESIS: Return to sport (RTS) functional assessments often emphasize unidirectional anticipated movements, though sport requires unanticipated change of direction in response to visual environmental stimuli. While recent data suggest that RTS assessments should reflect sport environments, defining and quantifying change of direction performance transfer to sport poses difficulty. Our purpose was to determine the reliability of a reactive change of direction task in healthy individuals to improve the ecological validity of RTS testing. We hypothesized that layering a reactive component on a standard change of direction test would demonstrate good to excellent reliability and result in slower performance compared to the original test.

NUMBER OF SUBJECTS: Twenty-six active uninjured college-aged students participated (17 females, 23.1±1.8years, 170.9±10.2cm, 71.4±14.5kg, Tegner Activity Scale 5.1±0.7).

MATERIALS AND METHODS: Participants completed two visits separated by 14 days. Each visit consisted of a traditional (TS) and reactive (RS) 5-10-5 shuttle test in randomized order. For the TS, participants were provided a random direction (left or right) prior to the task, which indicated the direction they sprinted first. For the RS, sprint direction was initiated when one of two lights illuminated within a randomized 3-7 second time window. Participants completed one practice and three successful trials with 1 minute of rest between trials. The fastest reaction time (RS only), first split time, and total time (seconds) of the test trials were analyzed. Test-retest reliability was established with intraclass correlation coefficients ($ICC_{3,1}$) using 2-way mixed effects with an absolute agreement and 95% confidence intervals. Paired samples t-tests were used to determine between test differences ($\alpha=.05$) on visit 1.

RESULTS: TS first split time ($ICC_{3,1}=.97[0.94-0.98]$) and TS total time ($ICC_{3,1}=.99[0.96-0.99]$) demonstrated excellent reliability. RS first split time ($ICC_{3,1}=.96[0.86-0.98]$) and RS total time ($ICC_{3,1}=.96[0.88-0.98]$) demonstrated good-to-excellent reliability. RS reaction time ($ICC_{3,1}=.75[0.45-0.89]$) demonstrated poor-to-moderate reliability. On average, the RS resulted in significantly slower split time (-24.24%, $p<.01$) and total time (-13.31%, $p<.01$) relative to the TS.

CONCLUSIONS: Split time and total time outcomes demonstrated good-to-excellent test-retest reliability and a reactive start induced a significant performance deficit when compared to the traditional shuttle test.

CLINICAL RELEVANCE: Our findings align with previous studies that have augmented traditional RTS hop tests with neurocognitive loads and found good to excellent reliability. Our study extends the traditional RTS testing battery by neurocognitively loading dynamic change of direction. Previous research suggests that individuals with lower-extremity injuries perform similarly to healthy controls in single-task scenarios but show deficits when dual-tasks are introduced. This test may provide reliable insight on an athlete's ability to maintain change of direction performance under unpredictable circumstances when determining readiness for RTS.

SP038**ACCURACY OF A SMARTPHONE APPLICATION FOR KNEE RANGE OF MOTION MEASUREMENTS PERFORMED BY ASYMPTOMATIC LAYPERSONS**

Elizabeth S. Norris, Karen Furgal, Jacob W. Pooler, Mina M. Samer, Ethan P. Warren

PURPOSE/HYPOTHESIS: Smartphone applications (apps) provide a potential way in which patients can self-monitor knee range of motion (ROM) at home or during remote therapy visits. While previous research has established psychometric properties of app-based knee ROM measurements conducted by medical professionals, less information is available for measurements conducted by a layperson (LP). The purpose of this study was to investigate the intra and inter-rater reliability and validity of knee AROM measurements made by LPs using a smartphone application.

NUMBER OF SUBJECTS: 31 (mean age 21.4±3.0) LPs with pain-free AROM and no experience in measuring knee ROM.

MATERIALS AND METHODS: Knee flexion and extension AROM were measured by LPs using the Curovate app (LP-app) and by a single physical therapist using the app (PT-app) and a goniometer (PT-gonio). LPs were instructed in the use of the app and allowed to practice self-measuring knee AROM following verbal instructions provided by the app. To ensure consistency of each motion, a wedge was used for foot placement during knee flexion, and a towel roll was placed under the leg during knee extension. Two repeated trials of each knee motion were performed. For each trial, measurements were conducted by the LP-app, PT-app, and PT-gonio while knee position was maintained. LPs and the PT were blinded to individual measurements and each other's measurements. The protocol was performed with and without tape placed above and below the patella for smartphone placement.

Intraclass correlation coefficients (ICC) were calculated to assess intra-rater reliability across 2 trials of each knee motion, inter-rater reliability using the average of 2 repeated trials for each motion, and concurrent validity of LP-app measurements to PT-gonio measurements. Limits of agreement (LoA₉₅) and minimal detectable change (MDC₉₅) were computed.

RESULTS: Intra-rater reliability of both LPs and PT and inter-rater reliability between LP and PT was good to excellent (ICC = 0.81-0.96) for knee AROM performed with the app. The agreement between the LP-app and PT-gonio was good to excellent (ICC > 0.88) for knee flexion but poor (ICC < 0.372) for knee extension. The use of tape for smartphone repositioning did not improve reliability. The mean difference between LP-app and PT-app measurements was 1 and -3 degrees for flexion and extension, respectively. The mean difference between LP-app and PT-gonio measurements was -5 and 1 degrees for flexion and extension, respectively. The intra and inter-rater reliability MDC₉₅ values of app measurements was 6 and 2 degrees, respectively for knee flexion and 4 and 5 degrees, respectively, for knee extension.

CONCLUSIONS: After one session of practice, a LP can produce knee AROM measurements with an app that is reliable and has high agreement with app measurements performed by a PT. The agreement of LP-app knee AROM measurements to PT-gonio measurements is supported for knee flexion but not for knee extension.

CLINICAL RELEVANCE: The Curovate app used by LPs is a reliable and valid method and instrument for measurement of knee flexion which may be useful during self-monitoring or remote rehabilitation sessions.

SP039**PREVALENCE OF PRIOR PATELLAR TENDINOPATHY AND ASSESSMENT OF CLINICAL OUTCOMES IN PROFESSIONAL BASKETBALL PLAYERS**

Dan O'Brien, Naoki Ito, Bryan C. Heiderscheit, Scott Allan Epsley, Peter Meisel, Asheesh Bedi, Wiemi Dougouih

PURPOSE/HYPOTHESIS: Patellar tendinopathy is a common debilitating injury for jumping athletes. Most studies have focused on athletes who are symptomatic at the time of testing, but the clinical presentation of athletes

with a history of patellar tendinopathy, regardless of symptoms at the time of testing, has been less frequently studied. The purpose of this cross-sectional analysis, using data from a larger longitudinal pilot study, was 1) to assess the prevalence of prior patellar tendinopathy in professional basketball players and 2) to compare baseline clinical outcomes between athletes with a history of patellar tendinopathy versus those who do not at the start of their regular season. We hypothesized that at baseline, players with a history of patellar tendinopathy would present with worse clinical outcomes compared to those without a history.

NUMBER OF SUBJECTS: 41 male basketball players from four NBA G League teams (age: 24.9 ± 2.1 years, BMI: 24.9 ± 2.6 kg/m²).

MATERIALS AND METHODS: At the start of the season, athletes reported history of patellar tendinopathy and completed the Victorian Institute of Sport Assessment-Patellar Tendon (VISA-P). Patellar tendon B-mode ultrasound (GE Healthcare, Chicago, IL) and shear wave elastography were obtained bilaterally. Tendon cross-sectional areas (CSA) and shear wave speeds (SWS) were measured. Peak countermovement jump (CMJ) height, single leg jump (SLJ) height, and peak force during isometric belt squats were assessed using force plates (Vald, Newstead, Queensland). Values were averaged across limbs for athletes without a history of patellar tendinopathy and those with a history of bilateral tendinopathy. For athletes with a history of unilateral tendinopathy, the previously injured side was used. Independent t-tests were conducted for each clinical outcome of interest to compare between athletes with (PT) and without (NoHx) a history of patellar tendinopathy.

RESULTS: Fifty-one percent of the athletes reported a history of tendinopathy, with 43% reporting having a history of bilateral symptoms. VISA-P showed marginally significant differences between groups (NoHx 92±11 vs PT 85±12, p = 0.06). No significant group differences were found in SWS in long axis (NoHx 8.0±1.1 m/s vs PT 8.4±1.3 m/s, p = 0.40), short axis (NoHx 5.27±1.1 m/s vs PT 5.74±1.5 m/s, p = 0.29), CSA (NoHx 146±23 mm² vs PT 153±30 mm², p = 0.62), CMJ (NoHx 38±5 cm. vs PT 37±4 cm, p = 0.35), SLJ (NoHx 19±3 cm vs PT 18±4 cm, p = 0.22), and belt squat force (NoHx 24±5 N/kg vs 24±6 N/kg, p = 0.75).

CONCLUSIONS: Despite the high prevalence of prior patellar tendinopathy, clinical outcomes were similar between professional basketball players with and without a history of patellar tendinopathy. The VISA-P was marginally lower in those with a tendinopathy history.

CLINICAL RELEVANCE: Findings underscore the high prevalence of patellar tendinopathy in professional basketball players and the possible importance of comprehensive screening and treatment plans even if symptoms are not present. Future analysis will analyze longitudinal pilot study data to investigate the effect of a G League season on the patellar tendon.

SP040**IMPACT OF CUSHIONED SPORTS FLOORING ON KNEE JOINT CONTACT FORCES**

Thomas Jackson, Erica Boswell, Ankur Padhye, Stacey A. Meardon, John David Willson

PURPOSE/HYPOTHESIS: Exposure to mechanical stimuli is increasingly recognized as an important rehabilitation consideration for athletes following knee joint injury. Due to the repetitive nature of gait activities associated with return to sport, factors eliciting small changes in knee joint articular cartilage force each step may produce meaningful cumulative effects relevant to joint health and disease processes. Cushioned vinyl flooring is the most widely used indoor sports flooring and purports to reduce musculoskeletal injury risk by damping impact loading. It is unknown if sports flooring affects knee joint forces during athletic tasks and if this impact varies based on task demands. The aim of this study was to test for sports flooring effects on tibiofemoral joint (TFJ) and patellofemoral joint (PFJ) contact forces during walking, running, and sprinting.

NUMBER OF SUBJECTS: 20 recreational athletes (10M/10F, 1.73 m, 74.12 kg, 23.9 yr)

MATERIALS AND METHODS: 3D lower extremity kinematics (200 Hz) and ground reaction forces (GRF) (2000 Hz) were recorded during five stance phases of walking (1.5 m/s), running (3.5 m/s), and sprinting (5.5 m/s) performed overground with and without sports flooring (12.4 mm, ASTM F2772 Class 4 shock absorption properties). Gait data were input to a biomechanical model previously validated against TFJ *in vivo* ambulatory loads to estimate total TFJ force, medial compartment TFJ force (mTFJ), and PFJ stress from which peak magnitude, average loading rate, and impulse variables were identified. Explanatory variables, including peak knee flexion, peak vertical GRF, and GRF average loading rate were also examined. All variables were tested using separate 2-factor ANOVAs ($\alpha = .05$), where both flooring (bare, flooring) and task (walk, run, sprint) were repeated factors.

RESULTS: No flooring main effects were observed for total TFJ ($p=.63$) or mTFJ peak force ($p=.33$), TFJ ($p=.80$) or mTFJ ($p=.56$) loading rate, or TFJ ($p=.67$) or mTFJ ($p=.38$) force impulse. Flooring main effects were not observed for PFJ peak stress ($p=.97$), PFJ stress loading rate ($p=.82$), or PFJ stress impulse ($p=.99$). Peak vertical GRF ($p=.79$), vertical GRF loading rate ($p=.99$), and peak knee flexion ($p=.79$) also did not differ between activities performed on cushioned sports flooring compared to concrete. Effect size values (partial Eta squared) for all flooring main effects were small, ranging from $<.01-.05$, as were percent differences (0-2%). No interaction of flooring and task was identified for any dependent variable of interest.

CONCLUSIONS: Compared to bare floor, the sports flooring tested, which had the maximal commercially available shock absorption properties with mechanical testing, did not significantly alter TFJ or PFJ contact forces during walking, running, or sprinting tasks, nor did flooring effects depend on task demand.

CLINICAL RELEVANCE: Physical therapists should not expect sports flooring to alter knee joint loads or kinematics experienced during gait tasks, regardless of task demands. Clinical rehabilitation decisions regarding knee joint load management can be insulated from consideration of flooring effects.

SPO41

RELIABILITY OF THE VISUAL-COGNITIVE REACTIVE AGILITY T-TEST FOR RETURN TO SPORT TESTING

Ava Schwartz, Moein Koohistani, Grant Norte, Randi Moak Richardson, Matt S. Stock, Kylie McGlone, Gaston Dudley, Meredith Chaput

PURPOSE/HYPOTHESIS: Efficient reaction to unanticipated stimuli is required during sport. However, return to sport (RTS) readiness tests emphasize anticipated movement. Mostly RTS tests involving a single, uniplanar movement (i.e. triple hop) have been successfully augmented with a visual-cognitive component to improve ecological validity. The traditional agility T-test (AT) is a common performance test involving three types of movement in multiple planes. Therefore, our purpose was to develop and test the reliability of a visual-cognitive reactive agility T-test (VCR-AT) to further improve the ecological validity of RTS testing. We hypothesized the VCR-AT would show excellent reliability and significantly slow test time compared to the AT.

NUMBER OF SUBJECTS: 26 active uninjured individuals (17 females, 23.1 ± 1.8 years, 170.9 ± 10.2 cm, 71.4 ± 14.5 kg, Tegner Activity Scale 5.1 ± 0.7).

MATERIALS AND METHODS: Participants completed two identical visits 14 days apart consisting of the AT and VCR-AT. For each test, a 10-meter forward and horizontal distance was marked on the floor in the shape of a "T". Participants sprinted forward, side shuffled left and right, and backpedaled the marked distance as quickly as possible. For the AT, participants self-started and were randomly assigned to first side shuffle right or left. For the VCR-AT, a "GO" color on peripheral lights signaled the start, followed by a directional "Green" indicator on either end of the "T", and then a central memory light that illuminated 3 colors. Each participant performed one practice and 3 successful test trials with 1-minute rests in

between. Timing gates recorded test time (seconds) and the fastest trial was used in analysis. Test-retest reliability was established with intraclass correlation coefficients (ICC_{3,1}) using 2-way mixed effects with an absolute agreement and 95% confidence intervals.

RESULTS: AT and VCR-AT test times demonstrated excellent reliability (AT: ICC_{3,1} = .97 [0.92-0.99]; VCR-AT: ICC_{3,1} = .97 [0.95-0.99]). The VCR-AT resulted in a slower test time of -1.51% relative to the AT.

CONCLUSIONS: Test-retest reliability of the VCR-AT is excellent and results in a significant performance deficit compared to AT performance.

CLINICAL RELEVANCE: After lower extremity injury, athletes dedicate more conscious attention to movement, which may increase the likelihood of decision-accuracy errors in response to unexpected stimuli. This shift in attention, coupled with greater knee loading during unanticipated movement, poses a risk of re-injury upon RTS. Traditional RTS testing has not evaluated reactive movement, leaving clinicians to make RTS decisions without information essential for assessing an athlete's readiness to perform in a sport environment. To date, RTS tests that have been augmented with cognitive challenges mostly involve uniplanar movement. The VCR-AT test builds upon this work by simulating in-sport attentional demands in a test involving movements in multiple planes.

SPO42

MANAGEMENT AND PLYOMETRIC REHAB PROGRESSION OF A PARTIAL PCL TEAR IN A BASEBALL PLAYER

Joshua Huhn

BACKGROUND AND PURPOSE: The purpose of this case study is to describe the evaluation, management, and return to sport progressions in an 18-year old baseball pitcher with a grade 2 PCL sprain and concomitant grade 2 hamstring strain. Due to the limited research on partial PCL tears in youth athletes, there is little information on return to sport guidelines, protocols, and outcomes for this population. PCL tears account for only two percent of all high school knee injuries. In addition, the impact of an athlete's mental health and psychological readiness to return to play is a growing topic, and is proving to be a valuable aspect of the rehabilitation process, so it is crucial to use outcome measures such as the Psychological Readiness to Return to Sport Scale. Finally, there is little to no available clinical resources for plyometric progressions in this population. Because of this, a four-stage approach, designed for ACL repairs, was used to progress the patient through weeks of plyometric and sport-specific training. The exercises transitioned from bilateral low intensity activities to sport specific unilateral activities.

CASE DESCRIPTION: An 18 year old patient presented to physical therapy with left knee pain after the previously mentioned injury. The mechanism of injury involved the patient diving back to a base and landing on his left knee in full flexion with the ankle in full plantarflexion. He is a high school senior with hopes to pitch at a community college next season. The patient presented to physical therapy six weeks after the initial injury. During the first six weeks, he used an extension brace. This case study explores the evaluation, evidence-based treatment interventions, and outcomes of a baseball player with a grade 2 PCL tear and grade 2 hamstring strain.

OUTCOMES: The patient initially presented with deficits in range of motion and strength. Objective measures used were handheld dynamometry, Y-Balance, and hop testing. A handheld dynamometer was used to test quadriceps and hamstring strength at weeks 7, 14, and 21. Quadriceps limb symmetry index (LSI) improved from 90% to 95.9% to 105.9% while hamstring LSI improved from 71.7% to 85.7% to 100.2%. The Y-Balance Test was completed twice, and LSI improved from 84.6% overall to 95.5% overall. Hop testing was also completed twice with LSI measuring below 90% for all tasks at week 14 and above 90% for all tasks at week 21. Other outcome measures used were the LEFS and Psychological Readiness to Return to Sport Scale, which both improved

to 100% by discharge. Following a four stage plyometric program, this patient returned to full baseball participation at 21 weeks post-injury.

DISCUSSION: There is scarce evidence regarding PCL tears in athletes, specifically baseball players, in regards to returning to sports and plyometric progressions. This patient's plan of care utilized research on outcome measures, plyometric progressions and timelines, and return to sport testing in order to facilitate a full return to play. This case study highlights a need for future research on PCL injuries in athletes and plyometric/return to sport guidance for this population.

SP043

DIFFERENCES IN PSYCHOLOGICAL READINESS AND QUADRICEPS STRENGTH SYMMETRY BASED ON GRAFT TYPE AFTER ACL RECONSTRUCTION

Michael Scott Crowell, Will J. Pitt, Erin Marie Miller, Paul Kuwik, Joanna Borawski, Jamie Bush Morris

PURPOSE/HYPOTHESIS: The success of anterior cruciate ligament reconstruction (ACLR) is influenced by factors such as time since surgery, psychological readiness to return to play (RTP), neuromuscular asymmetries, and ACLR graft type. The purpose of this study was to compare psychological readiness to RTP and neuromuscular asymmetry between ACLR graft types and athletic competition levels.

NUMBER OF SUBJECTS: Participants were 59 military academy Cadets who underwent ACLR.

MATERIALS AND METHODS: The Anterior Cruciate Ligament - Return to Sport after Injury scale (ACL-RSI) assessed psychological readiness to RTP. Neuromuscular asymmetry was assessed with quadriceps limb symmetry index (QuadLSI) calculated from peak torque. Time since surgery, type of ACLR graft (patellar tendon [BTB]; quadriceps tendon [QT]) and level of athletic competition (NCAA; intramural [IM]) were recorded. Separate multivariate analyses of variance (MANOVA) were used to determine if differences existed in ACL-RSI scores and time since surgery based on graft type, and if differences existed in QuadLSI and time since surgery based athletic skill level. Differences in the proportion of athletes who achieved QuadLSI > 90% between graft types and athletic competition levels was examined with Chi-Square tests.

RESULTS: There were 32 participants with a BTB graft and 27 participants with QT graft; there were 36 NCAA Division I athletes and 23 IM athletes. There was a significant difference in ACL-RSI with time since surgery ($F=10.8, p < .001$) and QuadLSI with time since surgery ($F=10.6, p < .01$) based on graft type. While all athletes had returned to full sport and military activities, time since surgery was 616 (288) days in the BTB group and 403 (113) days in the QT group. The mean ACL-RSI was 69 (15) in the BTB group compared to 53 (22) in the QT group. The mean QuadLSI was 90 (22) in the BTB group versus 67 (22) in the QT group. The proportion of participants who achieved a QuadLSI > 90% in the BTB group (44%) was significantly greater than the QT group (19%) (Chi Square=4.27, $p=.04$). There was not a significant difference in ACL-RSI ($F=0.75, p=.48$) and QuadLSI ($F=0.004, p=.97$) based on athletic competition level. The proportion of participants who achieved a QuadLSI > 90% was not significantly different among athletic competition levels (Chi Square=1.03, $p=.31$).

CONCLUSIONS: Participants who had an ACLR with a QT graft had less psychological readiness to return to sport and 22% less quadriceps strength symmetry than those with a BTB graft. There were not significant differences in psychological readiness or quadriceps strength symmetry based on athletic competition level. Prospective, longitudinal research should examine changes in psychological readiness and quadriceps strength during rehabilitation with different graft types and attempt to determine factors that explain observed differences.

CLINICAL RELEVANCE: Physical therapists treating patients recovering from an ACLR with a QT graft should be aware of and provide interventions to address any reductions in psychological readiness to RTP and quadriceps strength limb symmetry.

SP044

PATELLAR TENDON GRAFT LENGTH AFFECTS RETEAR RATES FOLLOWING ACL RECONSTRUCTION

Scot Bauman, William Claussen, K. Donald Shelbourne, Rodney Benner, Adam Norris

PURPOSE/HYPOTHESIS: Retear rates following anterior cruciate ligament reconstruction (ACLR) continue to be relatively high, with reports upward of 17% for those in high risk populations. Previous literature demonstrates that outcomes following revision surgery are inferior to primary surgery, therefore surgeons and physical therapists are continuing to discover variables that can be modified to lower re-tear rates. The purpose of this study was to determine if the patellar tendon graft properties of thickness and length affect re-tear rates following ACLR.

NUMBER OF SUBJECTS: 3220

MATERIALS AND METHODS: Between 1990 and 2022, 3220 patients having an ACLR were retrospectively reviewed for this cohort study. Patients were selected for review based on having an ACLR utilizing a patellar tendon graft (PTG) at a minimum two years from surgery. Patients were excluded with revision surgery, postoperative activity rating <7, failure to reach preinjury activity rating postoperatively, or were missing data needed for analysis. Ultimately 3220 patients were analyzed (mean age = 24.2 years and 57.3% were male). All patients had a standard graft width (10mm) and followed a similar postoperative rehabilitation program under the guidance of a physical therapist. The primary outcome of the study was the presence of a graft tear. The determination of a graft tear was based on the answer to a survey question that was distributed to the patient for the first time at one year postoperative and continued yearly thereafter. A logistic regression aimed at determining the odds of tearing the graft after surgery was conducted with the following predictor variables: sex, age, graft thickness, and graft length. Sex and age were extracted from the medical record while graft measurements were measured intraoperatively. The logistic regression model was conducted using IBM SPSS version 25.

RESULTS: The population yielded an overall re-tear rate of 7.0%. The variables that statistically significantly contributed to the logistic regression model included age (OR = 0.907, $p < 0.001$) and graft length (OR = 1.053, $p < 0.001$). Specifically, for every increase in one year of age, the odds of sustaining a graft tear decreased by an OR of 0.907. Additionally, for every increase in 1mm of graft length, the odds of sustaining a graft tear increased by an OR of 1.053. Sex (female OR = 0.750, $p = 0.085$) and graft thickness (OR 1.036, $p = 0.657$) did not significantly contribute to the model.

CONCLUSIONS: For patients returning to high level sports following ACLR, the odds of sustaining a graft tear were higher for younger patients with longer grafts. In our model, sex and graft thickness did not affect graft tear rates.

CLINICAL RELEVANCE: Preoperatively, orthopedic surgeons could potentially alter their surgical plan with younger patients that have longer than normal patellar tendons due to the higher risk of re-tear with longer grafts. Postoperatively, physical therapists can educate patients with long patellar tendons on the risk of returning to high level sports as the rate of re-tear is higher for those with longer grafts.

SP045

THE INFLUENCE OF PERSONAL AND SITUATIONAL FACTORS ON PSYCHOLOGICAL READINESS FOR SPORT AFTER ACL RECONSTRUCTION

Elizabeth Catherine Niemuth, Allison M. Palmsten, Terese Chmielewski

PURPOSE/HYPOTHESIS: Clinicians and a conceptual model theorize that personal and situational factors shape psychological responses to sports injury. The purpose of this study was to examine the influence of personal and situational factors on psychological readiness for sport during the return to sport phase following anterior cruciate ligament (ACL) reconstruction. The hypothesis was that younger age and a contact mechanism

injury would be associated with higher psychological readiness for sport following ACL reconstruction.

NUMBER OF SUBJECTS: 56 patients with primary ACL reconstruction; 33 (58.9%) females; mean \pm SD age: 18.6 \pm 5.1 years; graft type: 40 patellar tendon, 16 hamstrings.

MATERIALS AND METHODS: Patients completed the Anterior Cruciate Ligament-Return to Sport after Injury scale (ACL-RSI) following surgeon clearance to return to sport participation. ACL-RSI evaluates psychological readiness for sport in the domains of emotion, confidence and risk appraisal. Scores range from 0 to 100, and high scores indicate better psychological readiness. Personal and situational factors were age, sex, graft type, mechanism of injury (contact or non-contact), and sport type (collision, contact, non-contact). Univariate association of ACL-RSI score with personal and situational factors was assessed with Pearson or Spearman rank correlation, as appropriate. Variables with significant association ($p < 0.05$) were included in separate stepwise linear regression models for ACL-RSI score or the domain scores as dependent variables.

RESULTS: Patients were tested 7.5 \pm 0.6 months post-surgery. Mean ACL-RSI score was 79.0 \pm 16.0. Forty patients (74.1%) had non-contact injuries. Patient distribution by sport type was 14 (25%) collision, 32 (57.1%) contact, and 10 (17.9%) non-contact. Age, graft type, and sport type each showed significant correlation with ACL-RSI score ($p < 0.05$). Only age was retained in the regression models for ACL-RSI score ($r = -0.593$, $R^2 = 0.351$, $p < 0.001$), emotions domain ($r = -0.504$, $R^2 = 0.254$, $p < 0.001$), and confidence domain ($r = -0.615$, $R^2 = 0.379$, $p < 0.001$). Both age and graft type were retained in the model for risk appraisal ($r = -0.533$ and 0.261, respectively; $R^2 = 0.663$, $p < 0.001$).

CONCLUSIONS: Patient age consistently explained variance in ACL-RSI score and on each domain, while graft type explained a smaller amount of variance on the risk appraisal domain. Younger age and patellar tendon graft were associated with higher psychological readiness for sport. Mechanism of injury and sport type were not associated with psychological readiness.

CLINICAL RELEVANCE: Psychologically informed treatment may need to be directed based upon patient age, and potentially graft type, to address psychological readiness for sport after ACL reconstruction. Future research is needed to evaluate the role of situational factors in psychological readiness for sport.

SP046

CHARACTERISTICS OF THE REHABILITATION EPISODE OF CARE AND RETURN-TO-SPORT TESTING IN ATHLETES FOLLOWING ACL RECONSTRUCTION

William H. Suits, Corey M. Snyder, Olivia Roe, Luke Voss

PURPOSE/HYPOTHESIS: The purpose of this study was to explore the relationship between qualities of the rehabilitation episode of care and return-to-sport (RTS) testing outcomes in athletes following anterior cruciate ligament (ACL) surgery. The hypothesis was that athletes who perform better on RTS testing will have a longer episode length, a greater number of rehabilitation encounters, fewer unique rehabilitation providers, and a greater frequency of rehabilitation encounters in the later stages of rehabilitation.

NUMBER OF SUBJECTS: 262 patients following ACL surgery (age 20.69 \pm 6.69 years, 131 female) who underwent rehabilitation and elective return to sport testing at a single hospital-based rehabilitation setting.

MATERIALS AND METHODS: This was a retrospective study analyzing the results from elective RTS tests. Performance measures included triple hop symmetry, single leg vertical jump symmetry, and Lower Extremity Functional Test. The episode of care characteristics included total supervised rehabilitation encounters, episode length, number of unique rehabilitation providers, and the frequency of rehabilitation encounters in each quartile. Patients were classified as high or low performers if they

were in the top (high performers) or bottom quartile (low performers) of at least two of the three performance measures. Analyses of covariance with Bonferroni corrections were performed to assess between-group differences with age and sex as covariates.

RESULTS: Fifty-two patients were classified as high performers, and 46 were classified as low performers. Compared to high performers, low performers had a significantly lower frequency of rehabilitation encounters in both the third (-0.39 visits/week; 95% CI -0.60, -0.18; $p < 0.01$) and fourth quartile (-0.34 visits/week; 95% CI -0.54, -0.14; $p < 0.01$). Compared to average, low performers had a significantly lower frequency of rehabilitation encounters in the third quartile (-0.20 visits/week; 95% CI -0.36, -0.03; $p = 0.04$). There were no other significant differences found in this study.

CONCLUSIONS: Athletes who performed worse in RTS tests had differences in the distribution of rehabilitation encounters compared to both average and high performers, with a significantly lower frequency of rehabilitation encounters during the latter half of the episode of care.

CLINICAL RELEVANCE: This study demonstrated a significant relationship between the frequency of rehabilitation encounters in the later stages of rehabilitation and performance on RTS tests in athletes following ACLR. Supervised care during the later stages of rehabilitation often focuses on athletic qualities such as power production and agility, and this may have contributed to the greater outcomes on RTS tests. Clinicians and patients should consider the timing and distribution of rehabilitation encounters when creating and modifying a plan of care. Further research should include prospective studies, barriers towards attending supervised rehabilitation, and identifying relationships between episode characteristics and long-term outcomes in this population.

SP047

PHYSICAL ACTIVITY AND PSYCHOLOGICAL READINESS TO RETURN TO SPORT AFTER ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

Lauren Schlacht Butler, Sophia Ulman, Dylan P. Roman, Cody Walker, Taylor E. Douthitt, Christopher Kuense, ACL Reconstruction Rehabilitation Outcomes Workgroup, Shelby Baex

PURPOSE/HYPOTHESIS: The purpose of this study is to examine the relationship between physical activity (PA) and psychological readiness to return to sport (RTS) in adolescents and young adults after ACLR. Our hypothesis is that low PA, measured with the Marx Activity Rating Scale (Marx) and the Tegner Activity Scale (Tegner), at the time of RTS test completion after ACLR, will be significantly correlated with lower psychological readiness to RTS.

NUMBER OF SUBJECTS: 236

MATERIALS AND METHODS: Participants 14-30 years of age, who were 6-12 months post ACLR, and who completed the Tegner Activity Scale (Tegner), Marx Activity Rating Scale (Marx), and the Anterior Cruciate Ligament Return to Sport after Injury Scale (ACL-RSI) were recruited from a multi-site outcomes registry. We operationally defined acceptable and unacceptable ACL-RSI scores using an established cutoff of 77 ($< 77 =$ unacceptable). A logistic regression was performed to determine if lower Tegner and Marx scores increase the odds of reporting an unacceptable ACL-RSI score with sex, age, and time since surgery as covariates. Significance (α) was set to 0.05.

RESULTS: 236 participants (59.7% female; 19.1 \pm 3.6 years; 8.5 \pm 2.0 months from surgery) were included for analysis. Mean Tegner and Marx scores were 6.9 \pm 2.0 and 13.2 \pm 3.6, respectively. 54.7% of participants indicated unacceptable psychological readiness (ACL-RSI: 70.14 \pm 23.88). The logistic regression identified that for every one-point increase in Tegner and Marx scores there was a 39% and 11% decrease, respectively, in the odds of having an unacceptable ACL-RSI score (Tegner: $p < 0.001$, Odds ratio: 0.61, 95% CI: 0.50-0.73, Marx: $p = 0.034$, Odds ratio: 0.89,

95% CI: 0.80-0.99). Age, sex, and time since surgery, were not significant covariates.

CONCLUSIONS: Lower PA, measured with the Tegner and Marx at the time of RTS test completion after ACLR, was associated with poor psychological readiness.

CLINICAL RELEVANCE: Given the association between PA and psychological readiness to RTS, clinicians should prioritize PA counseling during rehabilitation. Future studies should determine if the Tegner and Marx, assessed at earlier post-operative time points, are able to predict ACL-RSI scores at the time of RTS test completion to further guide clinical practice.

SP048

A MULTIMODAL APPROACH TO ACL INJURY PREVENTION: COMBINING VR, STROBOSCOPIC, AND NEUROCOGNITIVE TRAINING

James Zachary Odenthal

PURPOSE/HYPOTHESIS: The anterior cruciate ligament (ACL) is the most common injured knee ligament requiring surgery in the United States. ACL injuries are usually non-contact in nature, whereby the athlete fails to maintain knee stability during rapid movements. Non-contact ACL injury has several modifiable risk factors that are targeted by injury prevention programs (IPP) to increase strength and neuromuscular function. IPP include plyometrics, strengthening, agility and landing technique training. However, this approach may not target neurocognitive risk factors that have growing evidence in the literature. We hypothesized that by integrating neurocognitive challenges into group IPPs clinicians can target the combined neurocognitive and motor risk factors simultaneously and reduce injury incidence.

NUMBER OF SUBJECTS: 14

MATERIALS AND METHODS: We employed an integrated neurocognitive-motor IPP in a Division I women's college basketball team (n=14). The program occurred two times per week over a six-week period. Training blocks were interspersed during the teams practice sessions during the pre-season and completed in small working groups per station. Weeks 1 and 2: Single leg stance with virtual reality (VR, Meta Quest 2) using 360 videos of tight-rope walking (3 sets, 30 s, 30 s rest). Stroboscopic glasses (Senaptec) drop landing with counter jumps from a 12" box (2 sets, 5 reps, 30 s rest) and Blazepod reactive neurocognitive stimulus during lateral hops (3 reps, 20 s, 30 s rest). Weeks 3 and 4: VR balance added a foam surface, stroboscopic training progressed to a rebound task and Blazepod neurocognitive training was progressed to have athlete dribble to illuminated pod, while calling out the number hanging on the wall that matched the pod color. Weeks 5 and 6 consisted of VR with a 360 roller coaster during SLS on foam, stroboscopic training to included dyad training with partners to add sport specific reactive challenges, and Blazepod neurocognitive training was progressed to have an additional neurocognitive demand, by saying the word that corresponded to the color, the color did not match the word in most instances, i.e. if a green pod was illuminated the word in green was red. Twelve of 14 members of the team completed all training sessions and activities. Two individuals were unable to participate in the VR and stroboscopic glasses stations due to motion sensitivity. A statistical test of two proportions was calculated on injury incidence between the intervention season and the prior season.

RESULTS: In the prior (baseline) season 5 ACL injuries occurred out of a 14-athlete roster size, and in the intervention season 0 ACL injuries occurred (proportion t-test: $p=.007$).

CONCLUSIONS: Due to the limited sample size of 14 athletes in each season, inferential statistics should be interpreted with caution, however the neurocognitive-motor integrated IPP was tolerated well and may reduce injury risk.

CLINICAL RELEVANCE: This program was likely not the sole cause of injury reduction but seems to be a positive adjunct to ACL injury prevention programs.

SP049

HOW GROUP THERAPY AFFECTS SOCIAL CONNECTEDNESS AMONG YOUNG ATHLETES AFTER ACLR: A MIXED METHODS STUDY

Gabriel Jose Caceres, Grant Ryan Poston, Jason A. Hugentobler, Lainey Anthony, Mark Vincent Paterno, Christin Marie Zwolski

PURPOSE/HYPOTHESIS: Mid-stage rehabilitation following anterior cruciate ligament reconstruction (ACLR) is often described as the most mentally and physically challenging phase for young athletes. At 3-6 months post-ACLR, many patients have regained normal daily function, yet ongoing absence from sport participation has been shown to lead to feelings of isolation and disconnectedness from peers. The purpose of this study was to understand how participation in a group therapy model is related to perceived changes in social connectedness among young athletes after ACLR.

NUMBER OF SUBJECTS: 13 participants, median age 16.1 years (range 13.9-20.3 years), recruited from the active patient population of a pediatric medical center at a median 4.9 months (range 2.9-8.6 months) after ACLR.

MATERIALS AND METHODS: A convergent mixed methods design was used for this study, as part of a larger, ongoing intervention trial. All participants were enrolled into a 10-week group therapy program focused on lower extremity strengthening. At the start and end of the program, self-reported social connectedness was measured with the 8-item Social Connectedness Scale (SCS; scored 8-48). Change scores (post score - pre score) were calculated for each participant. At program completion, all participants also partook in individual semi-structured interviews in order to elicit perspectives on lived experiences as members of the group therapy program. All interview audio was recorded, and transcribed verbatim. Thematic analyses were guided by the procedures of the constant comparative method, allowing for identification of themes from open and axial coding. For each generated theme, representative quotes from each participant were paired with SCS change scores in a joint display for full integration of qualitative and quantitative data.

RESULTS: Nine participants (69.2%) demonstrated a positive change score (2-14 points), two (15.4%) demonstrated no change (0 points), and two (15.4%) demonstrated a negative change score (2-12 points). Four themes related to social connectedness were generated from participant perspectives. 1.) Support, 2.) Social Environment, 3.) Self Discovery, and 4.) Shared Struggle. All participants perceived the program to provide a boost to their social connectedness. Overall, participants described the supportive benefit of working with others in pursuit of a mutual goal: returning to sport after ACLR. One participant (Leslie, SCS change score: 0) stated that "As a group, you notice when people don't have great days. But you understand that too, from a recovery perspective. So then you're able to like help push them through it."

CONCLUSIONS: Following the group therapy program, the majority of participants (70%) reported positive change scores. Qualitatively, participants reported exclusively positive perceptions about social connectedness following participation in a group therapy program after ACLR.

CLINICAL RELEVANCE: Addressing psychosocial aspects of recovery through a group therapy model may mitigate young athletes' feelings of isolation during mid-phase rehabilitation after ACLR.

SP050

FEASIBILITY OF COLLECTING MOMENTARY KNEE SYMPTOMS IN YOUNG ADULTS POST-ACL RECONSTRUCTION

Katherine R. Prina, Elanna K. Arhos, Stephanie Di Stasi, Nicholas Wile, Laura C. Schmitt, Caroline Lewis Brunst

PURPOSE/HYPOTHESIS: Knee joint symptoms can vary after anterior cruciate ligament reconstruction (ACLR) and may indicate poor tolerance to increasing demand on the patient's healing joint. Tracking symptoms throughout a patient's care is critical for informing progression but is limited to recall during individual physical therapy (PT) visits. Real-time assessment of symptoms using ecological momentary assessments (EMAs)

during daily activities may better inform clinical decision-making. The purpose of this feasibility study was to quantify EMA completion rates, valid accelerometer wear days, and participant experience over a 7-day free-living period. We hypothesized that young adults post-ACLR would demonstrate acceptable EMA completion ($\geq 80\%$) and wear rates (≥ 4 days, 10hrs/day) and report initial acceptability of study procedures.

NUMBER OF SUBJECTS: 7 individuals in PT following primary ACLR (25.3 years (5.6), 24.6kg/m²(4.3), 2 females; 11.1(5.5) months post-ACLR; Knee Injury and Osteoarthritis Outcome Score Symptoms subscale, KOOS Symptoms: 84.8 \pm 9.5).

MATERIALS AND METHODS: Participants were recruited during PT visits using flyers with QR codes, screened for eligibility, and enrolled prior to the onboarding session. Consented participants completed baseline surveys about their pain and knee symptoms (KOOS-Symptoms) prior to their wear week. During the 7-day wear week, physical activity (PA) was captured with waist-worn ActiGraph GT3X accelerometers and individuals completed EMAs six times daily on their smart phone. Using numeric rating scales (0-100) informed by the KOOS-Symptoms questions, participants rated the severity of joint pain, stiffness, mechanical symptoms, and difficulty flexing and extending. Feasibility data on ActiGraph wear and EMA completion rates, and symptom data were reported as average (standard deviation).

RESULTS: In a 14-week recruitment period, 16 individuals completed the QR code survey and 7 were enrolled (6 did not respond to follow-up, 1 was not interested, 2 were ineligible due to exclusion criteria). Valid wear days averaged 5.3(2.5) and EMA completion rate was 78.9%(35.4); one enrolled participant did not complete any EMAs or device wear. Of the 6 remaining participants, all met criteria for a valid wear week (≥ 4 days and ≥ 10 hrs/day), valid wear days averaged 6.2(0.9), and EMA completion rates were 92.1%(6.8). Survey completion was rated from 'Neither Easy nor Hard' to 'Very Easy,' with all participants reporting EMA frequency as 'Just Right.' Average EMA (out of 100) pain was 6.0(5.3), stiffness was 10.8(9.1), mechanical symptoms were 2.7(3.4), ease with bending was 10.2(9.5), and ease with extending was 3.0(3.5).

CONCLUSIONS: These data demonstrate the initial feasibility of collecting real-world symptoms and activity in young adults post-ACLR. Knee joint symptoms inform PT progression and may limit PA. Using EMAs with activity monitoring could support more targeted exercise prescription and should be included in future research post-ACLR.

CLINICAL RELEVANCE: These preliminary data indicate the feasibility of using EMA surveys and objective activity assessment as a means to track real-world symptoms and activity post-ACLR.

SP051

WHAT DEFINES LOWER EXTREMITY DOMINANCE AND SHOULD IT BE CONSIDERED IN LIMB SYMMETRY INDEX TESTING?

William A. Stodart

PURPOSE/HYPOTHESIS: Return to sport criteria following Anterior Cruciate Ligament Reconstruction (ACLR) commonly includes a series of functional hop tests to assess symmetry of lower extremity (LE) performance. This study examined the criteria used to define LE limb dominance and assessed potential differences between dominant and nondominant limb performance in a series of hop tests. The hypothesis was that the leg used to kick a ball and the preferred unilateral landing leg would coincide to determine limb dominance and that there would be a $> 10\%$ limb symmetry index (LSI) difference, with the dominant LE outperforming the nondominant.

NUMBER OF SUBJECTS: Fifty healthy subjects (34 female; 16 male) between 18 and 30 years of age participated in the study.

MATERIALS AND METHODS: The preferred kicking leg was determined by questionnaire, and the preferred landing leg was determined by a unilateral drop jump landing. Each subject then performed four functional hop tasks (single hop, triple hop, and triple crossover hop for distance, and 6-meter timed hop) in randomized order.

RESULTS: The preferred kicking and landing LE were homogenous (the same) for the majority (76%) of subjects. However, Phi Coefficient ($\phi = 0.23$; $p = 0.098$) and Chi-square analysis ($\chi^2 = 2.74$; $p = 0.098$) revealed no statistically significant association between the preferred kicking and landing LE. In addition, linear regression analysis showed that regardless of whether the preferred kicking and landing LE's were homogenous or mixed, no statistically significant relationship was found to predict which LE would be best performing on the four functional hop tests ($p > .05$).

CONCLUSIONS: A significant relationship was not found between the preferred kicking and landing legs to define LE dominance or to identify the likelihood of one LE outperforming the other on functional hop testing. The results of this study challenge both the criteria used to define LE dominance and the relevance of limb dominance in the interpretation of LSI hop test performance.

CLINICAL RELEVANCE: Consistent criteria for defining LE dominance remain to be identified and may not have relevance to the clinician's interpretation of hop test performance for return-to-sport decision-making.

SP052

GREATER KNEE FLEXOR STRENGTH DEFICITS DURING ECCENTRIC NORDIC CURLS FOLLOWING HAMSTRING HARVEST FOR ACL RECONSTRUCTION

Dan Ogborn, Rebecca Franklin, Greg Stranges, Jarret Woodmass, Robert Longstaffe, Sheila McRae, Jeff Leiter, Peter MacDonald

PURPOSE/HYPOTHESIS: The semitendinosus (ST) and gracilis tendons (STG) are commonly harvested for graft creation during anterior cruciate ligament reconstruction (ACLR) which can result in persistent deficits in knee flexor strength. The Nordic Hamstring Curl (NHC) may more specifically test semitendinosus function as compared to other exercises, which may be important as reduced ST activation, muscle volume and anatomical cross sectional area have been observed following ST harvest. Consequently, deficits in strength may be greater during the NHC as compared to the gold standard of concentric isokinetic dynamometry. The purpose of this study was to evaluate knee flexor strength using concentric isokinetic dynamometry and the eccentric NHC while considering the influence of differing graft types for primary ACLR.

NUMBER OF SUBJECTS: 182 patients with STG (n=58), bone-patellar tendon-bone (BPTB, n=54) and quadriceps tendon (QT, n=70) grafts were assessed approximately 12 months after primary ACLR.

MATERIALS AND METHODS: Five repetitions of concentric isokinetic knee flexion (Biodex System 4, Biodex Medical Systems, New York, USA) were completed in the seated and supine positions at 90°/s. Three eccentric NHC repetitions (NordBord Hamstring Dynamometer, Vald, Queensland, AUS) were completed thereafter. Relative torque and force on each device and position were compared with a two-way ANOVA and the limb symmetry index (LSI) was compared with a one-way ANOVA.

RESULTS: Affected limb isokinetic relative torque was reduced in seated and supine regardless of graft ($p=0.01$). Deficits in affected limb relative force during the NHC were greatest in STG (mean difference -0.87 n/kg (95%CI $-1.2 - -0.5$ n/kg), $p = 0.03$). Consequently, the lowest LSI values were found for STG during the NHC (73.68% LSI (95%CI 69.85 - 77.51% LSI)) compared to supine (86.08% LSI (95%CI 82.47 - 89.70 % LSI), $p < 0.001$) and seated concentric isokinetic knee flexion (86.47% LSI (95%CI 82.88-90.06% LSI), $p < 0.001$).

CONCLUSIONS: Deficits in knee flexor strength are larger in those with STG versus other graft types for primary ACLR when assessed with the NHC. Further research is required to clarify whether these observed deficits are specific to the NHC or the eccentric mode of contraction.

CLINICAL RELEVANCE: The anatomical complexity of the hamstring muscle group necessitates comprehensive assessment. Measurement of knee flexor strength during the eccentric NHC may be required to fully assess knee flexor function in patients following STG harvest for ACLR as opposed to relying on concentric isokinetic strength assessment alone.

SP053**PSYCHOLOGICAL READINESS ACROSS THE REHABILITATION CONTINUUM FOLLOWING ACL RECONSTRUCTION: A DESCRIPTIVE ANALYSIS OF 1,945 PATIENTS**

Jena-Claire Auten, Mason Chimenti, Steven Richard Higbie, Jacquelyn Lee Kleihege, Brian Randall Duncan, Lane Bailey, Walter R. Lowe

PURPOSE/HYPOTHESIS: Psychological readiness can be a significant barrier in returning to pre-injury level of sport following anterior cruciate ligament reconstruction (ACLR). The 'Anterior Cruciate Ligament Return to Sports after Injury Scale' (ACL-RSI) is a validated self-reported outcome tool designed to assess athletes' psychological readiness following ACLR. Establishing baseline values along the continuum of care can provide insight to delineate those at lower psychological readiness to aid in treatment intervention. The purpose of this study was to establish normative values for ACL-RSI scores in patients undergoing ACLR across the rehabilitation continuum.

NUMBER OF SUBJECTS: 1,945

MATERIALS AND METHODS: A matched case-control study was conducted in accordance with the STROBE guidelines. Subjects aged 13-70 undergoing primary or revision ACLR were eligible for participation and excluded if they sustained a multi-ligamentous knee injury. Baseline demographics and pre-injury activity were collected. The ACL-RSI was administered at 8-12 weeks, 12-16 weeks, 16-20 weeks, 20-24 weeks, and at time of return to sport (RTS). Between group differences were examined for age group, gender, graft type and surgical setting (primary vs revision). Data were analyzed utilizing repeated measure mixed model ANOVA with *Tukey's post-hoc* corrections and an *a priori* $\alpha = .05$.

RESULTS: A significant main effect difference for ACL-RSI score existed for age, gender, graft type, and surgical setting ($p < .001$). Gender differences were present at 12-16w ($p = .001$), 16-20w ($p = .011$) and 20-24w ($p = .001$). Primary vs revision setting demonstrated differences at 12-16w ($p = .015$), 16-20w ($p = .005$), 20-24w ($p = .001$) and time at RTS ($p = .001$). Interactions (age x time) were present at each study timeframe for <13 years and 13-18 groups ($p < .05$). Patients > 45 years of age exhibited lower ACL-RSI scores at RTS (64.7 ± 17.2 , $p < .001$) compared to all other age groups. Quadriceps tendon autografts had lower ACL-RSI scores at the 8-12w, 12-16w, and 16-20w time points. Contralateral patellar tendon autografts had lower ACL-RSI score at the 20-24w and RTS timeframes ($p < .05$).

CONCLUSIONS: Psychological readiness following ACLR is influenced by factors such as age, gender, and surgical setting across the continuum of care. In general, younger individuals had higher ACL-RSI scores compared to older subgroups; females, revision setting and contralateral patellar tendons autografts display lower psychological readiness.

CLINICAL RELEVANCE: These results serve as benchmark values for ACL-RSI scores accounting for multiple variables, including age, sex, and surgical setting across the continuum of care following ACLR. These values may help clinicians further identify individuals lacking psychological readiness based on multiple contextual factors. Early identification of sub-optimal ACL-RSI scores may also allow clinicians to prescribe timely interventions to improve psychological readiness, and in turn, safe RTS in the ACLR population.

SP054**UTILIZATION OF ADVANCED TRAINING FOR RETURN TO SPORT AFTER ACL RECONSTRUCTION**

Terese Lynn Chmielewski, Andrea J. Lange, Charlie Sheroheim, Matthew C. Bouche, William Yungtum, Cameron Cooper

PURPOSE/HYPOTHESIS: Advanced neuromuscular training (i.e., advanced training) improves knee function, knee-related confidence, and secondary knee injury rate in patients with anterior cruciate ligament (ACL) reconstruction. Advanced training bridges traditional impairment-focused

rehabilitation and sports participation. The purpose of this study was to 1) describe the utilization of advanced training in adolescent and young adults with ACL reconstruction, and 2) compare age, sex, and pre-injury sport level between patients who did or did not participate in advanced training. The hypothesis was most patients with ACL reconstruction would utilize advanced training, especially those who played organized sports before injury.

NUMBER OF SUBJECTS: 133 patients with ACL reconstruction

MATERIALS AND METHODS: Review of electronic health records identified 339 patients with ACL reconstruction between January 1, 2017, and December 31, 2018, and age 14 to 21 years at surgery. Of these, 206 patients were excluded due to prior ACL reconstruction or no pre-injury sports ($n = 52$) or rehabilitation outside the health system ($n = 154$). Standard practice in the health system is to offer patients with ACL reconstruction a cash-based, group-format, advanced training program, consisting of 2 visits/week for 6 weeks (12 visits). Training visits last 1.5 hours and include dynamic stability, plyometric and agility exercises. Advanced training is initiated when patients pass clinical entry criteria. The proportion of patients who participated in advanced training, time to initiation of advanced training, and number of training visits completed were computed. Age, sex, and pre-injury sport level (organized or recreational) were compared between patients who did or did not participate in advanced training using t-test or Chi square test. Statistical significance was $p < 0.05$.

RESULTS: A total of 43 patients (32.3%) participated in advanced training; 1 patient participated outside the health system. Mean \pm SD time to initiation of advanced training was 29.4 ± 5.8 weeks post-surgery, and advanced training visits completed were 10.8 ± 1.3 . Patients who participated in advanced training were significantly younger than those who did not participate (16.2 ± 1.6 vs 17.0 ± 1.9 years, $p = 0.02$), but no significant differences were found in sex or sport level [females: 27/43 (62.8%) vs 49/90 (54.4%), $p = 0.29$; organized sports: 40/43 (93.0%) vs 81/90 (90%), $p = 0.60$].

CONCLUSIONS: Only 1/3 of the patients with ACL reconstruction participated in advanced training. On average, advanced training was initiated around 7 months post-surgery, and patients completed 90% of the visits. Comparisons between patients who did or did not participate in advanced training should be interpreted with caution.

CLINICAL RELEVANCE: Uptake of advanced training was low, meaning patients with ACL reconstruction may rely on traditional rehabilitation to prepare for sports participation. Identifying facilitators and barriers to participating in advanced training after ACL reconstruction is warranted.

SP055**PREDICTING EARLY REHABILITATION OUTCOMES FOLLOWING ACL RECONSTRUCTION IN ADOLESCENTS**

Nicole Melfi, Nicholas Keith Purcell, Katy Eileen Mitchell, Kayla Marie Fern Panos, Matthew Ruhe

PURPOSE/HYPOTHESIS: The overall purpose of this study was to determine if 4, 8, and 12 weeks post-surgical rehabilitation outcomes could be predicted from initial physical therapy evaluation findings following ACL reconstruction with or without a meniscal repair.

NUMBER OF SUBJECTS: 207

MATERIALS AND METHODS: Participants were recruited from outpatient pediatric sports clinics within the Texas Children's Hospital system in the Houston area. All assessors were experienced PTs in adolescent sports. Data was collected from PT records from 2022 to 2024. The data set was sub-divided by those having a meniscal repair (MR+) and those who did not (MR-). Study outcomes included ROM, strength, functional performance, and discharge status. Descriptive statistics and logistic and multiple linear regression analyses were conducted.

RESULTS: 95.2% of the sample had either a patellar or quad tendon repair. 60.9% were in the MR+ group. 63.3% of the sample was provided a neuromuscular electrical stimulation (NMES) unit at the initial PT evaluation post-surgery.

Initial knee flexion ROM was able to significantly predict 4 week discharge with crutches or brace ($p < .001$). NMES (yes/no) and MR (yes/no) when entered together were able to significantly predict 4-week discharge with crutches or brace ($p < .001$) and again at 8 weeks with crutches or brace ($p = .006$).

Initial knee flexion ROM could predict single leg (SL) squats performance to 45 degrees, $p = .031$, and cleared to run status both at 12 weeks, $p = .002$. NMES and MR when entered together could predict 12-week performance on the Y balance test ($p = .008$).

Initial surgical knee flexion could predict 4-week flexion ($p < .001$), 8-week flexion ($p < .001$), but not 12-week flexion. Similarly, initial knee extension could predict 4-week extension ($p = .004$), 8-week extension ($p < .001$), but not 12-week extension ($p = .101$). NMES and MR could significantly predict knee extension and flexion ROM at 4 weeks ($p = .027$ and $p < .001$), knee flexion ROM at 8 weeks ($p < .001$), and knee flexion at 12 weeks, $p = .031$.

Type of surgical repair or the ability to perform a straight leg raise without a quadriceps lag at the initial evaluation were not predictive of any of the 4-, 8-, or 12-week outcomes.

CONCLUSIONS: This study suggests that variables such as initial surgical knee ROM, the use of NMES, and the repair of the meniscus are strong predictors of outcomes at the 4-, 8- and 12-week mark of rehabilitation. Even clearance to return to running at 12 weeks post-surgery could be predicted by initial post-surgical knee flexion ROM. The type of graft was not found to be predictive of outcomes at any of the time periods. These initial findings suggest that patients with more ROM, using NMES, and those who did not undergo MR were most likely to make earlier gains in therapy.

CLINICAL RELEVANCE: This study suggests that clinicians may be able to effectively estimate performance up to 3 months following surgery with initial evaluative findings such as ROM, use of NMES, and surgical history. These findings may help physical therapists set realistic goals and determine those in need of additional therapy in order to achieve a successful outcome.

SP056

EARLY QUADRICEPS STRENGTH RECOVERY IS NOT RELATED TO SECOND ANTERIOR CRUCIATE LIGAMENT INJURY IN ADOLESCENTS

Adam Pierce Weaver, Dylan P. Roman, Christopher Kuenze

PURPOSE/HYPOTHESIS: Anterior cruciate ligament (ACL) injuries are common injuries in the adolescent population. Lack of appropriate quadriceps strength after ACL reconstruction (ACLR) at return to play has been linked to second ACL injury. However, the relationship between early quadriceps strength recovery and second ACL injury is unknown. The purpose of this study was to compare early isometric quadriceps peak torque and limb symmetry (LSI) measured 3 months post-ACLR between individuals who experienced or did not experience a second ACL injury. We hypothesized that individuals with greater quadriceps strength impairments at 3 months post-op would have higher re-injury rates.

NUMBER OF SUBJECTS: 201 subjects (15.7±1.7; 51% female).

MATERIALS AND METHODS: A retrospective chart review was conducted on 584 patients who underwent primary, unilateral ACLR between January 2013 and December 2022. Records were reviewed for second ipsilateral or contralateral ACL injury, and completion of primary ACLR 3-month post-operative isometric strength testing and completion of the International Knee Documentation Committee Subjective Knee form (IKDC) and ACL-RSI. Patients classified in the second ACL injury group had a documented second ACL injury, while patients without a second ACL injury were confirmed by a chart review of an orthopedic or physician well visit greater than 2 years after surgery. Isometric quadriceps strength was collected at 60° of knee flexion using an isokinetic dynamometer. Independent samples t-tests and Mann-Whitney U tests were used to determine differences in demographic data. One way ANOVA tests were used to compare differences in strength amongst side of second ACL injury.

RESULTS: 201 patients were included for analysis, 76 of whom experienced a second ACL injury. There were no significant differences between second injury groups based on sex, age, BMI, graft source, IKDC score (72.0±14.1 vs 70.7±11.7; $p = 0.49$) nor ACL-RSI score (61.6±22.3 vs 61.7±21.7; $p > 0.05$). However, the second ACL injury group demonstrated greater quadriceps limb symmetry (74.9±20.4 vs 71.8±22.4; $p = 0.16$) and greater ACLR limb normalized quadriceps strength when compared to the no injury group (1.6±0.6 vs 1.4±0.5; $p = 0.11$). When comparing side of second injury, there were no significant differences in LSI ($p = 0.94$) or normalized strength ($p = 0.82$).

CONCLUSIONS: There were no differences in normalized quadriceps strength or limb symmetry 3 months after ACLR between second ACL injury and no ACL injury groups. Early strength assessments may serve as a useful assessment for clinical decision making, but too early to be a predictor of risk of injury.

CLINICAL RELEVANCE: While the benefits of quadriceps strength and symmetry after ACLR have been well documented, this study suggests that clinicians should not assume early quadriceps strength recovery will reduce second ACL injury. Though emphasis of quadriceps strength should remain a priority in rehabilitation, further work is needed to identify early risk factors for second ACL injury.

SP057

DETERMINING BETWEEN-LIMB DIFFERENCES IN MAXIMAL AND SUBMAXIMAL QUADRICEPS TORQUE STEADINESS AFTER ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

Anne Leung, Abbey Finkill, Ryan David Zarzycki

PURPOSE/HYPOTHESIS: Quadriceps muscle dysfunction, most commonly described as deficits in peak torque, persists for years after anterior cruciate ligament reconstruction (ACLR). Emerging evidence indicates deficits also exist in surgical limb quadriceps torque steadiness (TS) after ACLR. Existing research with participants after ACLR uses maximal voluntary contractions to calculate TS. To our knowledge, research has not examined submaximal steadiness in participants post-ACLR. Therefore, the purpose of this study was to determine differences between surgical and non-surgical quadriceps TS during submaximal and maximal quadriceps isometric contractions. We hypothesized that submaximal contractions will detect between-limb differences in TS better than maximal contractions.

NUMBER OF SUBJECTS: Nine females 4-9 months post ACLR

MATERIALS AND METHODS: For this cross-sectional study participants performed three quadriceps maximal voluntary isometric contraction (MVIC) at 60 degrees of knee flexion on an isokinetic dynamometer. Participants then performed three submaximal contractions at each of following efforts: 25%, 50%, and 75% of participant's peak MVIC. Participants were instructed to match the torque to a visual target for each 5-second trial. TS was calculated as the coefficient of variation ($CV = \text{standard deviation} / \text{mean} \times 100$) from 1-4s of MVIC (TS_{MAX}) and 2-5s for each submaximal trial (TS_{25} , TS_{50} , TS_{75}). Means of 3 trials were used for analysis. Paired samples t-tests were used to determine between-limb differences (surgical vs non-surgical) on each contraction type. Limb symmetry indices ($LSI = \text{non-surgical} / \text{surgical}$) were calculated and counts of participants >80% symmetry were performed.

RESULTS: There was a statistically significant difference between limbs for TS_{MAX} (Surgical, $S = 5.6 \pm 1.4\%$, Non-surgical, $NS = 3.8 \pm 1.6\%$; $p = 0.006$), there were no between limb differences in TS for any submaximal contractions (TS_{25} : $S = 3.0 \pm 1.1\%$, $NS = 2.6 \pm 1.5\%$, $p = 0.501$; TS_{50} : $S = 2.2 \pm 0.7\%$, $NS = 2.2 \pm 1.0\%$, $p = 0.927$; TS_{75} : $S = 1.8 \pm 0.4\%$, $NS = 1.8 \pm 0.7\%$, $p = 0.808$). LSIs were as follows (mean±SD, count>80% LSI (% of participants)): $TS_{MAX} = 67.5 \pm 23.5\%$, 3(33%); $TS_{25} = 91.2 \pm 45.5\%$, 6(67%); $TS_{50} = 101.6 \pm 29.2\%$, 7(78%); $TS_{75} = 102.8 \pm 25.1\%$, 7(78%).

CONCLUSIONS: Maximal contractions better detected between-limb differences in TS, with worse surgical limb TS (higher values indicate greater variability or less steadiness), and revealed larger deficits in TS LSI (worse

symmetry and fewer achieving >80% LSI) than submaximal contractions. A different construct or task may be necessary to better detect motor control and TS impairments with submaximal efforts.

CLINICAL RELEVANCE: Maximal isometric contractions detect TS deficits relative to the nonsurgical limb in patients after ACLR. Clinicians should consider TS in addition to peak torque when using MVIC strength assessments after ACLR.

SP058

EFFECT OF EARLY NEUROMUSCULAR ELECTRICAL STIMULATION ON REHABILITATION OUTCOMES FOLLOWING ACL RECONSTRUCTION IN ADOLESCENTS

Nicole Melfi, Katy Eileen Mitchell, Nicholas Keith Purcell, Kayla Marie Fern Panos, Matthew Ruhe

PURPOSE/HYPOTHESIS: The purpose of this study was to investigate the effect of neuromuscular electrical stimulation (NMES) provided at the initial PT evaluation on ROM, strength, functional outcomes, and discharge rates at 4-, 8-, and 12-weeks post ACL reconstruction with or without a meniscal repair in adolescents.

NUMBER OF SUBJECTS: 207

MATERIALS AND METHODS: Participants were recruited from outpatient pediatric sports clinics within the Texas Children's Hospital system in the Houston area. All assessors were experienced PTs in adolescent sports. Data was collected from PT records from 2022 to 2024. The data set was sub-divided by NMES use and by those having a meniscal repair (MR+) and those who did not (MR-). Descriptive statistics, t-tests, and chi-square analyses were conducted using SPSS 28.

RESULTS: 95.2% of the sample had either a patellar or quad tendon repair. 60.9% were in the MR+ group. 63.3% of the sample was provided a neuromuscular electrical stimulation (NMES) unit at the initial PT evaluation post-surgery. For the MR- group, those that received a NMES unit had significantly faster discharge rates with a brace as compared to those without a NMES unit at 4 weeks ($X^2=8.418, p=.004$). By 8 weeks, the MR+ group, had significantly faster discharge rates with a brace as compared to those without NMES ($X^2=6.469, p=.011$).

At 4 weeks, 23.6% of the MR+ with NMES group lacked full extension as compared to 7.1% of the MR- with NMES group. For those without NMES, 38.9% lacked full extension (MR+), and 25.0% (MR-). By 8 weeks, 5.1% of the MR+ with NMES group lacked full extension as compared to 0% of the MR- with NMES. For those without NMES, 32.4% lacked full extension (MR+), and 11.5% lacked full extension (MR-). There was no difference in achieving a normalized gait pattern at 4 or 8 weeks when comparing NMES groups subdivided by MR, $p<.112$.

By 12 weeks, there were no differences when comparing NMES groups in Y balance, 5 repetition max single leg (SL) press, SL squats, SL calf raises, or returning to run regardless of MR history ($p>.152$). However, those in the MR- group with NMES had the highest proportion of returning to run at 12 weeks, 25.5% compared to 11.8% in the group without NMES.

There was a significant difference in knee extension when comparing NMES groups (MR+) at 8 weeks at $t(45.9)=2.24, p=.015$ with the group receiving NMES exhibiting improved extension.

CONCLUSIONS: This study provides evidence supporting the early use of NMES in adolescents following an ACL repair regardless of MR status. The group who received NMES had earlier rates of discharge at both the 4 and 8 weeks. This group also achieved faster return of full extension at 8 weeks. Although not significant, there were more participants able to return to running at 12 weeks who received the NMES at the initial evaluation.

CLINICAL RELEVANCE: This study suggests that NMES may be a valuable tool to assist adolescents in achieving ROM, function, and discharge goals especially at the 4- and 8-week time frames. This information can be helpful to educate patients and family during the post-operative process regarding the benefits of this intervention.

SP059

IMPLEMENTATION OF NEUROCOGNITION INTO A LEARNING HEALTHCARE SYSTEM'S SPORTS REHABILITATION PROGRAM

Alison Burnham, Jennifer Campbell

PURPOSE: This project highlights utilization of knowledge translation interventions to effectively change PT practice patterns to include implementation of Neurocognition for postoperative athletes in a multisite healthcare system.

DESCRIPTION: Current evidence shows that traditional ACL-R and sports rehabilitation programs often miss neurocognitive interventions, resulting in higher re-injury rates and lower return-to-sport rates. This has led AdventHealth Sports Med and Rehab to utilize collaboration between Sports Orthopedic Physical Therapists and Speech Therapists to improve practices. AdventHealth's efforts to standardize practices through knowledge translation interventions like lectures, journal clubs, and skills labs are described.

SUMMARY OF USE: To change practice patterns and align more with current evidence, an educational series was established via an Outpatient System's Sports Special Interest Group. The following steps were implemented: 1) The Sports SIG hosted a local content expert to share current research and recommendations for integrating Neurocognition in ACL-R rehabilitation. Attendees included physical therapists, athletic trainers, speech therapists and system leadership. 2) Two educational lectures were provided system wide by the authors during biweekly Sports Journal Clubs. The lectures focused on teaching strategies for implementing Neurocognition into current rehabilitation practices, providing ideas for neurocognitive activities to be used in sessions, and cueing techniques for optimal motor learning. 3) A voluntary skills lab was held for all sports therapists in the outpatient system to attend. This lab focused on providing ideas and hands on implementation of low-tech and high-tech Neurocognitive interventions paired with a traditional physical intervention. Attendees were tasked with designing and sharing their own Neurocognitive interventions for immediate implementation at their respective clinics. Ongoing research will show that this process was successful in changing practice patterns of [FUTURE DATA%] of participating clinicians who attended the trainings based on self-reported survey results supported by electronic medical record chart reviews.

IMPORTANCE TO MEMBERS: The knowledge translation interventions were effective for implementing Neurocognition in a Multisite Sports Orthopedic Program. Through utilization of multiple educational modalities, changes in practice patterns of sports physical therapists was achieved by providing lecture, journal club learnings, in person and virtual skills lab, and hands on group demonstrations with focus on designing and sharing self-generated interventions. Future research should be completed to determine if changes in clinician practice patterns have a positive impact on re-injury and return to sport rates.

SP060

WHAT KNEE EXTENSION PERFORMANCE ACROSS THE VELOCITY SPECTRUM TELLS US ABOUT QUADRICEPS FUNCTION FOLLOWING ACLR

Adam Michael Culiver, Bryan Riemann, Emily C. Schlichting, David Bennion, Laura C. Schmitt

PURPOSE/HYPOTHESIS: Testing isokinetic quadriceps muscle performance at 60°/s is the current clinical recommendation following anterior cruciate ligament reconstruction (ACLR); yet testing at other isokinetic velocities is frequently reported. Assessing both peak torque (PT) and total work (TW) quantifies maximal and sustained quadriceps muscle performance which provides relevant information about function. Therefore, the purpose of this study was to investigate how knee extension PT and TW change across the isokinetic velocity spectrum. We hypothesized that PT and TW for the ACLR limb would demonstrate a different pattern of change across velocities, as well as lower PT and TW at each velocity.

NUMBER OF SUBJECTS: 18 participants following ACLR (9 females, 20.4±4.0 y.o., time from surgery to participation=3.9±0.7 months) and 20 control participants (12 females, age=25.7±1.9 y.o., Tegner Activity Scale: 6-9)

MATERIALS AND METHODS: Participants performed knee extension/flexion tests at 20,60,120,240,400°/s (5 repetitions at each velocity; 1 minute of rest between velocities). PT and TW were averaged across the middle 3 repetitions at each speed for analysis. Data were collected through full knee range of motion (ROM) but ROM was constrained to 90°-30° for analysis. The ACLR limb, uninvolved limb, and a control group limb (matched to ACLR laterality and dominant/non-dominant limb) were analyzed. Two-Way Repeated Measures ANOVA models evaluated between group differences for PT and TW across velocities. Post-hoc trend analyses examined velocity effects on each limb with pairwise comparisons identifying significant limb differences at each velocity.

RESULTS: The linear decline in PT and TW across the velocity spectrum was significantly less for the ACLR limb compared to the uninvolved (PT: $p<.001$, $d=1.8$; TW: $p=.002$, $d=1.1$) and control limbs (PT: $p<.001$, $d=1.6$; TW: $p<.001$, $d=1.7$), there were no differences between the uninvolved and control limbs for either measure (PT: $p=.16$, $d=.49$; TW: $p=.33$, $d=.34$). Post-hoc comparisons at each velocity found lower PT and TW for the ACLR limb compared to uninvolved (PT: $p\leq.006$, $d=1.0-1.7$; TW: $p\leq.009$, $d=1.1-1.6$) and control limbs (PT: $p\leq.002$, $d=1.0-1.8$; TW: $p\leq.002$, $d=1.0-1.8$). Comparisons between the uninvolved and control limbs found no differences for any velocity (PT: $p=1.0$, $d=.01-.31$; TW: $p=1.0$, $d=-10-.43$).

CONCLUSIONS: The ACLR limb had the flattest, or least negative, linear regression slope for PT and TW, indicating slower isokinetic testing velocities may be more discriminative for quadriceps performance and faster isokinetic velocities may not be as informative. The ACLR limb demonstrated worse quadriceps performance across the isokinetic velocity spectrum for both PT and TW compared to the uninvolved and control limbs.

CLINICAL RELEVANCE: Clinicians should consider testing at multiple isokinetic speeds, including speeds <60°/s to assess quadriceps performance at more discriminative velocities. Knee extension testing at faster speeds may not differentiate quadriceps muscle performance as well and therefore may not be as useful for clinical testing.

SP061

RECALL ACCURACY OF SPORT PARTICIPATION AND COMPETITION LEVEL UP TO 6 MONTHS AFTER ACL RECONSTRUCTION

Aubrey Denise Aguero, James J. Irrgang, Charity Galena Patterson

PURPOSE/HYPOTHESIS: After an orthopaedic injury, athletes are commonly asked to retrospectively recall details of sport participation prior to their injury and/or surgery in the clinic or as research participants. Although evidence suggests that individuals can reliably recall activity patterns for the past year and several years in the past, the level of accuracy of recall of sport participation and level of competition at later time points after orthopaedic surgery has not been demonstrated. The purpose of this study was to assess the level of agreement between responses given prior to surgery and 6 months after ACL reconstruction (ACLR) regarding pre-injury sport participation and level of competition.

NUMBER OF SUBJECTS: 16

MATERIALS AND METHODS: Participants were included as part of a larger randomized controlled trial at the Pittsburgh site of the ongoing multicenter STABILITY 2 Trial: ACL Reconstruction +/- Lateral Tenodesis with Patellar vs. Quad Tendon. As part of the protocol, participants completed a sport participation form prior to ACLR, which included reporting what sport(s) were played prior to injury and the level of competition for each, ranging from elite (playing at the highest level of professional competition 5-7x/week) to non-organized sport playing casually less than or equal to 1 day per week. The participants completed the same form 6 months after surgery to again rate their level pre-injury sports played and level of

competition. Cohen's Kappa was reported for the dichotomous yes/no answer to the questions asking about sport participation. Weighted Kappa was reported for the ordinal questions assessing competition level within each sport. As there are multiple responses from each participant, the clustered data were analyzed using a clustered bootstrap method to calculate the kappa statistic and its standard error.

RESULTS: 16 participants were included, which was comprised of 10 males (63%), a median age of 17.1 years old, and a median time from injury to surgery of 1.1 months. For recall of participation in a sport (dichotomous data), percent agreement was 97.40% with a Kappa of 0.91 (95% confidence interval (CI), 0.82-0.99), ($p<0.001$). For recall of level of competition in a sport (5 levels of ordinal data), percent agreement was 93.97% with a Kappa of 0.76 (95% CI, 0.57-0.95), ($p<0.001$). All discordant responses were 1 answer choice away from each other. The majority of discordant responses were comprised of a higher rating at baseline compared to 6 months.

CONCLUSIONS: The observed Kappa values of 0.91 and 0.76 for sport participation and level of competition, respectively, provide evidence that an athlete can provide accurate recall of pre-injury sports participation and competition level up to 6-months after ACLR. Although lower in agreement than sport participation, level of competition recall is still acceptably accurate.

CLINICAL RELEVANCE: These results are reassuring that an athlete can accurately recall their pre-injury sports participation and level of competition at the 6-month post-operative time point, which has important implications for recall of this information if not determined at the time of presentation after ACL injury.

SP062

FROM THE TABLE TO THE TRACK: CLINICAL PRACTICE PATTERNS IN DETERMINING RUNNING READINESS

Matthew Anton Kirchner

PURPOSE/HYPOTHESIS: Evaluate physical therapists' practice patterns, intervention selection, and criteria utilized to determine return to running readiness in patients following ACL reconstruction (ACL-R).

NUMBER OF SUBJECTS: 86 practicing physical therapists, with 37 participants (43%) possessing an Orthopedic Clinical Specialist certification and 13 participants (15%) possessing a Sports Clinical Specialist certification

MATERIALS AND METHODS: Online survey delivered through Google Forms and Upstream Rehabilitation's internal network to practicing clinicians.

RESULTS: No majority existed within the sample in terms of possession of an advanced certification with intervention selection in line with CPG recommendations. Objective criteria selection for determining return to running readiness varied within the sample but the majority of participants utilized timeline, MMT, and a variation of plyometric and/or hop testing as criteria.

CONCLUSIONS: Variance exists within physical therapists' clinical practice in intervention selection and objective criteria utilization during ACL-R rehabilitation. Despite multiple CPGs published on the subject, high-level supported interventions were not universally seen among the majority of respondents in practice. Physical therapists' use of objective criteria has the opportunity to continue to improve to not only further evaluate and treat isolated deficits in a more detailed manner, but also address the capacity of the entire lower quarter when determining return to running readiness.

CLINICAL RELEVANCE: There is a paucity of research evaluating clinical practice patterns of physical therapists during ACL-R rehabilitation despite an overwhelming amount of literature published on the subject. Physical therapists within this sample did not universally implement highly recommended interventions from CPGs during the early to mid-stage conditioning process. Post-operative timeline was the most utilized criteria to determine return to running readiness, which was selected by 94% of the sample, and allows time for the ligamentization process of the graft.

Manual muscle testing of the quadriceps and hamstrings was the most selected strength assessment, with 78% of the sample selecting this option, but lacks sensitivity in detecting asymmetry and force-generating capacity of the knee joint. Hip and calf strength assessments were also not universally utilized, with 58% and 57% of respondents assessing respectively, despite the high demand for both muscle groups during running. Hop testing variations was the most selected functional objective criteria at 92% but can fail in identifying knee extensor capacity due to intralimb compensatory patterns to complete the task. Understanding current practice patterns can help researchers understand pitfalls and barriers to best practice implementation in clinical practice to improve patient outcomes.

SP063

THE MULTIPLANAR PLYOMETRIC TEST: A NOVEL LAYER TO SCREENING ANTERIOR CRUCIATE LIGAMENT INJURY RISK

Kevin McDonald, Ligia Y. Mochida, Paulo R. P. Santiago, Guilherme Manna Cesar

PURPOSE/HYPOTHESIS: Identifying lower extremity (LE) movement deficiencies is paramount to preventing athletic injuries. Anterior cruciate ligament (ACL) injury typically occurs within 40 ms of ground contact during landing and cutting maneuvers with rapid change in momentum. While ACL injury screenings attempt to mirror mechanisms of injury, ACL return-to-sport protocols use hop tests such as the single-leg triple hop for distance (THD) to identify lower extremity (LE) side-to-side performance differences. This cross-sectional study explored a novel single-leg multiplanar plyometric task named CUBE to test if side-to-side differences, absent in contemporary hop tests such as THD, would emerge.

NUMBER OF SUBJECTS: Ten subjects (6 female, mean±SD age 23.2±2.0 yrs; height 1.75±0.11 m; weight 74.9±13.7 kg) with various athletic backgrounds were conveniently sampled.

MATERIALS AND METHODS: Participants performed three THD and three CUBE trials with the best trial used for each leg. CUBE utilizes a 3x3 cloth grid of 0.45 m squares and involves a single leg hop from the center square to each surrounding square in clockwise direction with return to center square after each hop. Participants were instructed to complete CUBE as quickly as possible without losing balance. Variables of interest for contrasting performance of both tests were THD distance (normalized by leg length, unitless) and CUBE completion time (s). To further explore CUBE, variables included ground contact time (s) and impulse within 40 ms (normalized by bodyweight, BW-s). A force plate under CUBE's center square measured variables for each of the seven returning foot strikes. Wilcoxon signed-rank test indicated side-to-side differences for THD and each CUBE direction separately.

RESULTS: For task performance, no significant side-to-side differences were observed in THD ($p=0.48$; right 6.29±.98, left 6.31±1.10) or CUBE ($p=0.29$; right 9.05±4.46 s, left 8.82±3.82 s). For CUBE ground contact time, foot strikes were longer on the right (0.47±0.35 s) versus left (0.43±0.22 s), but a trend towards significance was only observed in side-to-side difference on the seventh strike ($p=0.05$), characterized by the return from back left and hop to middle left. Impulse was greater on left (0.018±0.010 BW-s) versus right (0.016±0.008 BW-s) and side-to-side difference was significant on the fourth strike ($p=0.03$), characterized by the return from middle right and hop to back right.

CONCLUSIONS: While performance measures did not differ, CUBE identified side-to-side differences in LE performance not observed in THD.

CLINICAL RELEVANCE: Detecting side-to-side differences in LE performance is crucial for screening ACL injury risk. Approximately 40% of the 120,000 ACL injuries that occur annually in the US are non-contact and preventable. The high prevalence of non-contact ACL injuries highlights the need for improved injury screening and return-to-sport protocols. CUBE's ability to detect performance differences not seen in sagittal plane tasks may guide development of future protocols and aid in non-contact ACL injury prevention.

SP064

VISUAL COGNITIVE TASKS IMPAIR POSTURAL STABILITY AND FUNCTIONAL OUTCOMES IN BOTH ACLR AND HEALTHY CONTROLS

Jena Kay Berryman Ogston, Cassie Endsley, Sabrina Elder, Haley Rohwer, Samantha Sonstegard, Elias Tuominen, Austin Windsperger

PURPOSE/HYPOTHESIS: Recent research has attended to the high reinjury rates in individuals s/p ACLR (anterior cruciate ligament reconstruction) with specific investigation into neurocognitive motor deficiencies. Various assessments with visual and cognitive alterations have been proposed with aims to delineate these potential deficiencies with varied results. The purpose of this study was to evaluate the impact of visual cognitive disruption in ACLR individuals compared to healthy controls during various functional tests hypothesizing decreased performance in ACLR participants.

NUMBER OF SUBJECTS: 19

MATERIALS AND METHODS: This was a quasi-experimental, basic laboratory study. Participants aged 18-35 years (9 ACLR, 10 controls average age 23.7 +/- 3.3 yrs; 4 males, 15 females) were recruited within a college community. ACLR participants were required to be more than 1 year post-ACLR (average time from surgery = 5.6 years). Control participants did not have any history of lower extremity surgery or current pathology. Participants completed the following functional outcomes with and without visual cognitive (VC) load: step-down single legged balance task onto a force plate (95% ellipse), medial hop test and Y balance test. Outcomes were compared between groups with a 2-way ANOVA with two tailed t-test post-hoc evaluation (SPSS v27).

RESULTS: All evaluated outcomes showed a significant performance decrease in the VC condition when compared to the NVC condition when averaged across groups ($p<0.05$). When averaged across conditions, no significant differences were seen between the ACLR and control groups. Post hoc evaluation revealed a significant decrease in all outcomes within each group noting a decrease in performance in the VC compared to the NVC condition ($p<.001$).

CONCLUSIONS: The current findings are in general consensus with previous literature reporting decreased performance with challenged VC tasks in ACLR individuals although research in this area is just beginning to emerge. However, no differences were seen between the ACLR and control groups as seen in other studies where the visual cognitive tasks may not have been challenging enough discriminating differences in those s/p ACLR and/or adaptation occurred in this population with an average 5 years s/p ACLR. The decline in performance within both groups is likely a response to dual tasking where attention to all systems is limited.

CLINICAL RELEVANCE: Rehabilitation specialists are encouraged to integrate VC interventions and screening tests that mimic return to activity in aims of facilitating neurocognitive changes and be cognizant of various VC functional assessments noting an expected decline in performance without training. In order for VC testing to be discriminative, higher level challenges beyond simple math problems may have to be implemented. VC training is suggested throughout rehabilitation with aims of decreasing reliance on the visual system for motor control within the ACLR populations.

SP065

EFFECT OF VISUAL-COGNITIVE DUAL TASK ON QUADRICEPS PERFORMANCE IN PARTICIPANTS WITH ACL RECONSTRUCTION

Cassie Endsley, Jena Kay Berryman Ogston, Elias Tuominen, Cody Rae, Christina Raffail, Danielle Overman

PURPOSE: Reinjury after anterior cruciate ligament reconstruction is (ACLR) common. Restoring quadriceps strength has been well established as a means to decrease risk of reinjury after ACLR, however high reinjury rates remain. Recent research demonstrates an increased reliance on visual-cognitive processing for neural control when performing

motor tasks after ACLR, which may lead to inappropriate motor planning when returning to situations with high visual-cognitive load, such as sport. Assessing motor performance with an added visual-cognitive dual task during return to sport assessments with aims to capture the ability of the athlete to perform under higher visual-cognitive loads has been proposed. This study explored the impact of visual-cognitive challenges on quadriceps (QS) muscle activity and force production in individuals post-ACLR compared to controls.

SUBJECTS: 9 participants (2 male, 7 female) s/p ACLR (5.6 ± 3.7 years post-operative) and 10 control participants (2 male, 8 female) without current pathology.

METHODS: With the knee fixed at 90 degrees of knee flexion, participants performed five maximal isometric knee extensions under 3 randomized conditions: visual-cognitive dual-task (DT), virtual reality (VR), and traditional verbal cues (TC). Electromyography (EMG) was used to assess quadriceps activity and a Tindeq® dynamometer was utilized to assess QS peak force. EMG and force were normalized to a maximum voluntary isometric contraction. Peak force and EMG outcomes were evaluated by a 2x3 ANOVA with Tukey's post-hoc testing. Mean differences in performance between groups were evaluated by an independent two-tailed t-test (SPSS v.27).

RESULTS: Force output in the DT condition was significantly less than TC in both the ACLR and control group ($p < .05$). When evaluating EMG, the DT condition showed significantly less QS muscle activity than the TC and VR conditions ($p < .001$). There was no significant difference in the mean decrease in performance during the DT condition between ACLR and control groups.

CONCLUSIONS: While both the control group and the ACLR group demonstrated less QS force and muscle activity under the DT condition, the ACLR group did not have a larger impairment in performance. These findings differ from other recent literature, that suggest with an added visual cognitive dual task, individuals after ACLR demonstrate decreased postural control. Our findings suggest ACLR and control groups may perform similarly under visual-cognitive dual tasking conditions, the DT condition in this study was not challenging enough to be discriminative, or the ability to perform with dual tasks reintegrates with an increased number of years from surgery.

RELEVANCE: Recent literature suggests adding visual cognitive dual tasks to return to sport assessments, however, our findings do not demonstrate the ability to objectively assess differences in performance between ACLR and control individuals. Further research is warranted to assess performance in participants with more recent ACLR and more challenging visual-cognitive dual task conditions.

SP066

OUTCOMES OF REVISION VS PRIMARY ACL RECONSTRUCTION WITH CONTRALATERAL AND IPSILATERAL PATELLAR TENDON GRAFT

William Claussen, Scot Bauman, K. Donald Shelbourne, Rodney Benner, Adam Norris

PURPOSE/HYPOTHESIS: Results from revision anterior cruciate ligament reconstruction (ACLR) can be inferior to primary ACLR, possibly due to a change in graft choice. The purpose of this study was to evaluate the outcomes of ipsilateral/contralateral primary ACLR compared to ipsilateral/contralateral revision ACLR using a patellar tendon graft (PTG).

NUMBER OF SUBJECTS: 5508

MATERIALS AND METHODS: Between 1982 and 2022, 5508 patients having an ACL reconstruction using a PTG and a minimum two year follow up were retrospectively reviewed. Exclusion criteria included osteoarthritis at the time of surgery and bilateral procedures. Patients were split into four groups: primary ipsilateral (PI), revision ipsilateral (RI), primary contralateral (PC), and revision contralateral (RC). Postoperatively, both ipsilateral groups and both contralateral groups had similar rehabilitation programs, with the main difference between groups being immediate

strength training on the graft harvest site for the contralateral groups. The rehabilitation protocol did not differ between primary and revision surgeries. Outcome measures included KT-1000 testing, range of motion (ROM) for extension at 1 month and flexion at 3 months, isokinetic quadriceps strength compared to preoperative values, rate of scar resection (SR), rate of return to preinjury activity level in the first two years, and International Knee Documentation Committee (IKDC) subjective scores at a minimum 2 years. For stability and ROM, side to side differences were obtained and normal was defined as normal and nearly normal values on the IKDC objective form.

RESULTS: For the 5508 subjects (PI=1625, RI=205, PC=3425, RC=253), mean age was 23.5 years and 62% were male. Patients in the RI group had a lower distribution of normal postoperative stability compared to the other groups at 95.5%, $p=0.006$. Patients in the PI group showed to have a significantly lower distribution of normal extension and flexion at 96.3% and 76.5%, respectively (both $p < 0.001$). At the early, intermediate, and late stages of rehabilitation, the PI group demonstrated the lowest percent of patients within 10% strength compared to preoperative value (early 5%, intermediate 16%, late 41%), all $p < 0.001$. The PI group demonstrated the highest rate of SR at 4.4%, when compared to the other groups (PC 1.2%, RC 1.2%, RI 0.5%), $p < 0.001$. Minimum 2 year IKDC scores among the four groups were significantly different with PC at 87, PI at 84, RI at 80, and RC at 79, $p < 0.001$. The rate to return at the pre-injury level was the highest for the RC group (89%), followed by the RI (86%), then the PC group (85%), and lastly the PI group (80%), $p=0.001$.

CONCLUSIONS: Over 95% of patients in each group achieved normal post-operative stability. The PI group had stiffer ROM, less symmetrical strength, and a higher likelihood of a SR. Subjectively, primary ACLR patients scored better than revision ACLR patients, but both revision groups had a higher rate of return to preinjury activity.

CLINICAL RELEVANCE: Patients can achieve good results following revision ACLR with regards to ROM, strength and return to preinjury level of activity, although subjective scores may be lower.

SP067

KINESIOPHOBIA AND QUALITY OF MOVEMENT AT THE TIME OF RETURN TO SPORT AFTER ACL RECONSTRUCTION

Lauren Schlacht Butler, Alexa Rae Martinez, Gabriel Cardenas, Margaret Wright, Dai Sugimoto

PURPOSE/HYPOTHESIS: The purpose of this study was to assess the relationship between kinesiophobia and quality of movement at the time of return to sport (RTS) testing after anterior cruciate ligament reconstruction (ACLR) in youth athletes. Our hypothesis was that athletes with high kinesiophobia will demonstrate more sagittal plane movement errors and athletes with low kinesiophobia will demonstrate more frontal plane movement errors at the time of RTS testing after ACLR.

NUMBER OF SUBJECTS: 114 youth athletes (16.0 ± 2.3 years, female 25.4%) who underwent primary ACLR between 2014 and 2021.

MATERIALS AND METHODS: A retrospective chart review was performed. At the time of RTS, athletes completed the Tampa Scale of Kinesiophobia (TSK-11), triple hop for distance (THD), triple crossover hop for distance (TCHD), and a sidestep cut (SSC). A movement checklist qualitatively assessed the THD, TCHD, and SSC in the frontal and sagittal plane. For the hop tests, frontal plane variables included trunk alignment, noticeable valgus, and significant valgus, and sagittal plane variables included stiff landing. For the SSC, the frontal plane variables included trunk alignment, knee valgus, and cut width, and the sagittal variables included decreased knee flexion and decreased plantarflexion. The presence of each movement error and the total number of sagittal and frontal plane errors were compared between low (TSK-11<17) and high (TSK-11>17) kinesiophobia groups. Chi-square tests were performed, odds ratios (ORs) and 95% confidence interval (95%CI), and p-value ($p < 0.05$) were used for statistically significant values to compare the two groups.

RESULTS: In total, 34% of athletes reported low kinesiophobia (74.4% male). Mean time from ACLR to the RTS test was 10.2±4.4 months. Compared to the high kinesiophobia group, the low kinesiophobia group had 3.9x increased odds of a stiff landing on the uninjured limb during the THD ($p=0.031$, OR:3.972, 95%CI: 1.06-14.28) and 2.9x increased odds of a stiff landing on the involved limb during the TCHD ($p=0.030$, OR:2.89, 95%CI: 1.08-7.69). Additionally, the low kinesiophobia group had 8.1x increased odds of significant valgus on the involved limb during the THD ($p=0.027$, OR:8.14, 95%CI: 0.91-76.92) and more sagittal plane errors on the involved limb during the SSC ($p=0.031$). Lastly, the high kinesiophobia group had 74% reduced odds of uninjured limb sagittal plane errors during the THD ($p=0.044$, OR:0.258, 95%CI: 0.70-0.943).

CONCLUSIONS: At RTS testing following ACLR, youth athletes with lower kinesiophobia demonstrated greater landing stiffness and more sagittal plane movement errors, on both limbs, across tasks.

CLINICAL RELEVANCE: Clinicians should be aware of movement strategy differences between athletes with low and high kinesiophobia and should aim to address both kinesiophobia and movement quality during the RTS phase of rehabilitation after ACL. Future studies should explore this relationship at earlier post-operative timepoints.

SP068

LIMB DOMINANCE IMPACT ON LIMB SYMMETRY INDEX VALUES FOLLOWING ACL RECONSTRUCTION

Paul Kuwik, Erin Marie Miller, Jamie Bush Morris, Timothy Benedict, John Sterling Mason, Crowell Michael

PURPOSE/HYPOTHESIS: Following anterior cruciate ligament reconstruction (ACLR), return to sport testing typically includes single-leg strength and hopping assessments. Limb dominance, if considered, is typically defined as the preferred limb to kick a ball. The primary aim of our study was to determine if ACLR participants preferred the same limb to kick a ball as performing a single-leg vertical jump (SLVJ) and if differences in strength and hopping existed based on the selection of limb dominance. The secondary aim was to determine if quadriceps strength and single-leg hop performance varied between ACLR participants who injured their dominant vs non-dominant limb.

NUMBER OF SUBJECTS: Twenty-six military academy cadets with an ACLR (median 13 months from ACLR surgery) were recruited for the study.

MATERIALS AND METHODS: Limb dominance was determined by two self-reported questions: which limb do you prefer to perform a SLVJ and which limb do you prefer to kick a ball? Each participant performed a functional assessment consisting of SLVJ, single-leg medial rotation hop (SLMRH), single-leg lateral hop (SLLH), and single-leg isokinetic quadriceps strength (at the following velocities: 60, 180, 300°/sec). Comparisons between groups were made via independent t-test, chi-square, and Mann-Whitney U tests.

RESULTS: Seventeen participants preferred the same limb to kick a ball and to perform a SLVJ. Eight participants preferred different limbs ($\chi^2=2.42$, $p=0.15$). There were no significant differences in any outcome when comparing the selection of the limb dominance by preference for kicking a ball versus single leg jumping ($p>.05$). Participants who injured their dominant limb defined by kicking a ball had significantly greater LSI symmetry for quadriceps strength at 180°/sec: 15.6% ($p=.02$). Participants who injured their dominant limb defined by performing a single leg jump had significantly greater LSI symmetry for SLMRH 9.9% ($p=.05$) and quadriceps strength at 60°/sec: 39.0% ($p<.01$).

CONCLUSIONS: For patients with ACLR, limb dominance can be defined by either the preferred limb to kick a ball or perform a SLVJ. ACLR patients who injure their dominant limb may have greater single-leg strength symmetry than those who injure their non-dominant limb. While not statistically significant, the point estimates of the mean LSI differences between dominant and non-dominant limbs were clinically meaningful for both kicking and jumping preference. The mean LSI difference between dominant and non-dominant limbs defined by preference for kicking a ball

ranged from 5.7 to 6.6% for single-leg jump and hop performance and 9.7 to 18.9% for quadriceps strength, while the difference between dominant and non-dominant limbs to perform a SLVJ ranged from 5.5 to 9.9% for single-leg performance hop and jump and 11.3 to 39.0% for quadriceps strength.

CLINICAL RELEVANCE: A clinician may determine limb dominance for ACLR patients by either using the preferred limb to kick a ball or SLVJ. Clinicians should consider limb dominance when assessing quadriceps strength and functional LSI for ACLR patients.

SP069

OUTCOMES COMPARISON FOLLOWING PRIMARY ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION IN FIELD AND COURT SPORTS

Andrew Edward Robinson, Olutayo Akinboboye, Jena-Claire Auten, Steven Richard Higbie, Jacquelyn Lee Kleihege, Lane Bailey, Walter R. Lowe

PURPOSE/HYPOTHESIS: Graft selection after ACL injury is often challenged by numerous biological factors and sport-specific demands that commonly vary by patient. Additionally, the evidence currently comparing outcomes by graft type between athletes participating in court and field sports is insufficient. Therefore, the purpose of this study was to compare return to sport (RTS) and 2-year outcomes between court and field sport athletes following primary ACLR with either bone-patellar-tendon-bone (PT) or quadriceps tendon (QT) autograft.

NUMBER OF SUBJECTS: 2,413

MATERIALS AND METHODS: A matched-case control study was conducted utilizing a sample of patients ages 15-35 years following ACLR that completed 2-year data collection with either PT or QT autograft. Athletes were grouped to field or court based upon their self-report of primary participation. Exclusion criteria consisted of revision ACLR reconstruction, contralateral knee injury, and multi-ligamentous knee injury. Objective and self-reported outcomes were obtained at time of RTS and included objective functional testing, patient-reported outcomes and postoperative complications. Two-year outcome measures included the Single Assessment Numeric Scale (SANE), graft failure rates, and RTS participation. Generalized linear models and non-parametric equivalents were conducted using *Tukey's post-hoc* analyses with an *a priori* $\alpha = .05$.

RESULTS: A total of 864 athletes [field ($n = 467$), court ($n = 397$)] met the criteria for this study. There was a main effects difference (sport group) for age, gender, weight, and MARX score ($p < .05$). There was a difference in proportion of graft types by group [PT autograft 79.3% (field) vs 72.6% (court), $P < .01$]. At RTS, the field sports group demonstrated significant differences in IKDC scores (field: 90.0±9.3, court: 88.1±9.8, $P = .036$), and lower flexion ROM deficits compared to the court sport group. There were no significant differences in ACL-RSI scores between groups ($P = .350$) or other functional performance metrics ($P > .05$). Two-year outcomes included higher SANE scores for field sport athletes (91.1±9.6 vs. 88.0±11.0, $P = .032$). There was also a higher main effects difference for graft reinjury rate in the QT group (6.4% vs 3.8%, $P = .01$) compared to the PT group. There were no significant interactions in the rate of participation of level I-II cutting pivoting sports ($P = .066$), rate of graft reinjury ($P = .798$), or complications ($P > .05$) between groups at 2-years.

CONCLUSIONS: Despite several demographic differences, few objective functional differences were present between field and court sport athletes. However, field sport athletes displayed lower flexion ROM deficits, and higher IKDC and SANE scores at 2-years in comparison to the court athletes. Also, graft reinjury was higher for QT versus PT autografts.

CLINICAL RELEVANCE: Surgeons and rehab professionals should consider that field sport athletes may exhibit some advantages to functional recovery after ACLR. In addition, the higher reinjury rate among QT autograft versus PT autograft in this study confirms prior investigations.

SP070**ASSESSING PLANNED AND UNPLANNED CHANGE OF DIRECTION MOVEMENT QUALITY IN FEMALE BASKETBALL PLAYERS***Evan Andreyo, Casey Unverzagt, Tom DosSantos, Jay Dawes*

PURPOSE/HYPOTHESIS: This quantitative research study investigated differences in change of direction (COD) movement quality across different movement conditions and competition levels among collegiate female basketball players.

NUMBER OF SUBJECTS: 60

MATERIALS AND METHODS: Qualitative movement assessment was conducted using 2-dimensional video recording of a COD maneuver and the Cutting Movement Assessment Score (CMAS), a valid and reliable qualitative COD movement assessment tool. Greater CMAS scores suggest a higher number of movements associated with ACL injury risk. Movement quality was compared across movement conditions (planned vs. unplanned) and collegiate divisions (division 2 vs. 3). Timing gates with immediate visual stimuli were used to promote greater ecological validity and testing standardization.

RESULTS: Paired sample total CMAS scores were significantly greater during planned conditions than unplanned ($p < 0.01$; $d = 1.065$). Six individual rubric items were significantly greater under planned conditions ($p < 0.05$), one was greater under unplanned ($p < 0.05$), and two were not significantly different. Group analysis demonstrated a significant difference between movement conditions ($p < 0.001$; $N_p^2 = 0.26$) but not division ($p = 0.537$).

CONCLUSIONS: Female collegiate basketball players may demonstrate a greater number of movement errors associated with ACL injury risk during planned than unplanned movement conditions. However, this outcome may reflect the associated agility task, type of unplanned stimulus, and the subject's movement velocity rather than the movement condition alone. COD movement quality may not be significantly different across collegiate divisions in female basketball players.

CLINICAL RELEVANCE: Clinicians should consider utilizing the CMAS with collegiate female basketball players to screen COD movement quality associated with ACL injury risk. However, practitioners must consider the challenges of promoting ecological validity and testing standardization when implementing unplanned COD movement assessments and the influence these variables may have on the testing results. Similar ACL injury mitigation strategies should be considered across division 2 and 3 collegiate basketball players, given the observed similarities in movement quality. While this investigation utilized a healthy population, this tool should also be considered post-injury.

SP071**DOES PAIN AT INITIAL EVALUATION PREDICT POST OPERATIVE ACLR RANGE OF MOTION AT 6 WEEKS?***Taylor E. Douthit, Logan Emery, Nicolas Dobson, Dhalston Cage, Laura Henderson, Adrienne Garcia, Stephen Laplante, John Abt, Lucy Phan*

PURPOSE/HYPOTHESIS: This retrospective cohort study aimed to investigate whether initial postoperative pain scores predict subsequent knee range of motion (ROM) outcomes in pediatric athletes undergoing ACL reconstruction with or without meniscus repair. It was hypothesized that higher pain scores at initial evaluation would correlate with decreased knee flexion and extension ROM at 3- and 6-weeks post-surgery.

NUMBER OF SUBJECTS: $n = 77$, 40 Females and 37 Males

MATERIALS AND METHODS: Seventy-seven pediatric patients (40 females, 37 males) who underwent ACL reconstruction between 2017 and 2020 were included in the study. Pain scores using the Numerical Rating Scale (NRS), knee flexion Active Range of Motion (AROM), and knee extension AROM were recorded at initial evaluation, three weeks, and six weeks post-op. Linear regression was used to analyze the relationship between initial pain scores and subsequent knee ROM outcomes.

RESULTS: Initial pain scores did not demonstrate a significant overall relationship with knee flexion or extension ROM at 3- and 6-weeks post-surgery across the cohort. However, when classified by sex, females with higher initial pain scores exhibited a statistically significant association with decreased knee extension ROM at subsequent follow up assessments. At 6 weeks post-op, 29.5% of patients had not achieved full knee flexion or extension.

CONCLUSIONS: While initial pain scores did not predict ROM outcomes in all pediatric athletes post-ACL reconstruction, there was a notable sex-specific effect in females. Higher initial pain levels may influence behavioral responses that impact rehabilitation progress, emphasizing the importance of early pain management and psychological support in the recovery process.

CLINICAL RELEVANCE: Understanding the relationship between pain and ROM outcomes can guide clinicians in tailoring rehabilitation strategies for pediatric athletes undergoing ACL reconstruction. Early identification of pain and kinesiophobia, particularly in female patients, can lead to targeted interventions that optimize recovery, enhance compliance to rehabilitation protocols, and improve overall postoperative outcomes.

SP072**THE RELATIONSHIP BETWEEN PSYCHOLOGICAL READINESS AND KINESIOPHOBIA IN ADOLESCENTS AND YOUNG ADULTS AFTER ACL RECONSTRUCTION***Lauren Schlacht Butler, Sophia Ulman, Dylan P. Roman, Cody Walker, Taylor E. Douthit, Christopher Kuenze, ACL Reconstruction Rehabilitation Outcomes Workgroup, Shelby Baex*

PURPOSE/HYPOTHESIS: The purpose of this study is to assess the relationship between psychological readiness to RTS and kinesiophobia in adolescent and young adult athletes after primary ACLR. Our hypothesis was that psychological readiness and kinesiophobia will demonstrate a strong inverse correlation in young adults, and no significant correlation in adolescents after ACLR.

NUMBER OF SUBJECTS: 323

MATERIALS AND METHODS: Participants who completed the Anterior Cruciate Ligament Return to Sport after Injury Scale (ACL-RSI) and the Tampa Scale of kinesiophobia (TSK-11) between 6-12 months after ACLR were included from a multi-site clinical outcomes registry. Acceptable and unacceptable scores on the ACL-RSI were operationally defined using an established cutoff of 77 by Mcpherson et al (≥ 77 : acceptable) and two age subgroups were created using a cutoff of 19 years (adolescent: 13-18, young adult: 19-30). Pearson correlations were used to assess associations between the ACL-RSI and TSK-11 scores for each age group. A logistic regression was performed to determine the association between TSK-11 score and the likelihood of reporting an unacceptable ACL-RSI score, with age and sex as covariates. Significance was set to 0.05.

RESULTS: A total of 323 participants (53.6% female; 18.1 ± 3.4 years; 8.2 ± 1.8 months from surgery) were included for analysis. ACL-RSI and TSK-11 scores averaged 73.6 ± 22.5 and 18.4 ± 4.9 , respectively, with 48.0% reporting unacceptable ACL-RSI scores. A moderate correlation was observed between ACL-RSI and TSK-11 scores for both the adolescent and the young adult group ($r = -0.56$, $p < 0.001$ and $r = -0.45$, $p < 0.001$). Greater TSK-11 scores were associated with unacceptable ACL-RSI scores, with 28% increased odds of having an unacceptable ACL-RSI score for every one-point increase in TSK-11 score ($p < 0.001$, OR 1.28, 95% CI 1.21-1.37). Older participants had a higher likelihood of having an unacceptable ACL-RSI ($p = 0.035$, OR 1.09, 95% CI 1.01-1.17).

CONCLUSIONS: Greater kinesiophobia was moderately associated with lower psychological readiness in both young adults and adolescents after ACLR. Older participants had a higher likelihood of having unacceptable psychological readiness and nearly half of all participants demonstrated poor psychological readiness.

CLINICAL RELEVANCE: Kinesiophobia and psychological readiness are associated in adolescents and young adults. Given the low psychological readiness scores found in this study, physical therapists should focus more attention on addressing psychological constructs during the RTS phase after ACLR. Our study also demonstrated an age disparity in psychological readiness after ACLR, which is an additional area that physical therapists should recognize and address during the rehabilitation process.

SP073

ASSESSING PLANTAR FLEXION STRENGTH SYMMETRY IN ADOLESCENTS FOLLOWING ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

Nicholas Gary Giampetruzzi, Lisa Cruz, Dylan P. Roman, Art Daniel Fredericks, Adam Pierce Weaver

PURPOSE/HYPOTHESIS: Knee strength deficits and their impact on successful outcomes following anterior cruciate ligament reconstruction (ACLR) has been studied extensively. More recently the impact of the ankle plantar flexors on ACLR rehabilitation and ACL injury mechanisms has started to be examined, but it is not well understood if there are ankle strength deficits after ACLR in adolescents. Therefore, the aim of this study was to examine the impact of ACLR in adolescents on plantar flexion strength symmetry. Our hypothesis was that isokinetic strength in the involved lower extremity would be significantly lower than in the uninvolved lower extremity.

NUMBER OF SUBJECTS: 14 patients (6 females; 15.62±1.29 years)

MATERIALS AND METHODS: A retrospective review was conducted on adolescent patients, 12 to 18 years old at time of testing, who underwent primary ACLR and completed the organizational post-operative testing battery between November 2022 and May 2024. Patient demographics and isokinetic ankle plantar flexion peak torque on HUMAC NORM at 60°/second in supine with knee flexed to 90 degrees were obtained. Peak torque was normalized to body weight and used to calculate limb symmetry index (LSI), by dividing the involved lower extremity by the uninvolved lower extremity. Patient data was excluded for subject that had a coefficient of variance greater than 20% for either limb. An Independent Samples T-Test was conducted to determine differences between normalized involved and uninvolved extremity isokinetic peak torques. Significance (α) was set to 0.05 a priori. Additionally, frequency of patients meeting LSI of 90% or greater was obtained.

RESULTS: 14 patients met inclusion criteria for return to play testing (9.6±1.4 months from surgery). Normalized isokinetic ankle plantar flexion peak torques were 0.83±0.22 Nm/kg and 0.83±0.30 Nm/kg respectively for the involved and uninvolved lower extremity. Significant differences were not seen between the involved and uninvolved limbs ($p=0.99$). Mean LSI was 106.21±26.7 with 9 of 14 patients meeting threshold of 90% or greater.

CONCLUSIONS: In adolescents following ACLR there were no significant differences in plantar flexion isokinetic strength between the involved and uninvolved lower extremity. Though there were no interlimb differences noted for the group, 5 of 14 patients were unable to meet typically assigned criteria of 90% LSI. Future investigation is needed to identify factors associated with patient's recovery of plantar flexion strength.

CLINICAL RELEVANCE: Following ACLR in adolescents plantar flexion strength should be included as part of strength testing protocols to guide rehabilitation plans as patients do not consistently achieve symmetry.

SP074

ACLR WITH MULTILIGAMENT INVOLVEMENT CAN YIELD SIMILAR OUTCOMES TO THOSE WITH ISOLATED ACL TEARS

Scot Bauman, William Claussen, K. Donald Shelbourne, Rodney Benner, Adam Norris, Deepak V. Patel

PURPOSE/HYPOTHESIS: Acute single-stage surgery for multiligament knee injuries (MLKI) can result in complications, including arthrofibrosis. Medial collateral ligament (MCL), posterior cruciate ligament (PCL),

and lateral side (LS) repair/reconstructions in combination with anterior cruciate ligament reconstruction (ACLR) may be better addressed non-operatively or as a staged procedure. The study aimed to compare the outcomes following ACLR for MLKIs to isolated ACLRs. Our hypothesis was that, with the proposed treatment, MLKIs would have similar outcomes to isolated ACLRs.

NUMBER OF SUBJECTS: 5419

MATERIALS AND METHODS: Between 1982 and 2021, 5419 patients having an ACLR using a patellar tendon graft and minimum two year follow up were retrospectively reviewed. Exclusion criteria were revision surgery, osteoarthritis at the time of surgery, and bilateral procedures. Patients were divided into three groups based on the structures involved: isolated ACL, ACL/MCL, and ACL/LS. All MCL injuries were treated nonoperatively, including possible casting in 20° to allow the MCL to heal prior to the ACLR. Treatment of LS injuries consisted of acute en masse repair of the torn lateral capsule prior to the ACLR. All PCL tears were treated nonoperatively. Regardless of group, each patient went through a similar postoperative rehabilitation program focused on immediate weight bearing and restoration of range of motion (ROM). Outcomes included side to side differences with postoperative stability (KT-1000 at 3 months) and ROM (1 year). Additional outcomes were International Knee Documentation Committee (IKDC) score at a minimum two years, rate of return to preinjury level at one year, scar resection rates, and graft tear rates.

RESULTS: For the 5419 patients (isolated ACL=5001, ACL/MCL=387, ACL/LS=31), mean age was 23.4 years and 61.3% were male. Postoperative stability was similar among the groups, with a cohort mean difference of 1.9 mm side to side, $p=0.123$. Extension and flexion ROM were similar between groups with a cohort mean difference for extension at 0° and 2° for flexion, $p=0.205$ and $p=0.690$, respectively. Minimum two year IKDC scores between groups were significantly different with the isolated ACL group at 86, ACL/MCL 84, and ACL/LS 87, $p=0.041$. Post hoc analysis revealed a difference of 2.4 points between the isolated ACL and ACL/MCL groups, $p=0.030$. The rate of return to preinjury level was 80% and this was not different among the groups, $p=0.108$. Scar resection and graft tear rates were not different between groups with an overall cohort rate of 2.3% for scar resections and 6.1% for graft tears, $p=0.652$ and $p=0.274$, respectively.

CONCLUSIONS: For MLKIs, when the MCL/PCL are treated nonoperatively and the LS is acutely repaired prior to the ACLR, the results following the subsequent ACLR are similar to isolated ACLRs in terms of stability, ROM, subjective scores, return to sport, scar resections, and graft tear rate.

CLINICAL RELEVANCE: Acute surgery for MCL/PCL tears and single stage ACLR with LS repair may not be necessary. The proposed treatment philosophy allows the collaterals to heal before the ACLR and reduces complications that accompany acute surgery with MLKIs.

SP075

A CLINICAL TOOL TO MONITOR THE TRAJECTORY OF KNEE RANGE OF MOTION RECOVERY FOLLOWING ACLR

Ryan Patrick McGuire, Alyssa Peacock Alkire, Parker Biseck, Grace Martin, Isabel Fairbanks, Gregory Hawk, Timothy Lee Uhl

PURPOSE/HYPOTHESIS: Previous research has demonstrated that 3% of patients have range of motion (ROM) loss after primary Anterior Cruciate Ligament Reconstruction (ACLR). Early gains in ROM post ACLR are critical for full recovery of mobility. Lack of full knee extension by 3-6 weeks increased the incidence of cyclops syndrome by 2-8-fold, respectively. Loss of total ROM greater than 50°, compared to the other side, by 8 weeks post-operatively was associated with arthrofibrosis. Based on these critical milestones but paucity of research, we sought to create a clinical reference tool to better guide care based on recovery of knee ROM across time. We hypothesized that surgical knee ROM will plateau by 3 weeks for knee extension and 8 weeks for knee flexion.

NUMBER OF SUBJECTS: 185 patient charts that underwent ACLR between 2021-2023 at our institution were reviewed to produce 132 patients (77 males, 55 females; age=25±11 years) post-ACLR who were measured for knee flexion and extension at the end of therapy at every visit for 16 weeks following surgery.

MATERIALS AND METHODS: Information that was extracted from each chart was surgical procedure, date of surgery, date of physical therapy service, patient's knee extension and knee flexion ROM. All knee extension is measured passively with a negative value indicating hyperextension, and knee flexion is measured actively assisted with patient using a strap around the ankle while sitting up on a plinth. This study only reported data collected up to 16 weeks post-operatively. All ACLR were included regardless of surgery being primary, secondary or having associated meniscal or ligamentous involvement. The data was analyzed using two approaches. A linear mixed model for repeated measures was used to determine the difference in both knee flexion and extension over the first 16 weeks with significance set a $p \leq 0.05$. Second a General Additive Model for Location, Scale and Shape (GAMLSS) evaluated 6 potential models to determine the line of best fit for non-linear time series data and identified percentiles. Extension and flexion were modeled separately.

RESULTS: The linear mixed model ANOVA for both flexion and extension were significant ($p < 0.001$). Bonferroni post-hoc analysis was applied and found plateauing occurred at 3 weeks ($-2.11 \pm 3.3^\circ$) for knee extension and 7 weeks ($131 \pm 13^\circ$) for knee flexion. No further significant gains in either direction occurred. The GAMLSS t-distribution model for knee extension, due to positive and negative values at three weeks had median (10^{th} , 90^{th} percentile) of -2.5 ($0.9, -5.9^\circ$). The Box-Cox t distribution produced the best fit with a median of 134 ($113, 147^\circ$) at 7 weeks.

CONCLUSIONS: Our hypotheses were supported as motions plateaued at 3 weeks for knee extension and 7 weeks for knee flexion, earlier than estimated. The knee ROM median values from the GAMLSS models supported that critical milestones were being met by at least half of our patients.

CLINICAL RELEVANCE: This information provides clinicians a tool that details ROM recovery trajectories post ACLR and would further assist with clinical decision making, guide care, and attempt to mitigate the risk of failing to regain ROM after ACLR.

SP076

IMPACT OF MENISCUS REPAIR ON TIME TO MEET RUNNING CRITERIA IN ADOLESCENT ATHLETES AFTER ACL-R

Beth Ackerman, Nicole Brody Gomes Cronshaw

PURPOSE/HYPOTHESIS: Rehabilitation following isolated Anterior Cruciate Ligament Reconstruction (ACL-R) has historically been centered on time-based milestones, with most physician protocols allowing return to running (RTR) in the 12th post-operative week based on biological healing time frames alone. In considering meniscus repairs, due to variable weight-bearing precautions, range of motion (ROM) restrictions, and hamstring strengthening precautions, guidelines suggest delaying RTR for up to 16 weeks. Previous research at our institution has established that for adolescents with ACL-R +/- meniscus repair the time to meet defined, objective RTR criteria was 25.3 weeks post-operative. The primary objective of this study was to determine the difference in time to meet RTR criteria between isolated ACL-R and ACL-R + meniscus repair. We hypothesized that ACL-R + meniscus repair would take longer than isolated ACL-R to reach all RTR criteria.

NUMBER OF SUBJECTS: 278

MATERIALS AND METHODS: A retrospective review of subjects included in an ACL-R Research Database was conducted. All subjects were aged 13-19 years and had completed rehabilitation post-ACL-R. Data points extracted include demographics, concomitant procedures, quadriceps, and hamstring strength via hand-held dynamometer (HHD), and the time to meet RTR from the date of surgery. RTR criteria were defined as hamstring strength Limb Symmetry Index (LSI) $> 70\%$ with HHD, quadriceps

strength (LSI) $> 85\%$ with HHD, and ability to perform defined movement skills.

RESULTS: A total of 278 records were included for analysis; 176 subjects underwent isolated ACL-R, 102 underwent ACL-R + meniscus repair. There were slightly more females (56.5%) than males (43.5%) in our dataset. For isolated ACL-R, the median time to meet hamstring strength was 12.5 weeks. The median time to meet quadriceps strength criteria was 17.4 weeks. The time to meet all strength criteria and movement skills criteria was 25.2 weeks. For ACL-R+meniscus repair, the median time to meet hamstring strength was 12.7 weeks. The median time to meet quadriceps strength criteria to initiate running was 20.7 weeks. The time to meet all strength criteria and movement skills criteria was 26.5 weeks. For isolated ACL-R, only 24% met quadriceps LSI goals by postoperative week 12. For ACL-R+ meniscus repair, only 29%. Additional data analysis to be completed on the effects of age, race, gender, graft type, and concomitant surgical procedures, on the length of time to meet RTR.

CONCLUSIONS: Compared to isolated ACL-R, adolescents with ACL-R+Meniscus repair met HS strength criteria only 0.2 weeks slower, quadriceps strength criteria only 3.3 weeks slower, and all RTR criteria only 1.3 weeks slower.

CLINICAL RELEVANCE: Despite differences in weight-bearing status, ROM restrictions, and hamstring strengthening precautions, there is limited clinical difference in timing to meet strength and movement skills criteria for RTR between adolescents with ACL-R+ Meniscus repair and those with isolated ACL-R.

SP077

ALTERATIONS IN QUADRICEPS TORQUE STEADINESS AFTER ACL RECONSTRUCTION: WHICH METRICS PROVIDE UNIQUE INFORMATION?

David Alexander Sherman, Ava Schwartz, Samantha Hornsby, Grant Norte, Micah C. Garcia

PURPOSE/HYPOTHESIS: Poor quadriceps force control is a common impairment after anterior cruciate ligament reconstruction (ACLR), with torque unsteadiness thought to reflect altered patterns of motor unit behavior. There is a growing interest in measuring this construct clinically as dynamometers capable of torque-time curve analyses become more readily available. However, adoption is complicated by the variety of metrics that characterize torque steadiness (e.g., coefficient of variation [CoV], root mean square error [RMSE], normalized RMSE [nRMSE], yank, approximate entropy [ApEn], sample entropy [SampEn], adaptive fractal scaling [AFS], mean instantaneous frequency [MIF]), especially because little is known about how they are related. Our purpose was to apply recently developed open-source software ("TORQlab"), which standardizes torque steadiness parameter selection, to investigate which metrics of quadriceps torque steadiness provide unique information after ACLR.

NUMBER OF SUBJECTS: 20 individuals with ACLR and 20 controls

MATERIALS AND METHODS: We used a publicly available dataset containing 240 trials (three 5-second trials per participant per limb) of maximal isometric knee extension during a single laboratory session. We evaluated torque steadiness using TORQlab, considering eight metrics from a recent systematic review: CoV, RMSE, nRMSE, yank, ApEn, SampEn, AFS, and MIF. We assessed differences between groups (ACLR/control) and limbs (involved/uninvolved) with linear mixed effect models using participants as random factors. We applied Tukey's HSD *post hoc* to detect significant effects and report the range of Cohen's *d* effect sizes in group*limb comparisons for each metric. We further assessed the associations among metrics using principal component analysis and variable clustering.

RESULTS: The ACLR involved limb exhibited higher CoV ($F=5.13, p=0.017, d=0.23-0.64$), nRMSE ($F=9.11, p<0.001, d=0.33-0.61$), and yank ($F=12.31, p<0.001, d=0.13-0.30$), but lower AFS ($F=11.45, p<0.001, d=0.66-0.72$) compared to uninvolved and control limbs; ApEn, SampEn, MIF, and RMSE did not differ between groups or limbs. Two clusters

explained 78.9% of the variance between variables. Yank best represented the largest cluster (cluster $R^2=0.82$, yank $R^2=0.93$), which also contained ApEn ($R^2=0.90$), RMSE ($R^2=0.83$), SampEn ($R^2=0.72$), and MIF ($R^2=0.61$). nRMSE best represented the second largest cluster (cluster $R^2=0.75$, nRMSE $R^2=0.94$), which also contained CoV ($R^2=0.90$) and AFS ($R^2=0.42$).

CONCLUSIONS: Several metrics of torque steadiness identified small to moderate magnitude alterations in the ACLR involved limb. The most representative being yank (rate of change in torque over time) and nRMSE (relative error from the torque target). The 6 other metrics were highly correlated, thus providing redundant information. Those with ACLR demonstrate greater yank and nRMSE in the involved limbs compared to uninjured and control limbs.

CLINICAL RELEVANCE: Torque unsteadiness during maximum contractions is best characterized by yank and nRMSE, which were sensitive to detecting impairments after ACLR.

SP078

FORWARD, 90 TURN & 180 TURN SINGLE LIMB LOADING MECHANICS IN INDIVIDUALS FOLLOWING ACLR

Kristamarie Pratt, Stefanie Lyn Bourassa, Monica Padykula, Evan Bouchard

PURPOSE/HYPOTHESIS: Deficits in sagittal plane knee loading during dynamic tasks in individuals following ACL reconstruction (ACLR) are well known. Previous research has demonstrated that performance on a forward single limb loading (SLL) task is related to how an individual loads their knee during a more dynamic task like running suggesting that the task could be used as a precursor to running during rehabilitation. It is unknown how the addition of a turn may influence an individual's ability to load their limb and therefore the purpose of this study is to investigate the loading mechanics of forward, 90° turn, and 180° turn single limb loading in individuals following ACLR.

NUMBER OF SUBJECTS: 16 individuals following ACL Reconstructive surgery age: 18±2 yrs, 8.25±4 months post-op, 11 females and 5 males)

MATERIALS AND METHODS: Kinematics, kinetics and energetics were calculated using 3D motion capture cameras and inverse dynamics during a single limb loading task in 3 directions (forward, 90, 180); 3 trials. Peak knee flexion (kAng), sagittal peak knee power absorption (kPow), peak vertical ground reaction force (vGRF) and ankle inversion (aInv) and plantarflexion (aPF) were calculated during deceleration (contact to maximal knee flexion) for both the surgical (Sx) and non-surgical (NonSx) limbs in all three tasks. Multivariate ANOVA was used to differences between limb and tasks. Post-hoc repeated measures ANOVA and paired t-tests were performed when appropriate. Significance was set at 0.05.

RESULTS: There was no main effect for limb in vGRF. vGRF during 180 was greater than 90 turn ($p<0.0001$), and 90 vGRF was greater than forward ($p<0.001$). kAng and kPow were all statistically significantly different between tasks and limbs ($p<0.001$ to 0.004). The NonSx limb exhibited greater kAng and more kPow than the Sx limb in all tasks. aInv was greater in the Sx limb than Non-Sx limb ($p<0.05$). There was no difference in aPF between limbs ($p=0.524$) nor tasks ($p=0.738$).

CONCLUSIONS: Despite landing on their limbs with greater force in each task (forward<90<180), kPow decreased as the task involved more out of plane motion. These results may indicate that the 90 and 180 tasks may be more challenging to properly load their knee. Greater aInv and less kAng in the Sx limb suggests the individuals are moving alternate planes to compensate and balance.

CLINICAL RELEVANCE: The different mechanics during a forward, 90 and 180 single limb loading task suggest that these tasks may be used as exercises in a single limb loading progression during rehabilitation following ACLR. Further work is needed to determine how healthy individuals perform these tasks and what additional motions are observed at the joints to accurately inform clinical practice.

SP079

PSYCHOSOCIAL CONTRIBUTING FACTORS AFTER ACL RECONSTRUCTION

Debi Lynn Jones, Arjun Khorana, William Davis, Audrey Wimberly, Snehal Patel, Answorth A. Allen, Riley J. Williams

PURPOSE/HYPOTHESIS: Psychological impairment after anterior ligament (ACL) reconstruction has demonstrated a significant impact on return to sport in athletes. Quantifying these impairments, and addressing contributing physical and functional factors has proven difficult in the rehabilitation process. The ACL-Return to Sports After Injury (ACL-RSI) is a 12-item questionnaire developed to determine an athletes psychological readiness for return to sport. The purpose of this study is to identify factors which may relate to ACL-RSI score in a group of subjects at the point of potential return to sport after ACL reconstruction.

NUMBER OF SUBJECTS: 71 subjects (42 females, age 22.45 years ± 8.0) who underwent return to sport (RTS) testing between 9 months post ACLR (±1 month)

MATERIALS AND METHODS: Subjects underwent a battery of RTS tests, which included quadriceps strength testing, markerless motion capture and a series of self-report questionnaires, including the single alpha-numeric evaluation (SANE) score, international knee documentation committee subjective form (IKDC) and ACL-RSI. Quadriceps strength testing was performed with an isokinetic dynamometer or isometrically using a pull dynamometer. A limb symmetry index (LSI) was calculated (involved force/uninvolved force x 100%). Subjects were evaluated performing a double-leg squat and double-leg jump with the DARI Motion markerless motion capture system. Double-leg squat depth and single-leg squat depth LSI were calculated. Squat depth and jump height were calculated using displacement of the base of the spine during the movement. Prior to any physical testing, subjects were asked to complete the SANE, IKDC and ACL-RSI. Correlation coefficients were evaluated to determine associations between questionnaires, and between quadriceps strength LSI, squat depth and jump height.

RESULTS: Significant correlations were demonstrated between SANE and ACL-RSI scores ($r=.583$, $p<.01$), and IKDC and ACL-RSI scores ($r=.53$, $p<.01$). While quadriceps strength LSI demonstrated a significant correlation with ACL-RSI score ($r=.478$, $p<.01$), both squat depth and jump height were not significantly correlated ($p=.85$, $.37$ respectively).

CONCLUSIONS: Increased ACL-RSI scores were correlated with higher self-reported scores on the IKDC and SANE. Additionally, increased quadriceps strength LSI also indicated higher ACL-RSI score, however jump height and squat depth did not significantly correlate with the psychosocial measure.

CLINICAL RELEVANCE: Unsurprisingly, the various self-reported measures of IKDC, SANE and ACL-RSI score were significantly related in this small population. This may indicate an athlete's unmeasured understanding of functional ability or psychological readiness's effect on self-report of function. Jump height and squat depth – two measures of functional performance – were not significantly related to ACL-RSI. Quadriceps strength LSI demonstrated a relationship with the psychological readiness, which may be due to the more knee-centric nature of this specific strength measure. Further research is needed to determine the relationship between these measures and psychological readiness.

SP080

ACHIEVING EARLY QUADRICEPS MILESTONES IMPROVES PERFORMANCE AT TIME OF RTP IN ADOLESCENTS FOLLOWING ACL-R

Joseph Patrick Hannon, Hana Jane Bernhardson, Theresa Coverick, Andres Burbano, Jeffery Nepple

PURPOSE/HYPOTHESIS: To assess the impact of achieving early quadriceps symmetry on RTP performance in adolescent athletes following ACL-R.

NUMBER OF SUBJECTS: We assessed 113 adolescent athletes following ACL-R. Patients were divided into group based on their performance on their quadriceps limb symmetry index (LSI) during isokinetic testing (ISKT) at

4 months following surgery. Participants were divided into a "high" group (N: 34 age: 14.6±1.9; BMI: 22.5±2.93) and a "low" group (N: 79, age: 16.0±1.69; BMI: 24.36±5.54).

MATERIALS AND METHODS: Participants completed serial testing following their ACL-R at two time points; approximately 4.5 months (early) following surgery and again at approximately 6.5 months (RTP) following surgery. ISKT LSI scores at 4.5 months were used to place participants into groups based on their LSI during ISKT at 180°/sec. At the 6.5 month point participants completed RTP assessments which included Isokinetic Strength Testing (ISKT) at 60, 180 and 300 degrees/second and the single leg hop (SHOP), triple hop (THOP), and Cross-over hop (CHOP). For all measurements, LSI scores were calculated as (involved/uninvolved*100). An independent t-tests with Bonferroni correction were performed to assess for difference in performance at the time of RTP assessment. P value was set at <0.008.

RESULTS: Participants who achieved 80% LSI during ISKT at 4.5 months following ACL-R performed statistically significantly better across all ISKT speeds at time of RTP compared to those who did not: ISKT at 60 (Mdiff: 16.89±2.51, p<.001), ISKT at 180 (Mdiff: 16.45±2.31, p<.001), and ISKT at 300 (Mdiff: 10.31±2.28, p<.001). Similarly, those participants who achieved 80% LSI during ISKT at 4.5 months following ACL-R performed statistically significantly better during all hop tests: SHOP (Mdiff: 6.07±2.18, p<.001), THOP (Mdiff: 6.16±1.89, p<.002), and CHOP (Mdiff: 7.53±2.05, p<.001).

CONCLUSIONS: Participants who achieved early quadriceps symmetry significantly outperformed those who did not achieve early symmetry during RTP testing.

CLINICAL RELEVANCE: These findings highlight the importance of optimizing early phase rehabilitation. Additionally the results of this study continue to highlight the utility of early objective clinical measures in ACL-R rehab.

SP081

RETROSPECTIVE ANALYSIS OF STRENGTH AND DARI MOVEMENT ANALYSIS IN KNOWN ACL REINJURIES

Michelle Cilenti, Letty Krueger, Snehal Patel, Joseph Nguyen, Debi Lynn Jones

PURPOSE/HYPOTHESIS: Despite advancements in surgical techniques and rehabilitation, anterior cruciate ligament (ACL) reinjury after reconstruction continues to be a common occurrence, with the risk of reinjury as high as 20%. A robust battery of return to sport (RTS) tests may allow for identification of factors which would reduce reinjury risk. This study's purpose was to compare objective measures taken during RTS testing in patients who suffered an ACL reinjury versus those who did not.

NUMBER OF SUBJECTS: Twenty-four subjects (15 controls, 9 reinjury) undergoing RTS testing between 8- and 10-months post ACL reconstruction (controls: 6 males, age 14.9-20 years, mean 16.3 ± 1.29, reinjury: 2 males, age 14-18 years, mean 15.4 ± 1.24).

MATERIALS AND METHODS: Subjects were chosen from a pool of subjects undergoing RTS testing after primary ACL reconstruction. Reinjury was defined as anyone who sustained a tear to either contralateral or ipsilateral ACL after performing RTS testing identified via retrospective chart review. Controls were chosen based on sex, age and graft type. Quadriceps strength, hamstring strength and marker less motion capture were performed. Quadriceps strength was measured isometrically in sitting at 90 degrees knee flexion with fixated dynamometry. Hamstring strength was measured isometrically in prone at 20 degrees of knee flexion with dynamometer fixated to a gait belt around the tester's waist. Three trials were performed, and the average was taken. Single-leg squat depth was assessed using DARI Motion, which is an eight-camera marker less motion capture system which records at 60 frames/second. Squat depth was determined based on displacement of the base of the spine. Subjects were read a standard script for consistency of testing, including position of hands and contralateral leg, which was held in neutral hip extension and

knee flexed to 90 degrees. Limb symmetry index (LSI) was determined for all three variables (involved/uninvolved x 100%). Independent samples t-tests were run to determine significant differences in strength LSI and squat depth LSI.

RESULTS: The control group demonstrated increased LSI in single-leg squat depth (98% vs 86%, p=.035). There were no significant differences in strength LSI between the two groups in either quadriceps (p=0.882) or hamstring (p=0.983).

CONCLUSIONS: At the 9-month RTS assessment, both groups had no significant difference in isometric strength LSI, but the group that went on to have known ACL reinjury had significant reduction in single-leg squat depth compared to their non-involved side. This study suggests that despite similar strength metrics, the reinjury group demonstrated quantitative differences in movement patterns compared to the group without reinjury.

CLINICAL RELEVANCE: Strength outcomes continue to be the center of attention regarding ACL injury rehabilitation. Previously it has been very challenging to look at movement assessments objectively, but with improving technology, this is now more available than ever. This study shows the need to further investigate objective movement-based outcomes in combination with various strength metrics to improve our battery for RTS testing.

SP082

AGE AND SEX DIFFERENCES IN ACL-RSI SUBSCALE SCORES OF EMOTION, RISK-APPRAISAL, AND CONFIDENCE AFTER ACLR

Dylan P. Roman, Sophia Ulman, Lauren Schlacht Butler, Cody Walker, Taylor E. Douthitt, Christopher Kuenze, Shelby Baez

PURPOSE/HYPOTHESIS: The ACL Return to Sport after Injury scale (ACL-RSI) is widely used after anterior cruciate ligament reconstruction (ACLR), but its three subscale domains of emotion, risk appraisal, and confidence are rarely considered when assessing Return to Sport (RTS) readiness. The purpose of this study was to investigate differences in ACL-RSI subscale scores by age and sex. We hypothesized that males and adolescents would report higher scores on emotion, confidence, and risk-appraisal subscales compared to females and adults.

NUMBER OF SUBJECTS: 155 subjects (20.2 ± 3.9 years; 54.2% female; 8.7 ± 2.1 months post-ACLR).

MATERIALS AND METHODS: ACL-RSI data were obtained from a multi-site clinical outcomes registry. Subjects were included if they were between 6-12 months after primary, unilateral ACLR, and between the ages of 14-30 years. Sex subgroups (female, male) and age subgroups (adolescent 14-18 years, adult 19-30 years) were established and compared to identify potential sex- and age-related differences in the ACL-RSI (total, subscales, and item scores). Descriptive statistics were computed for all variables, and independent samples t-tests were performed to determine significant group differences. Significance was set to p<0.05.

RESULTS: The total ACL-RSI score across the cohort averaged 71.76 ± 22.49, and the Emotions, Confidence, and Risk Appraisal subscales averaged 62.76 ± 28.21, 72.74 ± 26.04, and 67.39 ± 28.31, respectively. No significant differences were found between male (N = 71, 36.6% adolescent) and female (N = 84, 52.4% adolescent) subjects in the ACL-RSI total, subscale, or individual item scores. The adolescent group exhibited higher overall readiness (i.e., total score) compared to the adult group (mean difference: 9.6 points, p<0.001). Significant differences were found in all Confidence individual items and subscale as the adolescent group reported a 12.8 point higher average score compared to the adult group (p=0.001). The item analysis also identified that adolescents reported feeling more relaxed about playing their sport compared to the adult group (mean difference: 13.02 points, p=0.006), which contributed to the Emotions subscale.

CONCLUSIONS: Adolescents demonstrated significantly higher confidence in performance compared to adults. When assessing an adolescent athlete's psychological preparedness to RTS, target scores determined from

adult data may not be appropriate. Future work should strive to create age- and sex-specific ACL-RSI cutoff scores for successful RTS after ACLR in adolescent athletes.

CLINICAL RELEVANCE: Adolescent athletes should be prepared in all psychological domains before RTS after ACLR, but current guidelines for ACL-RSI scores are derived from adult-only studies. This study presents age- and sex-specific data on psychological readiness, providing context to guide the RTS decision making process with adolescent patients. By utilizing subscale scores from the ACL-RSI, clinicians can identify specific domains lacking psychological preparedness and provide tailored interventions.

SP083

PERSISTENT IMPAIRMENTS IN MOTOR UNIT RECRUITMENT STRATEGY OF THE QUADRICEPS AFTER ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

Amit Gohil, Brian W. Noehren

PURPOSE/HYPOTHESIS: Despite efforts to restore quadriceps strength after anterior cruciate ligament reconstruction (ACLR), quadriceps dysfunction persists for years after surgery. It remains unclear if quadriceps dysfunction is perpetuated by negative changes in motor unit activity, such as decreased firing rate of the motor unit pool. Analysis of high-density surface electromyography (HDsEMG) provides an understanding of how motor unit activity changes after ACLR via motor unit firing rate (MUFR) and recruitment threshold (RT). The slope and intercept of the MUFR-RT relationship explains the interaction between high and low threshold motor units, as well as overall excitability of the motor unit pool, respectively. HDsEMG also provides opportunity to grade severity of neuromuscular impairment by assessing MUFR-RT at varying contraction intensities. Thus, the purpose of the study was to evaluate quadriceps MUFR-RT between the ACL limb and noninvolved limb with submaximal and maximal intensity contractions.

NUMBER OF SUBJECTS: 11 participants (6F, 19.3 ± 5.4 yrs, 7.2 ± 1.0 months post ACLR)

MATERIALS AND METHODS: Participants performed isometric knee extension on an isokinetic dynamometer. To evaluate severity of MUFR-RT changes, trials at 30, 50, 70, and 100% of maximum voluntary isometric contraction (MVIC) were used. A trapezoidal pattern was used with a ramp up and down of 10% MVIC/s for submaximal and 20% MVIC/s for maximal trials. Two force-matched trials were performed on the non-involved limb at 30% and 50% MVIC of the ACL-involved limb. The HDsEMG was placed on the vastus lateralis and EMG decomposition was performed using the Precision Decomposition III algorithm. Linear regressions were fitted for MUFR (pps) and RT (Nm) for each trial and the slope and intercept was used to characterize the motor unit pool. A Wilcoxon Signed rank test performed to compare the regression slope and intercept of the involved (INV) and noninvolved (NON) limb for each contraction intensity.

RESULTS: Significantly steeper slopes were found for MUFR-RT on the INV limb at 50% (INV: -0.30 pps/Nm, NON: -0.18 pps/Nm, $p < .01$), 70% (INV: -0.27 pps/Nm, NON: -0.14 pps/Nm, $p < .01$), and 100% (INV: -0.22 pps/Nm, NON: -0.07 pps/Nm, $p < .01$) MVIC and force matched level of 50% (INV: -0.30 pps/Nm, NON: -0.17 pps/Nm, $p = .011$). No differences were found for 30% trials or intercepts across all trials.

CONCLUSIONS: A steeper MUFR-RT slope on the ACL-limb indicates an inability to either access or upregulate the firing rate of high threshold motor units, leading to decreased quadriceps peak torque. Concerningly, negative changes in MUFR-RT slope occurred as low as 50% MVIC, highlighting the severity of the neuromuscular dysfunction 6-9 months after ACLR. As these changes were consistent with a force matched trial at 50% MVIC, we conclude that these changes are not due to differences in strength between limbs.

CLINICAL RELEVANCE: Impairments in quadriceps function are evident at intensities as low as 50% MVIC which may limit the effectiveness of

resistance training interventions. Future work should seek to identify novel interventions that improve motor unit activity of high threshold motor units early after ACLR.

SP084

EPIDEMIOLOGY OF NECK INJURY IN SPECIAL FORCES COMBAT SOLDIERS AND THE EFFECT OF HEAD-SUPPORTED MASS

Timothy Sell, Ryan Zerega, Ret Taylor, Dale Bass, McFadden Devin, Muench Peter, Gary Means

PURPOSE/HYPOTHESIS: Special Forces Combat Soldiers (SFCS) are susceptible to cervical spine injuries as they perform missions that include parachute opening events and ground-based activities in demanding environments with head-supported mass (HSM). This HSM, which includes the baseline protective helmet, communications, specialized night vision technology, and other attachments, can weigh more than 3 kg. Consequently, SFCS are at risk for both chronic and acute injury to the c-spine. This study aimed to describe the injury epidemiology of c-spine injuries in SFCS with HSM exposure.

NUMBER OF SUBJECTS: A total of 182 male participants from a special forces unit voluntarily participated in the study. All participants were on active duty without restrictions.

MATERIALS AND METHODS: All participants provided a self-report of their cervical spine injury history that included a description of the tissue/pathology, cause of injury, result of injury, medical care sought, and information regarding the HSM relative to the injury. Participants were asked questions about their military experience, the number of parachute jumps, and head-supported mass exposure. All participants also completed a cervical spine pain questionnaire (previous 12 months) and the Neck Disability Index survey (NDI).

RESULTS: The 182 participants averaged 16.9 ± 4.5 years of active service, 8.1 ± 4.6 years of experience at their current unit, 17.0 ± 4.6 HSM exposure, 10.3 ± 5.3 deployments, and 264.3 ± 235.0 military free fall jumps. A total of 657 cervical spine injuries were reported, with strain/sprain (72.1%) being the most common injury type. Most injuries occurred during tactical training (48.7%) with parachute opening reported to be the most common cause (29.5%). 31% of these injuries resulted in time lost or restricted duties, 56% resulted in a medical professional visit, and 59% resulted in treatment. 92% occurred during military activities, and 90% occurred while the individual wore HSM. During the previous 12 months, 89.5% of the Soldiers reported neck pain/strain during military operational activity, with 92.5% reporting pain associated with HSM during military activities. Parachute opening shock was the most common maneuver or activity during which pain occurred. NDI surveys revealed that SFCS had issues related to pain, headaches, concentration, and sleeping.

CONCLUSIONS: The results of this study indicate that cervical spine injuries due to HSM are frequent and significantly impact SFCS. These injuries result in loss of duty time, restriction of duties, chronic pain, and issues with sleep and concentration. Many of these injuries occur during common tactical activities such as military free fall and other acceleration/deceleration events. Some caution in interpreting these results is necessary since most of the data is based on recall.

CLINICAL RELEVANCE: The results of this study demonstrate the need to explore in more detail the causes of cervical spine injuries and to determine potential interventions to reduce injury due to HSM, including physical interventions, equipment considerations, and policy recommendations.

SP085

IS PRESEASON FITNESS TESTING FOR SOFTBALL PLAYERS WORTH IT, OR JUST ASK THE COACH?

Ashraf Elazzazi, David Schilling, Tim Abraham

PURPOSE/HYPOTHESIS: The starting lineup for the season is contingent on the coach's preseason evaluation of players. This study aims to determine if

a coach's subjective preseason evaluation of players' offensive performance is associated with a battery of fitness tests for collegiate DIII softball (SB) players and whether either can predict in-season performance.

NUMBER OF SUBJECTS: Twenty-two SB players participated in this study.

MATERIALS AND METHODS: Division III collegiate SB players performed the following preseason fitness tests: grip strength (GS), countermovement vertical jump with arm swing (CVJ), medial to lateral jump (MLJ), medicine ball rotational throw (MBRT), agility T-test (AT), square upper body reactive agility test (SUBRAT), 60-yard dash, closed kinetic chain upper extremity stability test (CKQUEST) and batted ball velocity (BBV). The head coach, blinded to all preseason fitness testing results, subjectively rated the players' batting (power, ball contact, and form) and running performance (speed, agility, and form). The coach's combined batting and running scores represent the total offensive performance score (TOPS). The in-season performance was identified by the number of at-bats for each player. Bivariate correlation coefficients and linear regression analysis were used.

RESULTS: The number of at-bats was significantly higher for freshmen and sophomores than for juniors and seniors (74 and 45.3, respectively, $p=.05$). There was no significant correlation between the number of at-bats and any of the preseason fitness tests. However, the TOPS was significantly correlated with the following fitness tests: GS ($r = -0.549$, $p=0.008$), MBRT ($r = -0.477$, $p=0.025$), SUBRAT ($r = 0.446$, $p=0.038$), AT ($r = -0.587$, $p=0.004$). Linear regression indicated that the TOPS was the most important significant predictor of the number of at-bats ($r^2=0.258$, adjusted $r^2=0.221$, $p<0.001$).

CONCLUSIONS: The fitness tests performed did not correlate with the in-season offensive performance of the SB players in this study. The TOPS correlated with 4 of the 8 preseason fitness tests performed and was the most significant predictor of in-season offensive performance.

CLINICAL RELEVANCE: The coach's preseason evaluation of players predicts the in-season offensive performance of Division III SB players. The time-consuming nature of preseason fitness testing, combined with the lack of predictive ability, may limit their utility.

SP086

SLEEP PATTERNS DIFFER ACROSS TRAINING DAYS IN MALE AND FEMALE ADOLESCENT ATHLETES

Abigail Larson, Jena Heck Street, Roman W. de Guia, Jacob J. Capin

PURPOSE/HYPOTHESIS: Sleep is an integral part of human health and well-being. The American Academy of Sleep Medicine recommends that adolescents get 8–10 hours of sleep per day. Suboptimal sleep puts athletes at greater risk for injury, lengthens their recovery time, and decreases their performance. Adolescent athletes may sacrifice sleep as they balance athletic competition/practice and other commitments such as school, work, and social priorities. Our purpose was to compare sleep patterns in adolescent athletes across training days (i.e., competition, practice, and rest).

NUMBER OF SUBJECTS: 32

MATERIALS AND METHODS: Adolescent athletes (age 13–18) wore an activPAL accelerometer continuously for 14 consecutive days. Sleep was measured using activPAL software analysis of posture and movement to quantify sleep durations, bedtimes, and wake times. Athletes completed a sleep log noting training day status (i.e., competition, practice, or rest). Repeated measures ANOVAs ($\alpha = 0.05$) were conducted to compare sleep outcomes (i.e., sleep duration, time in bed, time out of bed, midpoint, and variability for all measures) across training days using sex as a fixed factor. Post-hoc t-tests were conducted using the least significant difference method.

RESULTS: Athletes (age 15.5 ± 1.0 years; 18 female, 14 male) averaged over 8 hours of sleep per night across training days (rest: 9.26 ± 1.39 hr; competition: 8.34 ± 2.06 hr; practice: 8.66 ± 0.94 hr, $p=0.091$). Regardless of sex, athletes went to bed later the night before a rest day ($23:06 \pm 0:52$ hh:mm) compared to a competition ($21:47 \pm 1:30$ hh:mm) or practice ($22:11 \pm 0:47$

hh:mm) day ($p<0.001$). There was a main effect of training day ($p<0.001$) for time out of bed ($8:22 \pm 1:23$, $6:07 \pm 1:22$, $6:50 \pm 0:39$ h:mm): athletes woke up later on rest days compared to competition and practice days (all post-hoc $p<0.01$). Athletes have greater sleep duration variability on rest days compared to competition days (2.12 ± 1.07 hr vs. 1.46 ± 1.26 hr, $p=0.04$). There was a main effect of training day ($p<0.001$) for midpoint variability ($1:22 \pm 0:41$, $0:35 \pm 0:32$, $0:53 \pm 0:31$ h:mm): athletes had more midpoint variability of going to bed and waking up on rest days compared to competition and practice days (all post-hoc $p<0.02$). Secondary analyses showed that athletes slept longer, went to bed later, and woke up later on weekend days compared to weekdays.

CONCLUSIONS: While adolescent athletes sleep >8 hours, their sleep patterns differed across training days and week versus weekend day. Athletes went to bed later and woke up later on rest days compared to practice and competition days. Athletes also had a higher midpoint variability across training days and sleep duration variability on rest days indicating that athletes' sleep patterns are shifting throughout the week depending on training day.

CLINICAL RELEVANCE: Our findings may inform clinicians about sleep patterns in adolescent athletes that may impact an athlete's performance, recovery, and injury risk.

SP087

PHYSICAL THERAPISTS' PERCEPTIONS OF SOCIAL DETERMINANTS OF HEALTH WHEN WORKING WITH ATHLETIC POPULATIONS

Cheyenne Koki, Cory Cory Manton, Jeffrey J.D. Andrión, Kelsey Picha

PURPOSE/HYPOTHESIS: While addressing the social determinants of health (SDH) is important in patient management in the health professions, little is known about physical therapists' perceptions of SDH when working with the athletic population. Physical therapists are positioned in health-care with an opportunity to learn about the lives of their patients through regular interactions. However, there is limited research on physical therapists' perceptions of SDH in practice. The athletic population is an understudied population when it comes to SDH, yet these patients are still impacted by SDH. Therefore, the purpose of this study was to explore physical therapists' perceptions of SDH when managing athletic populations.

NUMBER OF SUBJECTS: One hundred and sixty-two physical therapists (44.1 ± 13.4 years of age; 17.9 ± 12.8 years of experience) completed at least one question and 126 completed the survey (completion rate = 77.7%).

MATERIALS AND METHODS: This cross-sectional study was part of a larger study that used an online survey administered via Qualtrics (Qualtrics, Inc., Provo, UT, USA). The survey consisted of 23 questions validated by content experts and pilot tested to ensure clarity and relevance. Items included perceptions of SDH in clinical practice. Participants were recruited from the American Academy of Sports Physical Therapy and social media platforms. An email was also sent to the directors of sports physical therapy residency programs requesting them to share it with their residents.

RESULTS: Of the 162 participants, more than half reported either agreeing or strongly agreeing that physical therapists can address SDH in the athletic population ($n=93/162$, 57.4%). Additionally, the majority agreed that assessing SDH was part of their clinical practice ($n=109/162$, 67.2%). Interestingly, 70.3% ($n=114/162$) agree that SDH plays a role in their clinical decision making and 77.7% ($n=126/162$) agree SDH plays a role in rehabilitation adherence in the athletic population. Lastly, over half reported that SDH had influence on return to sport decisions ($n=90/162$, 55.5%).

CONCLUSIONS: A majority of physical therapists responding to the survey reportedly recognize SDH in their practice and the role it plays in the health and well-being of the athletic population. This suggests physical therapists recognize they have a role to address SDH with their patients. Additionally, physical therapists recognize that SDH can influence clinical decision making, rehabilitation adherence and return to sport decisions.

This suggests that physical therapists think holistically and in a broader context of a patient's life when making decisions. Overall, findings demonstrate that physical therapists recognize the importance of SDH when working with the athletic population.

CLINICAL RELEVANCE: These findings indicate a necessity for physical therapists to consider going beyond recognition to understanding and addressing SDH to enhance clinical outcomes in the athletic population. This gap underscores a need for training and resources to support physical therapists in integrating SDH into their practice.

SP088

MUSCULOSKELETAL CHARACTERISTICS AMONG PRACTITIONERS OF THE BHARATANATYAM DANCE

Danielle S. Essex, Kaleigh Iris Jenkins, Virginia Royal Shafer, Kelly O'Daniel, John Ryan Magill, Srikant Vallabhajosula

PURPOSE/HYPOTHESIS: Bharatanatyam is a classical Indian dance with high impact movements. Knowledge of musculoskeletal characteristics of Bharatanatyam dancers (BD) and how they compare to those of athletes from dynamic sports such as soccer can guide physical therapists in appropriate rehabilitation needs and injury prevention for BD. The purpose of our study was to compare musculoskeletal characteristics in BD and soccer players (SP).

NUMBER OF SUBJECTS: 12 female BD (mean age: 25 ±16.9 years)

MATERIALS AND METHODS: For BD, lower extremity range of motion (ROM) data were collected using goniometry and strength data were collected using handheld dynamometry. Corresponding ROM data from 418 female SP (12-17 years old) and strength data from 30 female SP (18-26 years old) were extracted from recently published literature. Strength data were normalized to body weight and reported in N/kg. A one-samples t-test was used to compare ROM and strength on dominant side (self-reported) of BD and SP.

RESULTS: ROM (°): BD (17.9±11.3) had significantly less hip extension ROM than SP (20.2±2.3; $p < 0.001$). BD (115.3±10.3) had significantly more hip flexion ROM than SP (109.8±4; $p < 0.001$). BD (30.3±6.2) had significantly more hip external rotation ROM than SP (20.2±2.3; $p < 0.001$). BD (34.1±6.9) had significantly more hip internal rotation ROM than SP (22.8±2.9; $p < 0.001$). BD (143.2±8.4) had significantly more knee flexion ROM than SP (123±2.9; $p < 0.001$). BD (-1.4±3.4) had no significant difference found in knee extension compared to SP (-0.2±1.3; $p = 0.176$). Strength (N/kg): BD (1.3±0.4) had significantly less hip abduction strength than SP (1.6±0.1; $p < 0.001$). BD (1.3±0.3) had significantly less hip adduction strength than SP (1.6±0.1; $p < 0.001$). BD (2.0±1.3) had significantly less hip extension strength than SP (2.5±0.1; $p < 0.001$). BD (1.9±0.8) had significantly less hip flexion strength than SP (3.3±0.1; $p < 0.001$). BD (2.1±1) had significantly less knee extension strength than SP (4.4±0.1; $p < 0.001$).

CONCLUSIONS: BD demonstrated increased lower extremity ROM with hip flexion, external and internal rotation, and knee flexion than SP. This may be due to the focus on flexibility and stretching as seen amongst many dance styles. BD also demonstrated decreased hip extension, which may be due to the increased hip extension required for kicking during soccer. BD demonstrated less lower extremity strength, possibly due to the heavy focus on strength training in soccer.

CLINICAL RELEVANCE: Recent literature suggests that dancers, like soccer players, experience high incidence of lower extremity injuries due to high-impact movements. Soccer is a popular sport and has been well studied in various populations. Soccer requires a lot of lower extremity strength and ROM, like Bharatanatyam, to complete the high impact movements. This study lays the foundation for understanding the musculoskeletal characteristics of BD for physical therapists as this dance form gains popularity in the United States. Knowledge of musculoskeletal characteristics of BD can help teachers and physical therapists educate dancers about injury prevention and rehabilitation.

SP089

SPORT-LIMITING INJURY IMPACTS PHYSICAL ACTIVITY AND SEDENTARY BEHAVIOR IN ADOLESCENT ATHLETES: AN EXPLORATORY ANALYSIS

Roman W. de Guia, Jena Heck Street, Abigail Larson, Jacob J. Capin

PURPOSE/HYPOTHESIS: While often meeting exercise guidelines, elite male athletes also may be highly sedentary. Athletes after sports injuries like anterior cruciate ligament ruptures exhibit greater sedentary behavior (SB) and less regular physical activity (PA) (i.e., fewer daily step counts and less moderate-to-vigorous PA). Little is known about how sport-limiting injury and training days (i.e., competition, practice, and rest days) impact PA and SB in adolescent athletes, especially females. Better understanding these PA and SB patterns could inform rehabilitation practice and promote athlete wellness long-term. Our purpose was to compare PA and SB in adolescent athletes with and without a self-reported injury limiting their ability to participate in sports or recreational activities.

NUMBER OF SUBJECTS: 38

MATERIALS AND METHODS: High school varsity basketball and club volleyball players (age 13-18 years) wore an ActivPAL accelerometer continuously for 14 consecutive days while in season. All athletes were cleared to participate fully in sports. Participants recorded the type of training day (i.e., competition, practice, and rest days) and responded to surveys, including: "Does a sports-related injury currently limit your ability to perform sport or recreational activities?" (Yes/No). Independent Samples t-Tests compared outcomes of interest (step count, metabolic equivalents [METs], total SB, prolonged [$>1hr$] SB); alpha was set at $p < 0.05$.

RESULTS: Thirty-eight adolescent athletes (age 15.6±0.9 years, 24 females and 14 males) participated. On competition days, athletes who were limited by an injury exhibited greater total SB (829±139 vs. 709±127 minutes, $p = 0.033$) and lower activity levels (34.9±1.4 vs. 35.9±0.9 METs, $p = 0.018$) compared to those without injury. On rest days, the injured group recorded higher step counts (8,230±3,113 vs. 6,136±2,685 steps, $p = 0.046$), higher activity levels (33.7±1.4 vs. 32.7±1.1 METs, $p = 0.043$), and less prolonged bouts of SB (79.4±47.4 vs. 157.6±118.7 minutes, $p = 0.007$) than the uninjured group. No significant differences in the variables of interest (step count, metabolic equivalents [METs], total SB, prolonged [$>1hr$] SB) were present between the groups for overall and practice days.

CONCLUSIONS: Among adolescent athletes who were fully cleared to participate in sports, those who reported being limited by injury were less active (i.e., greater total SB and lower METs) on competition days and more active (i.e., higher step counts, greater METs, and less prolonged bouts of SB) on rest days compared to their uninjured counterparts. Possible explanations include less playing time during competition, greater SB to prepare for or recover from competition, or greater involvement in other activities outside of sport due to their injury impacting sport participation. Further research is needed to investigate the reason(s) for the differences found.

CLINICAL RELEVANCE: Our findings may inform how clinicians educate athletes, parents, and coaches on the impact of injury on PA and SB in adolescents, which may benefit the rehabilitation process.

SP090

THE PREVALENCE OF URINARY INCONTINENCE IN NCAA DIVISION III FEMALE COLLEGIATE ATHLETES

Emma Watson, Lana L. Prokop, Arianna Larson, Betsy Walts, Shannon M. Kelly, Emma Meyer, Emma McAfee, Whitney Wenner

PURPOSE/HYPOTHESIS: Urinary Incontinence (UI) is defined as "the involuntary loss of urine" and has prevalence rates of up to 49.6% in a general population of women. Little research exists about the prevalence of UI in an athletic population, especially at the collegiate level. In prior studies, the average prevalence of UI in female athletes was found to be 33.7% vs 24.4% in non-athletic female counterparts. Other studies have found prevalence rates of 26-36% in female athletes.

The purpose of the study was two fold: 1) Identify the prevalence and frequency of UI in female collegiate athletes competing at a NCAA DIII university, and 2) assess if the prevalence of UI differs between athletes of different sports. The researchers hypothesized that 1) over 33% of participants would experience UI and of those who have UI, they will leak one or more times per week, and 2) athletes participating in high impact sports (running, volleyball, soccer) will have a higher prevalence of UI than athletes who participate in lower impact sports (golf, swimming, softball).

NUMBER OF SUBJECTS: 159 student-athletes from 11 women's sports at a NCAA Division III Midwestern University were invited to participate.

MATERIALS AND METHODS: An analytical, cross-sectional, observational questionnaire was used to assess the prevalence and frequency of UI, based on the modified ICIQ-UI-SF and Sandvik Severity Index outcome measures. The voluntary electronic questionnaire was emailed to participants' school email addresses and anonymously completed. The questionnaire was 24-52 questions long based on adaptive questioning and assessed UI in daily life and sport participation.

Prevalence was calculated in Excel spreadsheets. Chi-square analyses were completed using Number Cruncher Statistical Software to assess differences between high, moderate, and low impact groups. An alpha level of 0.05 was used for all statistical tests.

RESULTS: The overall response rate was 80.2% (128 respondents). The prevalence of UI in daily life was 59.4%, with 42.9% experiencing UI during sport. Of those who experienced UI, 18% reported experiencing UI less than once per month, 19.5% one to several times per month, and 10.2% weekly or daily. There was no statistically significant difference in the prevalence of UI between impact groups ($p=0.339$).

CONCLUSIONS: The prevalence of UI experienced in sport in DIII collegiate females was higher than hypothesized (42.9%). The frequency of UI episodes was lesser than anticipated. Contrary to our hypothesis and previous studies, there was no difference in UI prevalence between high, moderate, and low impact sports.

CLINICAL RELEVANCE: UI in athletes has been linked to lower quality of life and affects sport performance. Half of women stop or modify exercise due to their UI symptoms, which negatively impacts their physical and mental well-being. Given the high prevalence of UI in female athletes, advocacy is needed for screening this population early in adolescence and throughout their sport, with referral to the appropriate providers. Sport and orthopedic physical therapists and physical therapy assistants are well-positioned to screen for UI and assist these athletes.

SP091

CONCENTRIC AND ECCENTRIC ISOKINETIC HAMSTRING INJURY RISK AMONG 582 PROFESSIONAL SOCCER PLAYERS A 10-YEARS STUDY.

Ricardo Burigo, Robson Scoz, Cesar Ferreira Amorim

PURPOSE/HYPOTHESIS: Different authors have tried to correlate the peak isokinetic torque values with the incidence of soccer match injuries. However, due to the wide variety of assessment testing protocols, such an inference becomes difficult. This study aimed to verify the capacity of an isokinetic test to establish injury risk reference values for hamstring strain injuries.

NUMBER OF SUBJECTS: 582 Brazilian elite-professional soccer players.

MATERIALS AND METHODS: A retrospective cohort study based on isokinetic data and clinical records from the last 10 years was conducted in 582 Brazilian elite-professional soccer players, who were subjected to the same isokinetic test protocol, machine, and tester. A Multivariate Logistic Regression Analysis for Complex Data Sampling was used to generate injury risk statistical indexes.

RESULTS: Multivariate regression analysis of both legs provided important data to identify the cut-off values of Concentric Peak Torque (181.82 Newton/*metres), Concentric Work (236.23 watts) and Concentric Power (130.11 joules).

CONCLUSIONS: The injury risk indexes indicate that an increase of just one Newton unit in CPT (Concentric Peak Torque) and CJ (Concentric Power)

above those cut-off values, can reduce the risk of future injuries by 2% and 2.7%, respectively.

CLINICAL RELEVANCE: Cutoff values of Concentric Peak Torque, Work and Power that could guide clinical practice decisionmaking.

SP092

FEASIBILITY OF AN INJURY PREVENTION PROGRAM DELIVERED REMOTELY TO YOUTH SOCCER PLAYERS

Thomas Joseph Bellama, Sean P. Riley

PURPOSE/HYPOTHESIS: Adolescents injured playing soccer in the Northern Mariana Islands have limited healthcare resources. Injury prevention programs (IPPs) might decrease the need for healthcare resources, but staff necessary to deliver those programs are limited. This study aimed to determine the feasibility of an IPP delivered remotely by tracking compliance. Secondly, it aimed to assess IPP impact on biomechanics associated with injuries.

NUMBER OF SUBJECTS: 35 male and female participants aged 12 to 18 were recruited.

MATERIALS AND METHODS: Players participated in a tuck jump assessment then were provided two evidence-based IPPs per week for eight weeks. Links to videos were emailed, and clicks were tracked to determine compliance. If a predetermined compliance threshold of 33% was reached, the program would continue, the tuck jump assessment repeated, and biomechanics assessed.

RESULTS: 35 participants were recruited and provided IPPs. At eight weeks, the compliance rate was 1.61% so the study was terminated.

CONCLUSIONS: Remote delivery of video IPPs via email to adolescent players in the Northern Mariana Islands with weekly reminders did not reach the level of compliance necessary to impact the risk of injury. Future studies should consider alternative delivery methods, utilize additional accountability methods, and create local accountability to maximize compliance to examine the impact on the risk of injury.

CLINICAL RELEVANCE: Injury prevention programs are effective at reducing the risk of injury in youth soccer players, but this study did not provide evidence that the programs can be given remotely. Coaches and healthcare providers should continue to administer injury prevention programs to their players and teams until further research established the feasibility in remotely delivered injury prevention programs.

SP093

UTILIZING TOTAL BODY VERSUS SITE-SPECIFIC DXA SCANS FOR BONE STRESS INJURY SCREENING IN COLLEGIATE RUNNERS

Gavin Scott Harden, Mikel Joachim, Bryan C. Heiderscheid

PURPOSE/HYPOTHESIS: Poor bone health, as measured by dual x-ray absorptiometry (DXA), has been identified as a risk factor for bone stress injury (BSI) in collegiate distance runners. However, there are several metrics that can be obtained from a DXA scan to quantify bone health and there is no consensus regarding which measure of bone mineral density (BMD) best identifies runners at risk for BSI. The purpose of this study was to investigate whether total body BMD z-score or site-specific BMD values resulted in a better model for predicting BSI risk. It was hypothesized that utilizing site-specific BMD values would result in an improved model compared to total body BMD z-score.

NUMBER OF SUBJECTS: 55 NCAA DI cross-country runners (N = 25 males, age = 20.1 ± 1.6 years, BMI: 20.3 ± 1.3 kg/m²).

MATERIALS AND METHODS: Runners underwent a running gait assessment at their preferred speed, had a total body, and a bilateral proximal femur DXA scan prior to the start of each year. Center of mass vertical displacement (vCOM) during running was calculated, total BMD z-score was extracted from the total body scan, and femoral neck BMD for each limb and total hip BMD were extracted from the dual femur scans. Runners were followed for 12 months for BSI occurrence diagnosed by a medical professional. Data from 3 years were included. Separate linear mixed effects models

were performed, each including vCOM and 1 of the 3 BMD measures. Each model accounted for sex, running speed, BSI history, and limb, as appropriate. Model performance was assessed via quasi-likelihood (QICu) values, with lower QICu indicating a better fitting model. Odds ratios (OR) with 95% confidence intervals are reported for BMD measures.

RESULTS: A total of 93 pre-season assessments were included, with 10 BSI (metatarsal (3), sacrum (3), femoral neck (1), femoral shaft (1), fibula (1), tibia (1)). The model including total body BMD z-score (OR = 1.15 [0.97, 1.36], QICu: 67.4) demonstrated the best performance. The total hip BMD model performed similarly to the total body BMD z-score model (OR = 1.03 [0.99, 1.07], QICu 67.7). The worst performing model included femoral neck BMD (OR = 1.03 [1.00, 1.07], QICu 80.8).

CONCLUSIONS: Total body BMD z-scores and total hip absolute BMD values similarly identified collegiate runners at risk of BSI compared to region-specific total hip BMD values. The addition of DXA scans on more precise regions of interest, such as femoral neck, did not appear to yield any additional predictive value.

CLINICAL RELEVANCE: As total body and total hip BMD had similar value in identifying runners at risk for BSI, choosing the scan that is most easily incorporated into a pre-season screening protocol is recommended and should be used in conjunction with BSI history and RED-S risk assessment. Comparison of these findings to the spine DXA scan, which is also commonly performed, is warranted. Utilizing more precise BMD measures, such as femoral neck BMD, may still hold value for identifying bone-specific injury risk rather than identifying athletes with an elevated overall BSI risk.

SP094

THE ASSOCIATION BETWEEN PAIN SENSITIVITY, FEAR AVOIDANCE, AND PAIN CATASTROPHIZING IN RUNNERS

Shawn Farrokhi, Emma Beisheim-Ryan, Natalia Sanchez, Samantha Jeffcoat, Nina Ferreira, Susan M. Sigward, Jo R. Armour Smith

PURPOSE/HYPOTHESIS: Fear-avoidance beliefs and pain catastrophizing are thought to contribute to the development and persistence of heightened pain sensitivity. Fear-avoidance beliefs are the extent to which an individual fears pain and reinjury and believes that they should avoid physical activity and work while in pain. Pain catastrophizing is a negative thought pattern where the individual anticipates the worst possible outcome for their pain. Although musculoskeletal pain is common among runners, it is not known if fear-avoidance beliefs and pain catastrophizing contribute to runners' pain sensitivity and impact their running participation.

NUMBER OF SUBJECTS: 207 runners between 18 and 76 years of age.

MATERIALS AND METHODS: Runners who participated in a consistent running program (1-3 times a week for at least 3 months) were invited to complete a web-based survey. The Oslo Sports Trauma Research Center Overuse Injury Questionnaire (OSTRC-O) was used to assess the magnitude, symptoms, and consequences of overuse injuries over the past week. Based on OSTRC-O scores, participants were categorized into those with full participation without injury (non-injured) and those with overuse injuries and/or limited participation (injured). Participants also completed the Pain Sensitivity Questionnaire (PSQ), Pain Catastrophizing Scale (PCS), and Fear-Avoidance Beliefs Questionnaire (FABQ). Differences between the injured and non-injured groups were assessed using t-tests. Multivariate regression was used to determine the contribution of fear avoidance (FABQ), pain catastrophizing (PCS), and demographics to pain sensitivity (PSQ).

RESULTS: Age, sex, height, and weight did not differ between the injured and non-injured groups ($P > .05$). However, the injured group had a significantly higher PSQ total score (4.9 ± 1.8 vs. 3.7 ± 1.8), PCS total score (16.8 ± 12.5 vs. 9.4 ± 11.5), and FABQ total score (32.5 ± 19.4 vs. 17.7 ± 15.0) compared to the non-injured group ($P < .001$). Additionally, significantly higher scores were observed in the injured group for all subscale scores [sensitivity to minor painful stimuli via the PSQ; rumination, magnification, and helplessness via the PCS; and fear-avoidance with work

and physical activity via the FABQ ($P < .001$)]. The regression model for pain explained 39% of the total variance in pain sensitivity ($P < .001$), with PCS total score ($\beta = .06$), FABQ total score ($\beta = .03$), and age ($\beta = .02$) as significant individual factors.

CONCLUSIONS: Injured runners have significantly higher pain sensitivity, fear avoidance beliefs, and pain catastrophizing compared to their uninjured counterparts. Fear-avoidance beliefs, pain catastrophizing, and age can independently predict pain sensitivity in runners.

CLINICAL RELEVANCE: Fear avoidance and pain catastrophizing significantly influence pain sensitivity in runners; thus, these psychological factors should be addressed alongside the physical aspects of musculoskeletal injuries. Future studies are needed to determine if reducing fear avoidance and pain catastrophizing can improve rehabilitation outcomes in runners.

SP095

GAIT RETRAINING WITH REAL-TIME FEEDBACK REDUCES PAIN IN RUNNERS: A SYSTEMATIC REVIEW

Ryan C. Peterson, Michael P. DiLullo, Shane McKeon, Cameron S. Young, Michael Scott Crowell

PURPOSE/HYPOTHESIS: Running-related lower extremity (LE) pain limits training and performance. The purpose of this systematic review was to determine the effectiveness of gait retraining (GR) with real-time feedback (RTF) on LE pain in runners.

NUMBER OF SUBJECTS: N/A.

MATERIALS AND METHODS: A literature search was conducted in EBSCO, ProQuest, PubMed, and ScienceDirect using search terms: ("gait retraining" OR "run retraining" OR "feedback") AND (run OR running) AND (pain OR injury) and limits: English language, peer-reviewed, and human subjects. Selection criteria were: runners >18 years with LE pain, received GT with RTF, and assessed pain. Each study was independently assessed for methodological quality using the Oxford Centre for Evidence-Based Medicine Levels of Evidence (2011) and NIH Study Quality Assessment Tools (2021).

RESULTS: Of 217 articles screened, 9 met selection criteria. There were 2 level I studies, 2 level II studies, and 2 level IV studies. Both level I studies were rated as good quality; level II studies were rated as good and fair quality. Of level IV studies, one was rated as good quality and four were rated as fair quality. Sample sizes ranged from 21-69 for level I studies, 16-28 for level II studies, and 1-33 for level IV studies. Intervention groups received RTF including instruction to adopt a forefoot strike, increase step rate using a metronome, verbal feedback on running mechanics, and real-time visual feedback on biomechanics. The most common treatment frequencies were 8-10 sessions over 4-6 weeks. One RCT (8 sessions, 2 weeks) found a significant between-group difference in pain from pre-post treatment (mean difference 2.6 (95% CI 1.3, 3.9)) and from pre-treatment to follow-up (mean difference 3.6 (95% CI 2.2, 5.0)). The other RCT (3 sessions, 8 weeks) found no significant reduction in pain with GR compared to education but did find a significant within-group reduction in pain from pre-post treatment and pre-treatment to follow-up. All level II/IV studies reported within-group decreases in pain (5 studies utilized VAS, pre-post treatment decrease range = 2.2-5.0, pre-treatment to follow-up range = 1.4-5.0; 2 studies utilized NPRS, pre-post treatment decrease range = 2.1-5.2, pre-treatment to follow-up decrease range = 2.1-5.9).

CONCLUSIONS: There is low-level evidence to support GR with RTF to reduce LE pain in runners. Limitations included varied GR protocols, a small number of RCTs, heterogeneity in outcome measures, and high dropout rates. Further research should include randomized designs with larger sample sizes using well-defined training parameters and outcomes.

CLINICAL RELEVANCE: Clinicians may consider GR with RTF to reduce LE pain in runners. The most effective strategy appears to be 8-10 sessions over 4 weeks using real-time verbal feedback to achieve a non-rearfoot strike and increasing step rate with a metronome, with within group changes all exceeding the MCID for the VAS and NPRS. However, it is unclear if GR with RTF is more effective than standard treatments for LE pain in runners.

SP096**INFLUENCE OF AGING AND DUAL TASKING ON MOVEMENT VARIABILITY DURING RUNNING**

Hsiangling Sharon Teng, David Phong Nguyen, Gavin J. Garcia, Kassidy Burns, Quincy J. Smith, Jill Kathleen Finney, Malissa Kei Shadle

PURPOSE/HYPOTHESIS: This study examined the effects of aging and dual tasking (DT) on the variability of step characteristics and joint kinematics during running. We hypothesized that older runners would demonstrate lower variability and a greater reduction in variability during DT compared to younger runners.

NUMBER OF SUBJECTS: 8 older (59.6 ± 7.9 yrs) and 8 sex- and BMI-matched younger (25.1 ± 5.1 yrs) recreational runners

MATERIALS AND METHODS: This is an ongoing study. Participants ran at preferred speed under 3 task conditions: single-task running (ST), DT running with serial 2 subtractions (DT-easy), and DT running with serial 7 subtractions (DT-hard). During DT conditions, participants were instructed to prioritize the motor task by maintaining the same running form. Three-dimensional kinematics and kinetics were recorded using a 15-camera Qualisys motion capture system (200 Hz) and a Bertec instrumented treadmill (1000 Hz). Cadence, step width, step length, and peak trunk, pelvis, and lower extremity sagittal plane angles were calculated during the stance phase. Standard deviations of the stride and kinematic measures across 15 steps were computed to represent within-subject stride-to-stride variability. Two-way mixed-model repeated measures ANOVA with a covariate of speed were used to examine the main effects of age and task conditions and the age-by-task interaction effect on variability. The alpha level was set at 0.05.

RESULTS: Significant interaction effects were observed on the variability of peak hip flexion ($p=0.017$) and ankle dorsiflexion ($p=0.019$) angles. For both variables, older runners showed less reductions in movement variability under DT conditions compared to younger runners. Moreover, there were significant age effects on the variability of step width ($p=0.006$), peak hip flexion ($p=0.029$), ankle dorsiflexion ($p=0.028$), and trunk extension ($p=0.043$) angles, and a trend toward significant age effect on knee flexion angle variability ($p=0.051$). Older runners demonstrated lower variability on these variables compared to younger runners. There was no significant task effect.

CONCLUSIONS: This is the first study to reveal the interaction effects of age and DT on stride-to-stride variability. In contrast to our hypothesis, older runners showed less reduction in stride-to-stride variability under DT conditions compared to younger runners. This may be because older runners were more experienced and ran longer weekly distance compared to younger runners (21.1 ± 13.0 mi vs. 8.1 ± 5.1 mi). Consistent with previous studies, our results showed older runners had lower movement variability during running compared to younger runners.

CLINICAL RELEVANCE: Running typically involves multitasking (e.g. reading signs, monitoring pace, adjusting to different terrains) and has been growing in popularity among the older population. Aging is associated with an increased risk of running injuries. A sufficient level of variability is critical for motor performance and adaptivity during locomotion. Our findings suggest that older runners may be less adaptable, which may lead to increased injury risk. However, their movement variability was less impacted by DT conditions.

SP097**EFFECTS OF SPEED AND INCLINE OF RUNNING ON HIP EXTENSION BUFFER IN RECREATIONAL RUNNERS**

Marco Rodis, Frederick P. Zecha, Chloe Mei Lal, Cassandra Coss, Doria Centineo, Nestor A. Bautista, Justin Wager, Jason Keith Grimes

PURPOSE/HYPOTHESIS: The difference between joint motion utilized during a task and available range of motion (ROM) of that joint may be referred to as a "buffer." A negative buffer indicates joint motion during the functional task

surpasses what is available. This concept may be applied to running-related injuries (RRI). This study explored available hip extension and peak hip extension with running and investigated the impact of speed and incline on the hip extension buffer. A secondary purpose was to identify if ROM differences existed between runners with and without previous RRI.

NUMBER OF SUBJECTS: Twenty recreational runners (running 5-50 miles/wk, 10 males, median age 24.0 yrs)

MATERIALS AND METHODS: Available peak hip extension was measured passively (PROM) and actively using the Posterior Standing Overhead Arm Reach (P-SOAR) and SWING tests. Peak hip extension was also measured while running under various conditions: 0% incline at 5.0mph, 6.5mph, and 8.0mph, and 20% incline at 5.0mph. Participants were randomly assigned to running condition (20% incline or flat first). Data was captured using the Theia markerless system.

RESULTS: Running at 8.0mph resulted in the greatest peak hip extension, followed by 6.5mph, then 5.0mph on 0% incline, and lastly 5.0mph on 20% incline (Right: 26.1° , 23.7° , 19.9° , 16.4° ; Left: 26.4° , 23.3° , 19.8° , 16.9° , respectively). Running on 0% incline at 5.0mph, 6.5mph, and 8.0mph resulted in significantly greater hip extension than on 20% incline for both hips (Right: MD=3.6, 95%CI=1.2-5.9, $p=0.01$; MD=7.3, 95%CI=5.2-9.4, $p<0.001$; MD=9.8, 95%CI=7.5-12.0, $p<0.001$, respectively; Left: MD=2.9, 95%CI=1.1-4.8, $p<0.001$; MD=6.4, 95%CI=4.5-8.3, $p<0.001$; MD=9.6, 95%CI=7.2-12.0, $p<0.001$, respectively). PROM and P-SOAR were used to evaluate buffers due to difficulty adhering to SWING protocol by participants. In the right hip, the PROM buffer was -4.8 at 8.0mph ($p=0.02$) compared to +5.0 on 20% incline ($p=0.02$), +1.4 at 5.0mph ($p=0.40$), and -2.3 at 6.5mph ($p=0.23$). The P-SOAR buffer was -2.3 at 8.0mph ($p=0.10$) compared to +7.5 on 20% incline ($p<0.001$), +3.9 at 5.0mph ($p=0.01$), and 0.2 at 6.5mph ($p=0.90$). In the left hip, the PROM buffer was -2.6 at 8.0mph ($p=0.12$) compared to +7.0 at 20% incline ($p<0.001$), +4.1 at 5.0mph ($p=0.03$), and +0.6 at 6.5mph ($p=0.74$). The P-SOAR buffer was -2.3 at 8.0mph ($p=0.12$) compared to +7.2 on 20% incline ($p<0.001$), +4.3 at 5.0mph ($p<0.001$), and +0.8 at 6.5mph ($p=0.58$). Healthy runners had smaller buffers than those with previous RRI, indicating that healthy runners used more of their available motion during running, but the difference was not significant.

CONCLUSIONS: Increasing running speed required participants to utilize greater hip extension ROM compared to increasing incline, regardless of injury history. Running at 8.0mph resulted in a negative hip extension buffer, with 70% of participants utilizing more hip extension than they had available.

CLINICAL RELEVANCE: Clinicians should be aware of the effects of increasing speed and incline when progressing patients with hip pain, pathology (labrum, FAD), or post-operative precautions (THA).

SP098**THE EFFECT OF VARYING CADENCE AT TWO RUNNING SPEEDS ON STRIDE LENGTH AND RUNNING KINETICS**

Mark F. Reinking, Gina Behling, Kayla Neumann, Sean J.E. Burke, Sammi Quinn Tarnowski, Brian Baum

PURPOSE/HYPOTHESIS: The purpose of this study was to examine the effects of varying cadence (steps/min) at two running speeds on ground reaction forces (GRFs). We hypothesized that GRFs and stride lengths would be lower when running at higher cadence at both speeds.

NUMBER OF SUBJECTS: 30 runners ages 22-42 (18 female, 12 male) consented to participate. Inclusion criteria included running at least 15 miles/week for the past year, and no running-related injury in the past 3 months.

MATERIALS AND METHODS: Subjects completed a 6-minute acclimatization to an instrumented treadmill, during which they identified their self-selected speed and cadence. After a short break, the participants then ran at two predetermined speeds in the following order: 2.68 m/s (10 min/mile) and 3.35 m/s (8 min/mile). Participants ran at their self-selected cadence (SSC) at these speeds for two minutes. Participants then ran for two minutes each

at 5% below and 5% above SSC. Cadence was set using an audible metronome placed next to the treadmill. In the final 30 seconds of each running bout, kinetic variables were recorded through the instrumented treadmill deck. The kinetic variables measured were vertical impact peak (VIP), peak vertical force (PKVF), vertical average loading rate (VALR), vertical instantaneous loading rate (VILR), peak braking force (PKBF), and braking impulse (BI). Participants rated their exertion on the Borg Rating of Perceived Exertion scale at the end of each stage. Stance and step time were calculated from GRF onset and offset times. Temporospatial and kinetic variables were analyzed using repeated measures general linear model. Bivariate correlations were assessed using Pearson correlation coefficients. Force data from left and right limbs were compared using paired t-tests.

RESULTS: No significant differences existed between the right and left limb data so only the left limb data are reported. There were significant differences in VILR, VALR, PKBF, and BI between -5% cadence and +5% cadence at both the 10 min/mile and 8 min/mile speeds with lower forces and impulse at the higher cadence. There was a significant difference between -5% and +5% cadence at the 8 min/mile speed for PKVF, but not at the 10 min/mile condition. Stride length was also decreased at the higher cadence for both speeds. At their self-selected speed, participants with a SSC over 170 steps/minute ran at a faster pace (3.3 m/s) than participants with a SSC below 160 steps/minute (2.8 m/s). However, those running at a faster speed with a higher cadence did not have significantly higher kinetic variables as compared to participants who ran at a slower speed with a lower cadence.

CONCLUSIONS: The results of this study demonstrate that in a group of experienced runners, higher cadence at both speeds resulted in lower kinetic variable outcomes and decreased stride length.

CLINICAL RELEVANCE: These data add to the accumulating knowledge about running cadence, running speed, and kinetic variables, and contributes to the science of running-related injury management and prevention.

SP099

PROSPECTIVE MONITORING INCREASES RUNNING-RELATED INJURY IDENTIFICATION AND ASSESSES RUNNING ABILITY IN COLLEGIATE CROSS COUNTRY RUNNERS

Lace E. Luedke, Andrew M. Strasser, Evan Othmer Nelson

PURPOSE/HYPOTHESIS: The University of Wisconsin Running Injury and Recovery Index (UWRI) is a valid, reliable, running-specific, patient-reported outcome measure assessing perceived running ability after injury. The Oslo Sports Trauma Research Center Overuse Injury Questionnaire (OSTRC) is a patient-reported method to improve injury surveillance and assess the burden of overuse athletic injuries. Neither the UWRI or OSTRC have been assessed in competitive collegiate runners. The purposes of this prospective longitudinal study were to: 1) determine if OSTRC or UWRI scores differed between athletic trainer (AT) confirmed and self-reported injuries, 2) assess relationships between UWRI and OSTRC scores, and 3) assess relationships between change in UWRI or OSTRC scores and the 15-point global rating of change (GROC) during the cross country season.

NUMBER OF SUBJECTS: 40 collegiate cross country runners (45% female, mean±SD age 20.4±1.8 y and BMI 20.8±1.6 kg/m²).

MATERIALS AND METHODS: All runners completed a demographic survey on the first day of the season. During the season, runners were asked to complete a weekly electronic survey asking if their normal running volume or performance had been limited by pain or running-related injury (RRI) in the prior week. If a runner answered yes, display logic presented the UWRI (0-36, higher = better), OSTRC (0-100, lower = better) and GROC (-7 to +7, higher = better). Injuries were also tracked throughout the season by the team AT. Independent t-tests compared initial UWRI and OSTRC scores between AT-confirmed and self-reported RRIs. Pearson's correlations assessed the relationship between initial UWRI and OSTRC scores as well as changes in UWRI, OSTRC and the GROC.

RESULTS: Thirty runners completed ≥75% of the 12 weekly surveys. During the season, 7 (18%) runners experienced AT-confirmed time loss RRIs while 16 (40%) additional runners self-reported RRIs; the calf/lower leg (46%) and ankle (25%) were the most common injury locations. Initial UWRI scores were worse for AT-confirmed (13.0±9.0) than for self-reported (25.3±5.6) RRIs (p=0.02). Likewise, OSTRC scores were worse for AT-confirmed (59.7±24.2) compared to self-reported (34.6±13.3) RRIs (p=0.004). A moderate-good correlation was observed between initial UWRI and OSTRC scores (r= -0.68; p<0.001). UWRI and OSTRC change scores (r= -0.89; p<0.001) were strongly correlated. Change in UWRI (r=0.44; p=0.008) and OSTRC (r= -0.42; p=0.01) scores were moderately correlated with the GROC.

CONCLUSIONS: Most of the team consistently completed weekly reporting. During the season, RRIs limited running volume or performance for more than half of the team with AT-confirmed RRIs demonstrating significantly greater limitation in running ability than self-reported RRIs. Collegiate runners frequently continue running despite injury and the UWRI and OSTRC assess the RRI burden similarly. Prior work established content validity of the UWRI in runners and the current results support its construct-related validity in collegiate runners.

CLINICAL RELEVANCE: Runners seek medical care for more severe injuries. The UWRI offers a patient-reported mechanism to assess the full extent of RRI burden.

SP0100

PHYSICAL THERAPY MANAGEMENT OF PUBIC BONE STRESS INJURY IN A 38 YEAR OLD FEMALE RUNNER

Rachel Golden, Sarah Elizabeth Johnson, Stacey A. Meardon, Emily Grace Seguin

BACKGROUND AND PURPOSE: BSI is common in athletes whose sport requires repeated movements, specifically runners. Implementing a safe return to run (RTR) protocol is vital for preventing re-injury. This case report applied the concept of self-determination during physical therapy management of an individual competitive runner with recurrent BSI and describes the use of patient autonomy in decision-making, especially with return-to-run programs.

CASE DESCRIPTION: After restricting high-impact activities for 8 weeks, a 38-year-old female diagnosed with a pubic symphysis stress reaction presented to physical therapy with right hip and gluteal pain, right hip weakness, and a goal of participating in a 50km relay race in 10 weeks. Before injury, she participated in 3 to 5 races a year and trained year-round. Her training consisted of running, but she also utilized weightlifting and cross-training to supplement her long-distance runs. The patient had a history of left mid/distal tibia 4 years ago and proximal to mid right tibia BSI 6 years ago. Nutrition has been supplemented with Vit D for the last 4 years. A prior scanogram showed a leg length difference, corrected with custom orthotics 8 weeks. Since the injury, she reported swimming and walking to maintain fitness.

Patient interventions focused on patient autonomy; she was given the choice of following one of two RTR protocols. One protocol emphasized a more conservative approach to return to running, heavily emphasizing a walk-run progression. Our patient selected a protocol focused on running for the entire duration but at a reduced speed. Other interventions include lower extremity strength training, therapeutic dry needling, and education on managing symptoms with increasing activity. The RTR protocol was modified to achieve her distance goal by the race. Modifications included 1-2 days between runs until week 5 when back-to-back runs were initiated with shorter mileage. In the last 4 weeks and only if pain-free, run distance increases were accelerated to achieve her distance goal by the race.

OUTCOMES: The patient attended 6 PT sessions over 2 months. At the last PT follow-up 17 weeks post-injury, she had increased her running volume, was back to her baseline speed, and had increased strength. All PT goals

were met and was confident in her ability to use load management guidelines to return to prior activity level upon cessation of PT services. Email follow-up 19 weeks post-injury indicated that she had increased pain-free run distance from to 50 km without injury recurrence.

DISCUSSION: When treating runners with BSI, load management and progression, bone-strengthening activities, symptom management, and referrals to interdisciplinary providers are critical to recovery. The outcomes of this case study support the use of self-determination with RTR decision-making in the rehabilitation process of BSI. Further research is required to establish connections between successful RTR and autonomy in decision-making. Due to variations in BSI severity, more evidence on RTR protocols and adherence in conjunction with patient self-determination is needed.

SP0101

EXAMINING THE RELATIONSHIPS BETWEEN 2D KINEMATICS AND PATELLOFEMORAL JOINT LOADING DURING RUNNING

Emma Yeager, Cameron Buzzard, Thomas Gus Almonroeder

PURPOSE/HYPOTHESIS: Elevated patellofemoral joint reaction forces (PFJRFs) appear to be a contributing factor to patellofemoral pain (PFP) among runners. Clinicians often use two-dimensional (2D) video analysis when evaluating running mechanics for patients with PFP. However, few studies have examined whether kinematics derived from a 2D video analysis are related to patellofemoral loading. The purpose of this study was to examine the relationships between sagittal plane 2D kinematics and PFJRFs during running.

NUMBER OF SUBJECTS: 29 uninjured runners (19 females, 10 males), who reportedly ran 9.5 ± 5.7 miles/week.

MATERIALS AND METHODS: Subjects ran at a self-selected speed, with a rear-foot strike pattern, on an instrumented treadmill that recorded ground reaction force data, while three-dimensional kinematic data were recorded by a multi-camera motion capture system. These data were used to calculate joint angles and moments, which were input into a musculoskeletal model to estimate PFJRFs. A standard video camera (Canon, Inc.) positioned on the side of the treadmill was used to simultaneously capture 2D video data, which was used to derive sagittal plane segment/joint kinematics at initial contact (IC) and at the point of peak knee flexion during the stance phase. The following 2D kinematic variables were measured: trunk inclination angle, hip flexion angle, knee flexion angle, ankle dorsiflexion angle, tibial inclination angle, foot inclination angle, and the heel-to-CoM distance (i.e. horizontal distance between the runner's front heel and their center of mass [pelvis]). Partial correlation analyses were performed to examine the relationships between the 2D kinematic variables and the peak PFJRFs, while controlling for variation in running speed. PFJRFs were normalized by body mass. Preliminary analyses indicated that there were no significant differences between male and female runners for any of the variables of interest ($p > 0.05$). Therefore, data from the male and female runners were analyzed together. Correlation coefficients (r values) were interpreted as follows: 0.2 = weak relationship, 0.5 = moderate relationship, 0.8 = strong relationship. t -tests were also used to test the statistical significance of the correlation coefficients.

RESULTS: There was a weak-to-moderate, positive relationship between IC knee flexion angles and peak PFJRFs ($r = 0.38$, $p = 0.04$), indicating that making IC in a more flexed knee position was associated with higher PFJRFs. There was also a moderate, positive relationship between peak ankle dorsiflexion angles and peak PFJRFs ($r = 0.47$, $p = 0.01$), indicating that greater ankle dorsiflexion was associated with higher PFJRFs.

CONCLUSIONS: Runners who make IC with a more flexed knee and exhibit greater ankle dorsiflexion during stance tend to experience greater patellofemoral joint loading.

CLINICAL RELEVANCE: Clinicians who utilize 2D video to assess running mechanics should monitor IC knee flexion and ankle dorsiflexion angles, as these variables appear to be related to patellofemoral joint loading. Gait

re-training or other interventions to alter knee and ankle kinematics may be helpful when attempting to treat and prevent PFP.

SP0102

IMPACT OF SELF-TALK AND CUEING ON STEP RATE IN RECREATIONAL RUNNERS: A PILOT STUDY

Joel Sattgast, Kathleen Frein, Faith Carlson, Gabrielle Postma, Maddison Ruther, Mikayla Kinsey, Michael Truong

PURPOSE/HYPOTHESIS: An injury rate of 56-92% annually has been reported in recreational runners. Physical therapists are aptly positioned to mitigate risk and increase injury resiliency. This pilot study aimed to identify novel self-talk and cueing that would result in meaningful kinematic changes, specifically step rate, monitored via reliable, cost-effective and clinically applicable data collection units.

NUMBER OF SUBJECTS: 7 healthy adult volunteers (5 males, 2 females), averaging ≥ 15 miles p/week over the last 3 months without incurring a running related injury, were recruited and randomized into a control or experimental group.

MATERIALS AND METHODS: After completion of screening examination, subjects completed a warm-up and acclimation period on a motor-driven treadmill, followed by 2 efforts of 5 minutes each at a self-selected pace to establish baseline values. For subjects in the experimental group, verbal and visual educational instruction was provided on self-talk and cueing. After 4 weeks, both training groups returned for re-assessment, during which time the experimental group utilized self-talk and cueing during data collection. Kinematics were collected with 7 Noraxon inertial measurement units (IMU) on the pelvis and lower limbs.

RESULTS: When utilizing self-talk and cueing, experimental mean cadence improved by 2.99 ± 2.52 steps/min, representing a 1.812% increase, while the control mean cadence was -1.35 ± 3.19 steps/min, representing a 0.753% change. Experimental mean running speed increased by 0.131 ± 0.032 m/s while control mean running speed was -0.028 ± 0.092 m/s. An independent samples t -test compared mean values between experimental and control groups respectively ($t_{(5)} = 2.01$, $p = 0.049$; $t_{(5)} = 2.57$, $p = 0.098$). Statistical analysis was performed utilizing SAS Enterprise Guide 8.4 (SAS Institute Inc., Cary, NC).

CONCLUSIONS: These findings provide initial evidence supporting the use of self-talk and cueing to positively impact step rate. Combined with IMU assessment, this intervention and assessment may provide an efficient strategy to improve step rate and track kinematic data within a translational clinical environment.

CLINICAL RELEVANCE: Self-talk and cueing provide an approachable and cost-effective strategy to favorably impact step rate in recreational runners and may contribute to running injury risk mitigation.

SP0103

PRE-SEASON TO POST-SEASON CHANGES IN ISOKINETIC KNEE TORQUE IN ADOLESCENT CROSS-COUNTRY RUNNERS

Jeffery Allen Taylor-Haas, Ashley M. Moulder, Jason Long

PURPOSE/HYPOTHESIS: Strength training leads to improvements in muscle strength, running economy, and running performance in adult middle and long-distance runners. Maintenance of strength in this population over the course of a competitive season is not well-studied, but adult athletes in other sports (soccer and baseball) have demonstrated post-season decreases in muscle strength. The impact of cross-country season participation on isokinetic knee strength values is unknown. The purpose of this study was to evaluate changes in isokinetic knee extensor and knee flexor torque from pre-season to post-season in a healthy population of adolescent cross-country runners. When compared to pre-season values (PRE), adolescent cross-country runners will demonstrate reduced average and peak knee extensor torque values during post-season testing (POST).

NUMBER OF SUBJECTS: Thirty-one adolescent cross-country runners (16 Female/15 Male, age 17.0 ± 1.5 yrs).

MATERIALS AND METHODS: Testing took place during two time points: (i) pre-season and (ii) within ten days after the runner's final competition of the fall cross-country season. To be eligible for post-season testing, participants must have completed at least 80% of their cross-country season. At each time point, we measured isokinetic knee extension and flexion torques on a Biodex dynamometer at 60°/s. We calculated peak torques and average peak torques and used two-sided paired t-tests to assess change between time points. Significance was assessed at $p < 0.05$.

RESULTS: Significant reductions in peak knee extensor torque were identified during POST testing compared to PRE testing for the entire cohort (PRE 98.2 ± 27.1 Nm, POST 88.6 ± 23.2 Nm, $p < 0.0001$), males (PRE 98.1 ± 32.0 Nm, POST 90.3 ± 28.0 Nm, $p = 0.0024$), and females (PRE 98.3 ± 22.5 Nm, POST 87.0 ± 18.5 Nm, $p = 0.0003$). Significant reductions in average peak knee extensor torque were identified during POST testing compared to PRE testing for the entire cohort (PRE 89.1 ± 26.4 Nm, POST 79.8 ± 21.1 Nm, $p < 0.0001$), males (PRE 91.1 ± 31.7 Nm, POST 80.0 ± 23.7 Nm, $p = 0.0022$), and females (PRE 87.2 ± 21.2 Nm, POST 79.7 ± 19.2 Nm, $p = 0.0083$). No significant differences between PRE and POST were identified for peak and average knee flexor torque.

CONCLUSIONS: From PRE to POST, adolescent cross-country runners completing at least 80% of their season exhibited significant decreases in peak and average peak knee extensor torque but no significant changes in peak or average peak knee flexor torque.

CLINICAL RELEVANCE: Reductions in peak knee extensor torque may potentially impact key metrics of running performance and the likelihood of developing anterior knee pain. Future studies should consider evaluating the effectiveness of in-season strength training on muscle strength, running performance, and injury risk in this population.

SP0104

COMPARISON OF HAND-HELD DYNAMOMETRY MAKE VERSUS BREAK TEST DEFICITS IN SHOULDER PATHOLOGY

Michael John Mullaney, Malachy McHugh

PURPOSE/HYPOTHESIS: Hand-held dynamometry (HHD) is becoming increasingly popular in both research and clinical settings. A review of the literature shows a mixed use of "make tests" (MT) and "break tests" (BT). Both techniques have been shown to be valid and reliable in healthy individuals, but no work has compared these tests' ability to detect strength deficits in upper extremity patients. The purpose of this study was to compare MT versus BT ability in detecting upper extremity strength deficits in patients with shoulder pathology.

NUMBER OF SUBJECTS: 40

MATERIALS AND METHODS: Forty patients (52 ± 20 yr) with upper extremity pathology (Penn Score 70 ± 16) were included in the study. Patients performed a 6-minute warm-up on an upper extremity ergometer, followed by MT and BT strength testing protocol. Testing positions included seated flexion at 90°, seated abduction at 90°, and seated external rotation at 0°. The average of 2 trials on the involved and noninvolved sides was recorded for each MT and BT and strength deficits were computed [$((\text{noninvolved-involved})/\text{noninvolved}) * 100$].

RESULTS: There were no statistically significant differences in strength deficits between MT and the BT for flexion (MT $18.7 \pm 16.4\%$ vs. BT $20.7 \pm 14\%$ $P = 0.229$), abduction (MT $14.7 \pm 17.4\%$ vs BT $17.4 \pm 23.4\%$ $P = 0.138$), or external rotation (MT $12.8 \pm 18\%$ vs BT $14.2 \pm 16.5\%$ $P = 0.336$). There were significant correlations in strength deficits between MT and BT (flexion $r = 0.78$ $P < 0.001$, abduction $r = 0.77$ $P < 0.001$, external rotation $r = 0.86$ $P < 0.001$).

CONCLUSIONS: This study indicates that both MT and BT were able to detect similar strength deficits in patients with shoulder pathology. Although BT forces were significantly higher than MT forces, the deficits on the involved side for BT and MT were strongly correlated for shoulder flexion, abduction and external rotation. MT and BT should not be used interchangeably to measure strength because force outputs differ but both techniques reliably detect weakness.

CLINICAL RELEVANCE: Clinicians and researchers can utilize both MT and BT as options to detect strength deficits in patients with shoulder pathology.

SP0105

RETURN TO SPORT PROGRESSION IN A PROFESSIONAL BASEBALL PLAYER FOLLOWING ARTERIOVENOUS MALFORMATION RUPTURE

Daniel Deleandro, Alicia Anne Kempton, Joseph Vincent Hallock, Katherine Kozak Rethman, Matthew S. Briggs

BACKGROUND AND PURPOSE: Arteriovenous malformations (AVM) are relatively rare in the general population. This case study examines the rehabilitation process of a professional baseball player following rupture of an AVM, from collaborative treatments by physical therapists (PTs) specializing in neurology and sports. The purpose of this case report is to describe a successful return to professional baseball following an AVM rupture.

CASE DESCRIPTION: The patient was a 23 year-old male who was right hand dominant but batted left handed. He was playing third base in a professional baseball game, when he collapsed on the field from an AVM rupture. He quickly underwent two brain surgeries to stop the bleeding and remove the AVM. He presented to outpatient physical therapy three months after the rupture. The patient exhibited generalized weakness and poor flexibility, left hemiparesis, significant cervical dysfunction, activity intolerance, short-term memory loss, and decreased attention. Due to the patient-centered goal of returning to professional baseball, a neurologic PT specialist initiated a collaborative physical therapy plan with a sports PT specialist with a focus on baseball. The patient focused on the above deficits while with the neurologic PT and focused on improving coordination, whole body strengthening, and general conditioning while with the sports PT. As the patient progressed, he continued working with the sports PT on upper extremity strength, rotational power, and reactive agility. He was able to return to throwing, hitting, running, and fielding at high levels and signed a new professional contract 20 months after the initial injury. However, he was released due to his inability to slide and returned to physical therapy to relearn this task before returning to professional baseball the next year.

OUTCOMES: At 20 months, the patient was discharged from physical therapy with a left strength limb symmetry index (LSI) of 100% in shoulder flexion, abduction, and internal rotation, and 94% in external rotation. With isokinetic testing of his lower extremities, he achieved a strength LSI of 85% for quadriceps and 91% for hamstrings. The patient returned to an exit velocity off a tee of 93 mph, well within the normal ranges for a professional baseball player.

DISCUSSION: Although an AVM rupture may be career-ending to some elite athletes, our case highlights how the collaboration between the neurologic PT specialist and the sports PT specialist was vital in returning the athlete to professional baseball. While the patient had many neurological impairments addressed by the neurologic PT specialist initially, starting with a sports PT specialist early aided in his recovery timeline. Additionally, the communication between the PTs was imperative because the patient struggled early on with fatigue and by receiving multiple treatments on the same day his volume of activity needed to be managed appropriately. Additionally, this case highlights the need to test all aspects of an athlete's sport prior to clearing the athlete to participate, for example sliding.

SP0106

THE EFFECTIVENESS OF INSTRUMENT-ASSISTED SOFT-TISSUE MOBILIZATION VS. PASSIVE STRETCHING FOR SHOULDER ROM IN THROWERS

Colin Brockhouse

PURPOSE/HYPOTHESIS: The purpose of this systematic review is to determine if there is a difference in throwers' shoulder ROM with IASTM treatment.

NUMBER OF SUBJECTS: 0

MATERIALS AND METHODS: A systematic review was performed using PRISMA guidelines. Two reviewers independently examined all relevant

studies comparing IASTM to any passive stretching techniques through PubMed/Medline, Cochrane CENTRAL, Scopus, SPORTDiscus, PEDro, and CINAHL databases. Only randomized controlled trials, and comparative observational studies were examined. Studies that did not include throwing athletes or measure shoulder ROM were not included. Cohen's kappa (κ) was calculated to assess the agreement of the two reviewers following title, abstract, and full-text reviews. Data extraction and risk of bias assessment were performed after study selection. All outcomes were synthesized narratively due to heterogeneity in study designs and outcome measures. Titles, abstracts, and full-text articles were screened independently by the reviewers, with disagreements resolved through a third reviewer.

RESULTS: A total of 121 studies were identified during screening. After applying exclusion criteria, a consensus-agreed total of four studies were selected for inclusion (Figure 1). Reviewer agreement on study inclusion was excellent, $\kappa = 0.8966$. Upon closer inspection, two of the studies which were published by a common lead author (Bailey et al. 2015 & 2017) presented information on the same subject pool with some overlap in their results. The duplicate results were not included and we considered the two papers as a single experiment. Table 1 summarizes the primary findings. Further, two of the three experiments examined asymptomatic male baseball players, with the other assessing asymptomatic males and females as well as multiple overhead sports. Two of the three experiments also measured acute changes (one session) wherein the third utilized a longer (4 week) treatment protocol. All studies found statistically-significant improvements in shoulder ROM (internal rotation, cross-body adduction, total arc ROM) following treatment, favoring their experimental groups (IASTM) versus control (passive stretching). One study included IASTM with passive stretching as their control.

CONCLUSIONS: This systematic review suggests that IASTM may be an effective treatment option in managing ROM deficits that are commonly seen in throwing athletes. A direct comparison through meta-analysis and participant pooling is not possible at this time due to available study heterogeneity and indicates the need for further high-quality studies with standardized protocols to confirm findings and establish optimal treatment strategies for shoulder impairments in this population.

CLINICAL RELEVANCE: IASTM may be considered as a potential treatment option for achieving an acute improvement in ROM in the throwing athlete.

SP0107

PHYSICAL THERAPY MANAGEMENT OF A PROFESSIONAL ATHLETE STATUS POST HOOK OF HAMATE EXCISION

Amy Harcourt, Lauren Ashley Hanshaw

BACKGROUND AND PURPOSE: The hook of hamate is a hook-shaped bone on the ulnar side of the wrist forming a canal for the ulnar nerve and artery to supply the hand. Direct forces to the palm during gripping activities may fracture this bone. While a fracture to the hook of hamate is rare in the general population, it is more common in athletes playing baseball. During swing, direct forces to the lead hand transmit and disperse through the palm as the ball contacts the bat. Hook of hamate fractures accounted for 10.6% of all upper extremity injuries in professional baseball from 2011-2016, with a mean of 51.5 days of missed play. Time away from sport can be detrimental to a professional athlete. Standard of care includes surgical excision in many cases and current research supports physical therapy (PT) after excision. In one study, 41 baseball players receiving PT after hook of hamate excision returned to game play at 5 weeks post-op and to prior level of activity by 7 weeks. The purpose of this case report is to describe the PT management of a professional baseball player post right hook of hamate excision.

CASE DESCRIPTION: The patient is 21-year-old male professional baseball who started PT 2.5 weeks post right hook of hamate excision. He sustained a right hamulus fracture while swinging during batting practice. The patient is left hand dominant, and the affected right hand is

his catching side and lead swing hand. As an outfielder, the patient is required to catch fly balls which may impact his right hand at high forces. As a left-handed hitter, his lead right hand transmits more force as contact is made from the ball to the bat during swing. He received PT 6 days per week for an average of 4 hours per day in addition to baseball activity 6 days per week for an average of 2 hours per day. He is estimated to return to sport at 4 months post-op.

OUTCOMES: All measures including grip strength, Kapandji score, wrist range of motion (ROM), and shoulder strength improved over 3 weeks of PT. The patient's grip strength increased from 48 pounds to 108 pounds. The Kapandji score, a valid measure of thumb opposition ROM, increased significantly. At initial exam, the patient was able to oppose his thumb to his second proximal interphalangeal joint, indicating a major deficit in ROM. By reassessment, he was able to oppose his thumb to fifth metacarpal-phalangeal joint, indicating full ROM.

DISCUSSION: The patient significantly improved strength, ROM, and activity level over 3 weeks of treatment. He doubled his grip strength and normalized his thumb opposition ROM. Unimpaired thumb opposition is critical in baseball players as it is required for gripping a bat as well as closing a glove. The patient's grip strength returned to near pre-morbid levels in 3 weeks, and it was hypothesized that potentiation may have contributed to this gain over a relatively short period of time. The patient is currently 2 months post-op and plans to continue his progression and perform in a simulated live game to return to sport at the projected time frame of 4 months post-op.

SP0108

INTERPLAY OF HUMERAL TORSION AND PITCHING BIOMECHANICAL KINEMATICS IN COLLEGIATE PITCHERS

Hannah Zhao, Jakob Wolf, Kristen Nicholson, Garrett Fernandez, Chelsea Martin, Ellen Shanley, Daniel Kline, Charles Alden Thigpen, Matthew Hartshorne, Garrett Scott Bullock

PURPOSE/HYPOTHESIS: The extreme mechanical demands throughout the pitching motion contribute to anatomical adaptations of the throwing arm, such as humeral torsion (HT). While HT has been linked to differences in shoulder range of motion (ROM) and increased risk of arm injuries, the exact pitching mechanisms of injury have not been determined.

NUMBER OF SUBJECTS: A total of 12 pitchers (mean age, 19.7 ± 1.3 years; mean body mass index, 26.45 ± 1.9 kg/m²) were included.

MATERIALS AND METHODS: Participants were included in the study if they were currently pitching in college, a part of the Appalachian Summer League and participating in all baseball related activity but were excluded if they had any current injuries. Each pitcher threw 5 fastballs, 5 change-ups, and 5 curveballs; however, only fastballs were included in this analysis. Pitching biomechanics including max elbow external rotation and max elbow varus torque were measured and HT, shoulder passive ROM and trapezius strength were used to provide clinical measures. HT was measured using indirect ultrasonographic techniques with the subjects' lying supine on a standard treatment table, their shoulder at 90° abduction and elbow at 90° flexion. Due to the low sample size, a Bayesian mixed model evaluated the relationship between humeral torsion and max elbow external rotation and max elbow varus torque. Priors were informed from previous baseball biomechanics and clinical meta-analyses. Cluster accounted at the pitcher level and pitch velocity was controlled for in all models. A burn in of 1000 iterations with an additional 5000 iterations performed. Model results are reported as betas with 95% credible intervals (95% CI).

RESULTS: Dominant shoulder ROM (IR, $43.6^\circ \pm 9.9^\circ$; ER, $107.4^\circ \pm 8.9^\circ$), nondominant shoulder ROM (IR, $51.3^\circ \pm 10.0^\circ$; ER, $97.8^\circ \pm 9.3^\circ$), dominant trapezius strength (lower trapezius, $57.7^\circ \pm 16.9^\circ$; middle trapezius, $60.3^\circ \pm 12.6^\circ$), and nondominant trapezius strength (lower trapezius, $56.7^\circ \pm 14.5^\circ$; middle trapezius, $60.3^\circ \pm 13.3^\circ$) were measured.

Associations for both shoulder external rotation and elbow varus torque crossed 0 within this pilot sample. It was determined that for every 1° increase in dominant HT, there was a subsequent decrease of 0.17° in max shoulder external rotation (95% CI: -0.49, 0.14) and an increase of 0.12 Nm in max elbow varus torque (95% CI: -0.47, 0.22).

CONCLUSIONS: In this preliminary analysis, no association was found between HT and max elbow external rotation and max elbow varus torque during a fastball pitch, which should be interpreted with caution.

CLINICAL RELEVANCE: These results can be used for future more precise sample size calculations. The underlying elbow injury mechanisms concerning maximum pitching lay back require further causal investigations.

SP0109

AN INJURY REDUCTION PROGRAM FOR THE YOUTH AND HIGH SCHOOL-AGED BASEBALL ATHLETE: A PILOT STUDY

Ryan Joseph Monti, Rachel H. Lowell, Christopher Byers, Alec Srodawa, William Carter, Braydan Billman, Hunter Henneberger, Cole Heinlen

PURPOSE/HYPOTHESIS: Injury reduction programs for the youth baseball athlete have emphasized rotator cuff and scapular stabilizer strengthening with separate exercises for balance training. Further research is needed to observe strength improvements and monitor pain with throwing after the application of a strength program that simulates the throwing patterns of movement in youth and high school-aged baseball athletes. Utilizing prior evidence in the construction of an injury reduction program could combine lower extremity balance while performing upper extremity strengthening to observe the best results during seasonal play. The purpose of this study is to observe the strength characteristics and pain with throwing after participating in a 6-week baseball-specific strength training program in the youth and high school-aged baseball athlete.

NUMBER OF SUBJECTS: 9

MATERIALS AND METHODS: Male competitive baseball athletes (10-18 years-old) who were throwing without pain were recruited. Each athlete completed a progressive resistive exercise program for rotator cuff and scapular stabilizer musculature over the course of 6 weeks (2, 30 minute sessions per week) while in balance positions that simulated the throwing cycle. Dominant arm strength was assessed pre and post strength training using a digital handheld dynamometer against an externally fixated device in the following positions: external rotation (ER) and internal rotation (IR) in the scapular plane, ER and IR at 90 degrees (°) abduction (ABD) and 45° IR, and elbow extension and flexion at 90° shoulder flexion. Strength measurements were normalized to each subject's throwing arm ulnar length. The Kerlan-Jobe Orthopaedic Clinic Shoulder & Elbow (KJOC) Score was used to determine throwing with pain (<68.6/100) before and after participation in the above program and also during seasonal play.

RESULTS: Descriptive statistical analysis revealed increased percentage of strength in 9 baseball athletes (average age 14.4 + 2.0) regarding elbow extension (43.5%), shoulder ER at 90° ABD (25.6%), shoulder IR at 90° ABD (25.3%), shoulder IR in the scapular plane (21.3%), elbow flexion (19.5%), and shoulder ER in the scapular plane (7.3%). KJOC scores revealed a pre-test average of 88.1/100 (+7.0) and post-strength program mean of 92.6/100 (+ 6.9). After competitive participation in baseball for an average of 109.3 days (+ 19.7) the mean KJOC scores were 94.2/100 (+5.11).

CONCLUSIONS: Strength improvements within this sample of young athletes were observed after participation in a baseball-specific strengthening and balance combined training program. Additionally, all athletes were throwing with no pain during seasonal baseball participation as classified by their KJOC scores. Future research within a larger sample is necessary to identify if exposure to this type of program could aid injury reduction.

CLINICAL RELEVANCE: Developing a strength training program in combination with sport-specific patterns of movement could be feasible to improve arm strength, exposure to throwing, and apply standing exercises

during practice. There may be a need to consider alternative injury reduction strategies for the maturing athlete.

SP0110

INTRATER RELIABILITY OF AN INLINE DYNAMOMETER FOR SHOULDER STRENGTH ASSESSMENT IN DIVISION I OVERHEAD ATHLETES

William Alexander Fails, Jacob Michael Fine

PURPOSE/HYPOTHESIS: Strength assessment is an integral component in assessing the progress with rehabilitation for athletes and in making clinical return to sport decisions after injury and surgery. This research project aimed to preliminarily assess the interrater reliability of a load-cell inline dynamometer for the clinically efficient assessment of isometric shoulder strength in healthy, Division I overhead athletes. We hypothesized the device would demonstrate at least moderate interrater reliability (intraclass correlation coefficient (ICC) >0.5) for shoulder strength assessments.

NUMBER OF SUBJECTS: 20 healthy, active Division I overhead athletes (11 baseball pitchers, 9 women's volleyball players) were assessed by two board-certified clinical specialist Physical Therapists (one orthopedics, one sports).

MATERIALS AND METHODS: Isometric shoulder strength was assessed in 5 positions (seated external and internal rotation at 0 degrees abduction, seated external and rotation at 90 degrees abduction, and standing scapular plane elevation) bilaterally using the Tindeq Progressor (Blims AS, Trondheim, Norway). Each participant's strength was assessed on two occasions; once by each assessor with 7 days in between sessions. Three, 5-second maximal force reps were averaged in kilograms (kgs) for statistical analysis. Inter-rater reliability was assessed using ICC estimates and their 95% confidence intervals calculated using Stata 18 (StataCorp LLC, College Station, TX), based on a mean rating (k=3), absolute agreement, 2-way random-effects model. Standard errors of the measurement (SEM) and minimal detectable change (MDC) were calculated for each position and laterality in kgs. ICCs were interpreted according to the guidelines from Koo and Li (2016) with less than 0.5 considered poor reliability, 0.5 to 0.75 moderate, 0.75 to 0.9 good, and above 0.9 excellent.

RESULTS: Point ICC estimates for interrater reliability ranged from moderate (0.58 for right upper extremity scapular plane elevation) to excellent (0.97 for right upper extremity internal rotation at 0 degrees of abduction). The majority (7/10) of positions demonstrated at least moderate ICC values at the lower bounds of their respective 95% confidence intervals, and all positions demonstrated good to excellent reliability at the upper bounds of their 95% confidence intervals. SEMs ranged from 0.71 kg (left scapular plane elevation) to 3.47 kg (right internal rotation at 0 degrees abduction). MDC ranged from 1.96 kg (left scapular plane elevation) to 9.62 kg (right right internal rotation at 0 degrees abduction).

CONCLUSIONS: The Tindeq Progressor demonstrates moderate to excellent interrater reliability for isometric shoulder strength assessment in the positions described in this study. SEM indicated more precision in positions in which the athletes produced less force and the MDC was lower in those same positions.

CLINICAL RELEVANCE: The Tindeq Progressor is an affordable and reliable option for the assessment of isometric shoulder strength and can be utilized to assess patient progress throughout rehabilitation. Consideration of the SEMs and MDCs for each movement allows improved ability to detect true change.

SP0111

LARGE SAMPLE NORMATIVE DATA FOR THROWING ARM STRENGTH AND RANGE OF MOTION IN BASEBALL PITCHERS

Kevin A. Giordano

PURPOSE/HYPOTHESIS: Technological advancements have democratized access to objective data in athletes of all ages. This provides sports medicine professionals access to analyze vastly more data than ever before. Strength and range of motion (ROM) testing are critical in examining

a pitcher's upper extremity. However, current sports physical therapists rely on normative data published from clinicians gathering data, which is hard to generalize in small sample sizes. Therefore, we sought to provide normative strength and ROM data from a large pitching population to provide reference ranges for pitchers of all ages. Further, we assessed the role of anthropometrics on strength and ROM to provide clinicians with predictive models. We hypothesize height, weight, and age will be positive predictors of all strength metrics, positive predictors of external rotation (ER) and flexion ROM, and a negative predictor of internal rotation (IR) ROM.

NUMBER OF SUBJECTS: 7,654

MATERIALS AND METHODS: IRB exemption was approved to anonymously analyze a proprietary database. Inclusion criteria were actively training for baseball and pitcher listed as primary or secondary position, between 7-30 years old. Strength variables of interest were IR, ER, scaption, and grip. ROM variables of interest were IR, ER, and flexion. Participants used an inertial measurement unit and dynamometer for self-assessment after viewing educational videos on using the device. IR, ER, and scaption strength measurements were taken in supine against a fixed surface with the shoulder elevated 90 degrees. Grip strength was measured in half kneeling, with the throwing side knee down and the shoulder in 90 degrees of abduction and ER. All ROM tests were performed half kneeling with the shoulder abducted 90 degrees with the forearm on a wall (IR and ER), or with the entire arm on the wall (flexion) to prevent compensation.

RESULTS: Age, weight, and height were all positively associated with all strength measurements, however, height did not add predictability beyond age and weight. Strength variables could be predicted with the following equations: 1) $ER = 0.64*(age) + 0.16*(weight) - 3.54$ ($r^2=0.53$, $p<0.001$), 2) $IR = 0.59*(age) + 0.18*(weight)$ ($r^2=0.42$, $p<0.001$), 3) $SCAPTION = 0.54*(age) + 0.12*(weight) - 2.63$ ($r^2=0.61$, $p<0.001$), 4) $GRIP = 0.66*(age) + 0.12*(weight)$ ($r^2=0.41$, $p<0.001$). Age weakly predicted ER and IR ROM, using the following equations: 1) $ER = 104.59 + 1.03*(age)$ ($r^2=0.03$, $p<0.001$), 2) $IR = 100.38 - 1.01*(age)$ ($r^2=0.02$, $p<0.001$). Flexion ROM could not be predicted with an effect size $r^2>0.01$.

CONCLUSIONS: IR, ER, scaption, and grip strength are important clinical measures for baseball pitchers and can all be predicted using anthropometrics. Throwing arm ROM measurements are weakly dependent on anthropometrics and can likely be referenced to our provided normative values with minimal regard for anthropometrics.

CLINICAL RELEVANCE: Clinicians can look for deficiencies and red flags when monitoring return to through comparison to a database of over 7500 pitchers from the youth through the professional level.

SP0112

PHYSICAL THERAPY EXAMINATION AND DIAGNOSTIC IMAGING OF THE SUPRASPINATUS TENDON IN FEMALE COLLEGIATE VOLLEYBALL PLAYERS

Erin Marie Vogel, Mara Clark, Jace Likness, Paige McCracken, Jesse Lease, Austin Ryan, Dalen Blair

PURPOSE/HYPOTHESIS: To determine if there is a significant correlation between supraspinatus tendon thickness and shoulder examination findings pre- to post-season in collegiate volleyball athletes. Our hypothesis is that there will be an increase in the supraspinatus tendon thickness from pre- to post-season.

NUMBER OF SUBJECTS: 34 (17 controls, 17 athletes)

MATERIALS AND METHODS: Two portable therapy tables were used for collecting shoulder ROM and manual muscle test (MMT), which were utilized for seated, supine, and prone positions of the participants. Active and passive range of motion, as well as MMT was measured for internal rotation, external rotation, flexion, extension, and abduction. Range of motion was taken with a standard goniometer and MMT was taken with a hand-held digital dynamometer (microFET 2). The Lateral Jobe's Test was the special

test utilized to determine any rotator cuff pathology. Ultrasound measurements were taken with participants seated in a chair and dominant arm positioned behind the back to provide adequate longitudinal visualization of the supraspinatus tendon with digital calipers measuring from superior to inferior tendon sheaths just distal to the musculotendinous junction. Ultrasound measurements were taken with a GE LOGIQ E diagnostic US unit using the L4-12T linear transducer at a consistent frequency of 13mHz. **RESULTS:** Paired t-tests ($p<0.05$) were used to compare pre- to post-season measurements. Pearson correlation for the athletes was completed for post-season measurements. Lateral Jobe's test was positive for one subject pre-season and negative post-season, while another subject was negative pre-season and positive post-season. For both the control and athlete groups, all MMT measurements were statistically significant for strength increases. For the control group, passive ROM flexion, external rotation, and all MMT were found to be statistically significant with increases in each. For the athlete group, internal rotation active and passive ROM, and all MMT were found to be statistically significant showing increases in measurements. For the athlete group, US measurements were statistically significant showing a decrease in size. Pearson correlation for the volleyball athletes was completed for post-season measurements and showed statistical significance with post-season ER MMT compared to US measurements of supraspinatus tendon thickness, with increased MMT strength and decreased thickness.

CONCLUSIONS: Results suggest a significant statistical correlation between pre- and post-season strength, aspects of ROM, and tendon thickness. Correlational findings of decrease in size of the tendon and the increase in ER strength may indicate a compensation of the shoulder in response to these changes. This may lead to an increased risk of shoulder injuries in overhead athletes.

CLINICAL RELEVANCE: These findings may assist clinicians, coaches, and athletic trainers with prescribing individualized strength and conditioning programs for overhead athletes as well as individualized treatment for symptomatic patients.

SP0113

CONCURRENT VALIDITY OF PENN, FAST, & SANE IN ADOLESCENT OVERHEAD THROWERS

Daniel Gilbert Kline, Adam D. Lutz, Charles Alden Thigpen, Ellen Shanley, Thomas R. Denninger

PURPOSE/HYPOTHESIS: Supervised rehabilitation for adolescent arm injuries is typically guided by symptom report and objective measures like range of motion. However, there is minimal data providing benchmarks for patient function at the time of return to sport. While many patients are given region specific patient reported outcomes (PROs), they are not sport-specific and have demonstrated ceiling effects in athletic populations. Sport specific scales such as the Functional Arm Scale for Throwers (FAST) are specific, but lengthy. In other populations, the Single Assessment of Numeric Evaluation (SANE) has shown acceptable measurement properties; however, it has not been evaluated in the adolescent throwing athlete. The purpose of this study is to evaluate concurrent validity of the Penn Shoulder Score (PSS), FAST, and SANE in a population of adolescent throwing athletes.

NUMBER OF SUBJECTS: 146 throwing athletes, limited from sport, attending physical therapy for shoulder &/or elbow conditions.

MATERIALS AND METHODS: Male & female throwing athletes were identified prospectively and typical course-of-care metrics were tracked and measured retrospectively. PSS, FAST, & SANE PROs were routinely collected. Pearson's correlation coefficient (r) was used to assess the relationships between each of these PROs as available at initial visit & discharge evaluation, and therefore, a range of values with variable patient counts were observed. Significance was set a priori at $\alpha=0.05$.

RESULTS: Included athletes were 16.1±2.9 years of age, predominantly male (86%), right-handed (87%), and identified as pitcher (60%). Elbow

conditions represented a slight majority (55%). Height and weight were 175.1 ± 10.1 cm and 70.4 ± 16.6 kg, respectively. SANE displayed moderate correlation ($r=0.56-0.69$) with PENN and Quick DASH at IE and DC; however, weak or insignificant correlations were observed between SANE and FAST—including the pitching module. The SANE showed the strongest association for the discharge PENN satisfaction subscale ($r=0.68$) and discharge QuickDash Sport subscale ($r=0.72$). There were no other significant correlations.

CONCLUSIONS: Our results suggest that the SANE measures similar constructs as the PENN and QuickDASH, but not the FAST in adolescent throwing athletes. This is interesting given the robust nature of the development of each outcome scale and the simple, internal control of the SANE. Future studies are warranted to identify appropriate outcome measures in throwing athletes.

CLINICAL RELEVANCE: The SANE provides similar assessment of young throwing patients' function at the beginning and end of rehabilitation, but not with the FAST sport specific scale.

SP0114

DIFFERENCES IN HUMERAL RETROTORSION BETWEEN RIGHT- AND LEFT-HAND DOMINANT PITCHERS CONTRIBUTE TO UCL INJURY

Logan Voss, Bobby Jean Sanders Lee, Kalyssa Creed, Caitlin Anne Nadolny

PURPOSE/HYPOTHESIS: Humeral retrotorsion (HRT) is developed through repetitive forces at the shoulder in youth baseball players and the resultant change in range of motion (ROM) has been linked to increased forces at the ulnar collateral ligament (UCL). Research has found that differences in HRT between arms serves as a risk factor in elbow injury. Differences in HRT have been measured in right-handed (RHP) and left-handed pitchers (LHP). To date, there is limited research exploring HRT differences based on handedness and the risk of UCL injury. The purpose of this study was to explore the difference in the amount of HRT in pitchers based on their dominant extremity and presence of UCL injury compared to healthy controls.

NUMBER OF SUBJECTS: 165 male high school and collegiate baseball pitchers (mean age, 17.0 ± 2.4 years). 89 participants were diagnosed with a UCL injury and 76 were healthy controls. There were 120 RHP and 46 LHP.

MATERIALS AND METHODS: HRT at the shoulder was measured in each subject. Side-to-side differences were calculated to determine humeral retrotorsion difference (HRTdiff). Two 2x2 ANOVAs were conducted to examine the effect of arm dominance and presence of UCL injury on HRT and HRTdiff. Alpha level was set at .05 for all statistical analyses.

RESULTS: There was a statistically significant interaction effect of hand dominance and UCL injury on HRT, $F(1,161)=5.276$, $p=.023$, $\eta_p^2=.032$. LHP had significantly less HRT in their dominant arm than RHP in both the UCL ($MD=12.34^\circ$, $SE=2.19^\circ$, $p<.001$) and control groups ($MD=5.06^\circ$, $SE=2.29^\circ$, $p=.028$). LHP that had a UCL injury had significantly less HRT in their dominant arm than controls ($MD=5.813^\circ$, $SE=2.70^\circ$, $p=.033$). In RHP there was not a significant difference in HRT in those that had a UCL injury and controls ($MD=1.46^\circ$, $SE=1.66^\circ$, $p=.381$).

There was not a statistically significant interaction effect of dominant hand and presence of UCL injury on HRTdiff, $F(1,161)=.236$, $p=.628$, $\eta_p^2=.001$. Simple main effect tests indicated that the HRTdiff was significantly higher for RHP ($19.20 \pm 8.48^\circ$) than for LHP ($5.43 \pm 9.41^\circ$, $p<.001$). There was no significant difference in HRTdiff between patients with a history of UCL injury ($15.69 \pm 11.33^\circ$) and healthy controls ($15.16 \pm 9.90^\circ$, $p=.883$).

CONCLUSIONS: LHP had significantly less HRT than RHP in participants with and without UCL injuries. Furthermore, the difference in HRT between the throwing and nonthrowing arm was significantly higher for RHP.

CLINICAL RELEVANCE: Recognizing the differences in hand dominance for the baseball pitcher and its effect on HRT allows for physical therapists to mold their treatment to respect the developed advantageous adaptations of the athlete and to better contribute to reducing the potential for UCL injury.

SP0115

BLOOD FLOW RESTRICTION CYCLING AUGMENTS ROTATOR CUFF STRENGTH: A RANDOMIZED CONTROLLED TRIAL

Jason Jason Brumitt

PURPOSE/HYPOTHESIS: Blood flow restriction (BFR) training allows one to train at a lower load and achieve adaptations that are observed when exercising at a higher load. Studies have demonstrated distal and proximal increases in strength with BFR training. BFR training may be advantageous when rehabilitating patients with shoulder pathology; however, no studies have demonstrated increases in shoulder external rotation (ER) strength. It is possible that prior studies did not create a training environment suitable to trigger an adequate physiologic response. Two studies have demonstrated increases in biceps brachii strength (no-BFR) when combined with bilateral lower extremity exercises performed with BFR. The purpose of this study was to evaluate changes in rotator cuff strength in subjects who performed a six-week stationary cycling program with bilateral occlusion.

NUMBER OF SUBJECTS: Twenty-three (females $n = 10$) healthy subjects (mean age 24.7 ± 4.3 years) who performed upper extremity exercises twice a week.

MATERIALS AND METHODS: This trial was prospectively registered with ClinicalTrials.gov (NCT05344391). An *a priori* sample size of 16 was estimated using G*Power ($\alpha = 0.05$; $\beta = 0.80$; $f = 0.4$). Subjects were randomized to the BFR ($n = 13$) or non-BFR ($n = 12$; 2 unable to complete due to illness) groups. A baseline VO_{2max} cycling test was performed with a subject's max heart rate used to calculate heart rate reserve (HRR). Pretests/posttests included the collection of strength measurements using a hand-held dynamometer (MicroFET 2; Hoggan Scientific, Salt Lake City, UT). The investigator's intrarater reliability ($ICC_{3,\infty}$) for MMT testing was excellent (ER = 0.935 [$0.846, 0.972$]; supraspinatus = 0.978 [$0.944, 0.993$]). To establish baseline training loads subjects self-selected a dumbbell and performed repetitions to fatigue for each exercise. To calculate 1RM an estimation equation was utilized: ($1RM = [0.033reps] RepWt + RepWt$). Training weights were initially set at 30% 1RM. The training program was performed 3 times a week for 6 weeks with subjects performing 10 min of stationary cycling at 40% HRR (with or without BFR). Subjects in the BFR group cycled with bilateral tourniquets applied at the proximal thigh set at 80% limb occlusion pressure. After cycling both groups performed 3 sets of 15 repetitions of scaption and sidelying ER exercises (without BFR). Exercise training weights were increased by 1lbs. every two weeks.

RESULTS: Subjects in the BFR group experienced significant increases in ER and supraspinatus strength ($p < 0.001$), whereas no change was observed in the non-BFR group ($p = 0.133, 0.069$ respectively). There was also a significant between group difference in strength after six weeks (ER $p = 0.001$; supraspinatus $p = 0.005$).

CONCLUSIONS: Training with bilateral occlusion during stationary cycling followed by rotator cuff exercises augmented shoulder ER and supraspinatus strength.

CLINICAL RELEVANCE: This is the first study to demonstrate significant increases in shoulder ER strength when utilizing BFR. Future studies are warranted to determine efficacy when treating patients with shoulder pathology.

SP0116

USING AN ARM ACTION TRAINING DEVICE CAN INFLUENCE PITCH PERFORMANCE METRICS

Shant Minassian, Daniel O. Awokuse, Lori Michener, Jonathan C. Sum

PURPOSE/HYPOTHESIS: The relationships between arm mechanics and ball metrics have been well established. However, many pitchers have difficulty achieving ideal arm mechanics, especially after ulnar collateral ligament tears. Arm action training devices may enhance arm mechanics. The purpose of this study was to determine the effect of an arm action train-

ing device on arm metrics (arm slot, arm speed, elbow varus torque) and ball metrics (spin rate, ball velocity, ball position at point of release) during pitching. We hypothesized that using an arm action training device would increase spin rate, ball velocity, arm speed, ball position, and decrease elbow varus torque, which is a proxy to ulnar collateral ligament injuries.

NUMBER OF SUBJECTS: Seven healthy college-eligible baseball pitchers
MATERIALS AND METHODS: Pitchers threw 10 fastballs off an indoor mound. Data was collected on 5 fastballs at 100% effort, then the *PocketPath Arm Action Trainer*[®] (PP) was applied, and 5 fastballs were repeated. Spin rate, ball velocity, and ball position at point of release were measured using Trackman[®]. Arm speed (rotational speed of the forearm), arm slot (angle of the arm from the top of the pitching motion to the release point), and elbow varus torque (force across the medial elbow) were measured using Driveline PULSE[®]. Paired t-tests were used to determine differences between pitches pre-PP and post-PP. Non-parametric Spearman's correlations were used to determine relationships between arm metrics and ball metrics to further elucidate relationships impacting elbow varus torque.

RESULTS: Comparing measures pre-PP vs. post-PP revealed decreased ball velocity (mean difference (MD)=-0.99(95%CI:-1.7,-0.29);p=0.009), spin rate (MD)=-4.89 (95%CI:-33.72,23.93);p=0.71), elbow varus torque (MD)=-0.87(95%CI:-1.84,0.09);p=0.07), and ball position (MD)=-0.02(95%CI:-0.13,0.08);p=0.57), while there was increased arm speed (MD)=7.88(95%CI:-6.87,22.65);p=0.23) and arm slot (MD)=0.37(95%CI:-3.12,3.87);p=0.80). With PP, a negative relationship existed between arm speed and ball velocity ($r=-0.69, p=0.00$) and a positive relationship existed between arm slot and ball velocity ($r=0.44, p=0.02$). While a negative relationship between arm slot and elbow varus torque existed pre-PP ($r=-0.52, p=0.00$), this relationship weakened post-PP ($r=-0.30, p=0.12$). No significant relationship existed between ball velocity and elbow varus torque pre-PP vs. post-PP.

CONCLUSIONS: Using an arm action training device such as PP can influence ball metrics and arm mechanics which can impact pitching performance and elbow stress. While using the PP may decrease ball velocity, spin rate, and ball position at time of release, it may improve arm speed and arm slot. Moreover, using the PP was associated with decreased elbow varus torque, which may be advantageous in the rehabilitation and throwing progression when returning from elbow injury or surgery.

CLINICAL RELEVANCE: This study has clinical relevance for clinicians in understanding the impact of arm path on arm mechanics and ball metrics and can influence throwing progression design for performance enhancement and returning from injury.

SP0117

INTER-LIMB ASYMMETRIES INFLUENCE CHANGE OF DIRECTION SPEED IN COLLEGIATE MALE AND FEMALE FENCERS

Bilal Aburub, Amanda Eng, Brianna M. Scollan, Yuwei Ye, Jean Fitzpatrick Timmerberg, Michael Robert Johnson, Rami M. Said

PURPOSE/HYPOTHESIS: The sport of fencing demands the ability to repetitively move quickly into/out of lunging postures and relies on adequate range of motion (ROM), strength, and endurance in the upper and lower body. Previous research among sub-elite, elite, and professional fencers has shown that lunging velocity and change of direction (COD) speed are fundamental to success in fencing. Moreover, the literature has investigated how inter-limb asymmetries of ROM or strength may influence injury risk and lunging velocity, yet there is sparse information on the influence of inter-limb asymmetries on COD speeds, in collegiate fencing. Therefore, the purpose of this study was to examine the relationship between ROM and strength inter-limb asymmetries on COD speeds among collegiate male and female fencers.

NUMBER OF SUBJECTS: 45

MATERIALS AND METHODS: Twenty male (age = 20.2±1.15) and twenty-five female (age=19.9±1.08) collegiate fencing athletes participated in this

study. Assessments of ROM, including passive hip internal rotation (IR), hip external rotation (ER), weight-bearing dorsiflexion (WBDF), Hamstrings (HS) flexibility, Quadriceps (Quads) flexibility, and shoulder ER/IR in the 90/90 position, were measured with a digital inclinometer, while muscle strength tests of hip abduction (ABD), hip ER, HS, Quads, and shoulder ER/IR in the 90/90 position were measured using a hand-held dynamometer, and was then standardized to the subject's body weight. The COD speed was collected using a stopwatch while fencers performed a shuttle test in the 4-2-4-2m pattern. Descriptive data, p-values, t-tests and correlations were calculated using SPSS Statistics.

RESULTS: All fencers demonstrated a moderate positive relationship between COD and lead limb Hip IR ROM ($R=0.363, p<0.05$). Among epee fencers, a moderate negative relationship was found between COD and lead limb Hip ER ROM ($R=-0.536, p<0.05$), while a moderate positive relationship was shown between COD and HS flexibility on both limbs ($R_{lead}=0.541, p<0.05$; $R_{trail}=0.553, p<0.05$). More specifically, female epee fencers demonstrated a strong positive relationship between COD and HS flexibility of both limbs ($R_{lead}=0.793, p<0.05$; $R_{trail}=0.711, p<0.05$). Among foil fencers, a moderate positive relationship was found between COD and lead limb Hip IR ROM ($R=0.619, p<0.05$). Although there were no significant findings among all sabres, males demonstrated a strong negative relationship between COD and trail limb Hip IR ROM ($R=-0.962, p<0.01$), and a strong positive relationship between COD and trail limb Quad strength ($R=0.901, p<0.05$).

CONCLUSIONS: The results of this study demonstrate that limited Hip ER/IR ROM, HS flexibility, and Quads strength can have a significant impact on COD speeds among fencers, in particular when taking into account the inter-limb asymmetries between both limbs in both sexes, and specific to each weapon.

CLINICAL RELEVANCE: Further insight into weapon- and sex-specific inter-limb asymmetries can give deeper insight into the influence on COD speed. Clinicians and trainers can then design fencing-specific training programs to target these impairments in order to optimize COD speed and performance.

SP0118

PRE- AND POSTSEASON FITNESS AND HIP/KNEE STRENGTH ASSESSMENT OF ADOLESCENT FEMALE SOCCER PLAYERS

Walter Wilson, Jeffrey A. Damaschke, Sarah Jo Haag

PURPOSE/HYPOTHESIS: Anterior Cruciate Ligament (ACL) tears continue to be a common and severe injury that frequently occurs in young female sports especially soccer. Due to this, injury mitigation programs have been implemented to reduce occurrence of this injury, the most common program being the FIFA 11+ . The purpose of this study was to analyze how hip/knee strength and other fitness variables change during the course of a season implementing the FIFA 11+ program. It was hypothesized that hip/knee strength would increase throughout the season and the introduction of this program would reduce the number of lower extremity injuries during the season.

NUMBER OF SUBJECTS: 18 participants from the Heart of the City U15/U19 team were included for the preseason data. 7 of these participants were included for postseason data due to decreased attendance and participant program adherence.

MATERIALS AND METHODS: Each participant of the study completed fitness testing including 20/40m sprints, 3 hop test, single limb stance balance, push-up and sit-up tests during the pre and post season time points. In addition, hip/knee strength was measured via 2 tension-based dynamometers bilaterally for the following muscle groups on each participant: hip extension/external rotation, hip abduction/adduction, and knee flexion/extension. Each subject completed 3 trials of each movement and the value was recorded by a member of the research team. The primary investigator attended soccer practices biweekly throughout the season to administer the FIFA 11+ program with the team to ensure compliance and monitor progress.

RESULTS: Gross improvements in bilateral knee flexion and extension strength were noted at the postseason assessment. Pre- to postseason left hip abduction strength increased nearly to a statistically significant level ($p=0.051$), while pre-season to postseason right hip abduction and left hip adduction strength generally reduced from pre- to postseason. In terms of fitness data, the average 20 m sprint time increased by 0.32 seconds, but gross improvement was seen in right single limb stance with eyes closed increasing by 12.46 seconds. Left hip extension strength demonstrated a statistically significant improvement from preseason to postseason ($p=0.023$).

CONCLUSIONS: These findings indicate that the exercises involved in the FIFA 11+ program not only helped strengthen the participants, but allowed them to remain steady when placed in more physically demanding positions. No ACL or serious lower extremity injuries occurred over the course of the season, supporting the original hypothesis of the study.

CLINICAL RELEVANCE: This study sheds light on the possible overuse and reliance of these athletes on their dominant limb. This study displays how the incorporation of an injury mitigation program can aid in reducing ACL injury risk factors such as hip/knee weakness. Future studies are necessary in order to better analyze the effect of these warmup exercises and to continue to promote their importance to trainers, staff, and coaches at all levels of the sport.

SP0119

WEEKLY CHANGES IN BODY WATER COMPARTMENTS AND PEAK POWER ARE NOT ASSOCIATED IN COLLEGIATE HOCKEY

Richard Michael Morgan, Elizabeth Hodgson, Brock Montgomery, Derek Newberger, Joshua Martinson, Gary Dean Schindler, Mark Poolman, John Fitzgerald

PURPOSE/HYPOTHESIS: Bioelectrical impedance spectroscopy (BIS) has gained recent attention for the measurement of total body water (TBW), intracellular water (ICW), and extracellular water (ECW) since these variables demonstrate associations with strength and power. Due to limited research employing BIS and examining longitudinal relationships between variables, this study is aimed to determine if changes in BIS-derived whole-body and segmental compartment water predict changes in peak power and readiness to train in collegiate athletes.

NUMBER OF SUBJECTS: 25

MATERIALS AND METHODS: Data were collected as a part of the team's preparedness monitoring system and twenty-five NCAA Division I collegiate hockey players volunteered to participate in this study. A SOZO BIS device was used to assess body water and composition. Peak power was obtained using the 6-Second Test on a Wattbike. Readiness to train was self-reported and on-ice training load was assessed using PlayerLoad™ (triaxial-accelerometer data). All assessments were conducted at the same time on Wednesday each week for 16 weeks during the season. Week-to-week changes for each variable were calculated at the individual level and then the group mean was used for the analysis.

RESULTS: Pearson's r and partial correlation were used to assess the relationships. There were no statistically significant correlations detected in bivariate and adjusted models. A trend of a moderate and strong, positive correlation between leg ICW/ECW (measure of muscle quality) and self-reported readiness was observed in the bivariate ($r = 0.484$; $p = .067$) and adjusted models ($r = 0.517$; $p = .058$), respectively.

CONCLUSIONS: If relationships between body compartment water and peak power performance exists during typical in-season conditions, the strength of association is likely weak in ice hockey. We have observed BIS-derived body water compartment and composition measurements being stronger correlates of strength when compared to power in our athletes.

CLINICAL RELEVANCE: Practitioners should not interpret changes in body water, consistent with those reported in this study, to reflect changes in single effort peak power performance ability or readiness to train. Future research will need to track body water and performance changes for a long duration to achieve adequate statistical power to detect weak associations with confidence. Alternatively, researchers could examine conditions where larger

changes in body water compartments will likely be observed but are still practically relevant situations to team sport preparedness monitoring (e.g., before and after games). Future research should also assess the association between body compartment changes, especially ICW, and changes in other exercise performance measures such as repeated sprint performance.

SP0120

EFFECTS OF INTRINSIC FOOT STRENGTHENING INTERVENTIONS AND RELATIONSHIP TO SINGLE LEG HORIZONTAL JUMP DISTANCE

Jenna Lynn Encheff, Emma C. Fase, Sophia Perlich, Jacob Foster, Jacob Myers, Jacqueline Baughman, Kaitlyn Michelle Kazmierzak, Emma Browne, Connor Cottingham, Collin M. Stonebraker, Allison Bedwell

PURPOSE/HYPOTHESIS: The purpose of the study was to investigate the effects of three different exercise protocols on intrinsic foot muscle force and the relationship of force to single leg horizontal jump (SLHJ) distance.

NUMBER OF SUBJECTS: 63 healthy adults (41 females, 22 males; 24.3 ± 5.7 years)

MATERIALS AND METHODS: Participants were randomly assigned to one of four foot intrinsic strengthening groups: control ($n=21$), exercise only (EX) ($n=19$), neuromuscular electrical stimulation (NMES) ($n=18$), and blood flow restriction (BFR) ($n=7$). At pretesting, a mark was made on subjects' right dorsal naviculars after which they performed short foot exercise three times while force measures were obtained via force transducer positioned over the marks. Subjects then performed three right SLHJs and average force and SLHJ distance were documented. Six weeks of guided, progressive intrinsic foot muscle strengthening was then performed by the intervention groups, 3x/week. The NMES group performed exercises while stimulation was provided over the right abductor hallucis, while the BFR group performed all exercises with an automatic cuff placed proximally on the right lower extremity with arterial limb occlusion pressure set at 80%. Post testing occurred within one week following the exercise regimen in the same manner as pretesting. Mixed model ANOVA was performed to compare the differences pretest to posttest within and between groups on measures of force and SLHJ distance. Pearson's correlation was also run to identify relationship of force to jump distance.

RESULTS: Significant improvements in force were found for NMES ($p=.04$), and BFR ($p=.02$) groups with a trend towards significance in the EX group ($p=.057$). NMES and EX groups also had significant improvements in SLHJ distance, ($p = .02$ for both groups). Distance improved in the BFR group, but not significantly. Relationship between force and SLHJ distance was found to be positively correlated at posttest ($p<.001$; $r=.392$).

CONCLUSIONS: Six weeks of intrinsic strengthening resulted in improved intrinsic foot muscle force as measured during short foot exercise in all intervention groups as compared to the control group. NMES and BFR groups demonstrated significantly higher force when compared to the EX only group. All intervention groups improved jump distance posttest, while control group did not. Force had a moderate correlation with SLHJ distances, therefore intrinsic foot muscle strengthening may aid in improving SLHJ distance.

CLINICAL RELEVANCE: SLHJ distance may be improved by performing a 6-week foot intrinsic strengthening program. Because intrinsic force is positively correlated to jump distance, athletes who perform activities requiring single leg jumping or push-off may benefit from intrinsic foot muscle strengthening to aid in jump performance. Applying NMES or BFR may further increase the effects of the exercises.

SP0121

HYDRATION HUSTLE: WHICH ORAL REHYDRATION SOLUTION WORKS THE FASTEST?

Kristie Kalis, Penny Lauren Goldberg, Debi Lynn Jones

PURPOSE/HYPOTHESIS: The market for oral rehydration solutions (ORS) is overrun with products claiming to improve hydration speed. Exercise

increases sweat production for evaporative cooling. Fluid intake often fails to match fluid lost through sweating, resulting in dehydration. Research shows athletes and adults underestimate sweat losses by 40-50%. Minor dehydration (1-2% body weight lost) can impair strength, endurance, and cognitive performance, highlighting the need for effective rehydration. We hypothesized that skim milk rehydrates the fastest followed by sugar-free ORS, sugared ORS, and water.

NUMBER OF SUBJECTS: 2 (P1 and P2)

MATERIALS AND METHODS: Participants were healthy, able to exercise, and consented to participation. Trials were conducted over four days in 4 weeks. Participants were weighed using the scale portion of the InBody 570 Analyzer. Interstitial and extracellular water and the ratio of extracellular water to total body water were reported using the bioelectrical impedance function on the InBody device.

Participants self-selected the exercise and intensity until they achieved a minimum of 2% weight loss. During and after exercise participants did not consume any fluids and ate only dry foods to maintain dehydration. Twelve hours later, participants were re-analyzed with the InBody 570 and then ingested 0.5L of fluid for each pound lost. The four solutions used for rehydration were water (WA), a sugar-free ORS (ORS-SF), an ORS with sugar (ORS-G), and skim milk (SM). Rehydration occurred over 90 minutes; measurements were taken every 30 minutes for two hours following the rehydration period.

RESULTS: Average weight loss in the morning was 2.61% for P1 and 2.62% for P2. Average time to reach dehydration was 147 minutes for P1 and 146.5 minutes for P2. Rehydration did not return P1 to pre-exercise weight, while P2 regained lost weight with ORS-G and SM. ORS-SF and SM increased fluid volume fastest for P1 and P2. For P1, ORS-SF increased fluid volume within 30 minutes, while SM took 120 minutes. Both returned P1's fluid volume to baseline. For P2, ORS-SF and SM increased fluid volume within 30 minutes. ORS-SF raised P2's volume above baseline, whereas SM returned it to baseline.

CONCLUSIONS: As dehydration worsens, the body adjusts by shifting fluids between the vascular, interstitial, and intracellular spaces. ORS-SF and SM had faster increases in fluid volume than ORS-G or WA. Additionally, rehydrating based on weight may not be adequate. It may be appropriate to aim for 150% of the weight lost to account for sweat and urine losses.

CLINICAL RELEVANCE: Maintaining euhydration can improve performance. With 1-2% weight loss showing performance decrements, athletes must understand the importance of hydration and fluid replacement. Athletes who track hydration using weigh-ins should be advised that gaining 100% of weight lost may not be enough to restore hydration and that sugary solutions and water may be less effective than sugar-free options or skim milk.

SP0122

HOW IS LOAD MANAGED IN WEIGHTED BALL THROWING PROGRAMS?: A SURVEY OF COLLEGIATE BASEBALL PLAYERS

John Justyn, Ryan Joseph Monti, Heather Shannon Myers, Trevor A. Lentz

PURPOSE/HYPOTHESIS: The prevalence of throwing weighted balls in baseball has grown in recent years. Researchers have evaluated the effectiveness of weighted ball programs on increasing velocity, but not how these programs are utilized in real-world situations. We aimed to determine if college baseball players' participation in weighted ball throwing programs align with current recommendations that training should be tailored to individual goals, abilities, and timing and that these programs should be continually monitored and amended by coaching/conditioning/rehab professionals. We hypothesize that the majority of collegiate baseball players participate in generic (vs. individualized) weighted ball training programs without monitoring by appropriate coaching/conditioning/rehab professionals.

NUMBER OF SUBJECTS: 56

MATERIALS AND METHODS: A 34 question survey was distributed via email, and social media to college baseball teams' coaches and athletic staff.

Questions addressed physical attributes, playing history, injuries, details of their weighted ball programs, and the Kerlan-Jobe Orthopedic Clinic Shoulder & Elbow Score. An expert panel review and pilot testing were completed to finalize questions and format of the survey. Descriptive statistics were performed for all responses. Chi-square was performed to determine if there was a relationship between injury and personalized vs. generic weighted ball programs.

RESULTS: Among 56 college baseball player respondents, 73% utilized weighted ball programs. 95% of respondents were pitchers. Program guidance varied: 71% by pitching coaches, 56% by specific programs, and 66% by personal feel, while 61% of athletes did not have their program monitored. Prior to initiating a weighted ball program, 56% had a physical assessment completed by a coach and 17% by their Physical Therapist/Athletic Trainer. 41% of players completed a generic program in which 35% reported injury during, or within one season following completion of, their weighted ball program. Conversely, 11% of athletes who completed a personalized weighted ball program had injuries during the same timeframe. We did not find a statistically significant difference in injury rates based on type of program used.

CONCLUSIONS: We found significant variation in how weighted baseball programs are utilized in the collegiate setting. Most respondents did not have a physical assessment completed by a licensed medical professional prior to initiating their throwing program and are not monitored. Injury rates among respondents, 25%, are consistent with previous reports.

CLINICAL RELEVANCE: In the collegiate setting, the majority of baseball players are not following best practice recommendations for load management and injury prevention when participating in weighted ball throwing programs.

SP0123

THE ASSOCIATION BETWEEN REDUCED DORSIFLEXION RANGE OF MOTION, JUMP HEIGHT, HOP HEIGHT, AND LANDING FORM

Betsy A. Myers

PURPOSE/HYPOTHESIS: Reduced nonweightbearing (NWB) and weightbearing dorsiflexion range of motion (DF) is correlated with knee valgus when squatting or performing a lateral step down. Knee valgus is a known risk factor for a variety of lower limb injuries, including anterior cruciate ligament rupture. Reduced DF is also correlated with increased anterior tibial shear forces and reduced sprint speed. The relationship between DF and high-level sporting tasks in volleyball is unclear. Because unilateral strength and coordination deficits may be masked in bilateral tasks, assessing both bilateral and unilateral tasks is important. The purpose of this study was to examine the relationship between NWB DF, jump/hop height, and landing form.

NUMBER OF SUBJECTS: 27 NCAA Division I female volleyball players (mean age 22 years, range 18-22)

MATERIALS AND METHODS: NWB DF was measured in short sitting using a goniometer. Limited DF was considered less than 20 degrees. Vertical jump, vertical hop, and video assessment of landing form was performed using the Optojump testing device. Jump and hop heights were recorded to the nearest 1/10th cm. Two reviewers rated landing form by scoring the patella position, iliac crest level, and trunk position on a 0-2 scale with higher scores indicating poorer hop form. Jump form was scored by assessing patellar position using the same scale. Disagreements were discussed until consensus was made. Scores were summed to create composite jump and hop scores. A Chi-squared test was used to determine associations between median jump/hop height and DF. Effect sizes for correlations were calculated using phi and interpreted as follows: 0 = no relationship; .10 = negligible effect; .20 small effect; .30 medium effect; and .50 large effect. A rank biserial correlation coefficient was used to determine associations between DF and landing form.

RESULTS: DF was significantly correlated with jump height, $\chi^2(1) = 5.54$, $p = .019$ with a medium to large effect ($\phi = .47$). Dominant DF was significantly correlated with hop height, $\chi^2(1) = 4.49$, $p = .034$, with a medium to large effect ($\phi = .41$) but nondominant DF was not, $\chi^2(1) = 6.24$,

$p = .013$. DF was not correlated with jump form, $r_{rb}(25) = .054$, $p = .235$. Dominant DF was significantly negatively correlated with dominant hop form, $r_{rb}(25) = .005$, $p = .980$. Nondominant DF was not correlated with nondominant hop form, $r_{rb}(25) = .236$, $p = .235$.

CONCLUSIONS: Individuals with limited DF had significantly lower jump and dominant hop heights than those with normal DF. Limited dominant leg DF was associated with worse landing form. On the nondominant leg, limited DF was not related to hop height nor landing form.

CLINICAL RELEVANCE: Having normal DF may be beneficial in volleyball, particularly for front row players, to allow greater vertical excursion for blocking and attacking. While the relationship between limited DF and poor landing form is inconsistent, loss of DF may put a volleyball player at increased risk for injury. Because limited DF is easily rectified, screening and addressing restrictions is recommended.

SP0124

COMPARING THE MODIFIED BUTTERFLY AGILITY TEST TO OTHER PHYSICAL PERFORMANCE TESTS AMONG COMPETITIVE SOCCER ATHLETES

Richard Louis Cahanin, Troy Burley, Andy George Waldhelm

PURPOSE/HYPOTHESIS: The Butterfly Agility Test (BAT) has shown to be a valid and reliable measure of speed, agility, and muscular power; however, some aspects of the test are not optimized for clinical application. A modified BAT (mBAT) requires less area to conduct and has shown comparable reliability to the original version, but its validity has not been assessed. Therefore, the purpose of this study was to compare the mBAT to other validated physical performance tests among a population of young competitive American soccer athletes. The null hypothesis was that no significant relationships between self-reported 12-month history of lower body injury or player positions would be found between the mBAT, the single-leg vertical jump (VJ), and Y-Balance Test (YBT).

NUMBER OF SUBJECTS: A purposive sample of forty-two high-school and collegiate competitive American soccer athletes (55% female, mean age = 18.2 years, mean height = 1.70m, mean weight = 63.9 kg, and mean BMI = 22.1) were recruited.

MATERIALS AND METHODS: Each subject completed a physical performance testing battery consisting of the mBAT, VJ, and YBT in random order. Each subject performed two practice trials of each test prior to two recorded trials. The average of two recorded trials was used for data analysis.

RESULTS: The mean mBAT, relative composite YBT, and VJ performance were 13.68 ± 0.91 sec., $0.98-0.99 \pm 0.07$ %, and $32.76 - 36.07 \pm 6.88 - 7.66$ cm, respectively. Moderate relationships with the mBAT were found for age ($r = -0.48$, $p = 0.001$) and height ($r = 0.32$, $p = 0.038$). Significant relationships with the mBAT ($p = 0.013$) and YBT ($p > 0.037$) between male high-school athletes and female collegiate athletes were found; although no significant relationship was found with VJ ($p > 0.512$). Female collegiate athletes performed better than male high-school athletes on the mBAT ($\bar{x} = 13.37$ vs. 14.05 sec.). Conversely, male high-school athletes performed better on the YBT ($\bar{x} = 1.00-1.02\%$ vs. $0.96-0.97\%$). Additionally, no significant relationships were found between the mBAT, YBT, or VJ with player position ($p > 0.426$), although a trend was found for the mBAT between defenders and goalkeepers ($\bar{x} = 13.09$ vs. 14.19 sec., $p = 0.05$), with defenders demonstrating better performance. Finally, no significant relationships were found between the mBAT, YBT, or VJ with 12-month self-reported lower body injury history ($p > 0.126$).

CONCLUSIONS: Among competitive American soccer athletes, collegiate females performed relatively better on the mBAT and worse on the YBT compared to high-school males. Also, compared to the YBT and VJ, the mBAT demonstrated better ability to discriminate physical performance between high-school males and collegiate females. Furthermore, the mBAT demonstrated relatively better discrimination between player positions compared to the YBT or VJ.

CLINICAL RELEVANCE: The mBAT is a useful addition to a comprehensive physical performance testing battery to be used among competitive American Soccer athletes.

SP0125

HAMSTRING AND GASTROCNEMIUS MUSCLE VOLUME CONTRIBUTION TO NORDIC HAMSTRING EXERCISE FORCE IN COLLEGIATE FOOTBALL ATHLETES

João Barboza da Silva Neto, Mikel Renee Joachim, David Opar, Silvia Blemker, Brett Mortensen, Aaron Wayne Johnson, Emma Remington, Vera Lúcia dos Santos Alves, Bryan C. Heiderscheit

PURPOSE/HYPOTHESIS: The Nordic hamstring exercise is known as a knee flexor dominant exercise and an effective way to increase hamstring muscle volume (MV). However, the relative influence of individual hamstring and gastrocnemius MV on Nordic hamstring exercise (NHE) force in high-level athletes has not been described. Our purpose was to investigate the association between these muscle volumes and NHE peak force. We hypothesized that there would be a positive association between each individual hamstring and gastrocnemius MV and NHE peak force.

NUMBER OF SUBJECTS: 125 uninjured NCAA Division 1 collegiate football athletes.

MATERIALS AND METHODS: Athletes completed preseason NHE testing and underwent magnetic resonance imaging to quantify MV, bilaterally. After 3 warm up trials, each athlete completed 3 NHE maximum effort trials, with the highest normalized peak force value (N/kg) for each limb across the trials used for analysis. MV was calculated using automatic muscle segmentation for each hamstring and gastrocnemius muscle for each limb and normalized to body surface area (ml/m^2). A linear mixed effect model assessed the relationship between each individual normalized hamstring and gastrocnemius MV and NHE normalized peak force, controlling for hamstring strain injuries within prior 12 months and repeated observations across limbs.

RESULTS: Semitendinosus (ST; $p < 0.001$), biceps femoris long head (BFLH, $p < 0.01$), semimembranosus (SM, $p = 0.04$) and medial gastrocnemius (MG, $p = 0.03$) MV were significantly associated with peak NHEs, while biceps femoris short head (BFSH) and lateral gastrocnemius (LG) volumes were not. A $10 \text{ ml}/\text{m}^2$ increase in ST, BFLH and SM MV was each associated with $1.1 \text{ N}/\text{kg}$ (95% CI: $0.6, 1.6 \text{ N}/\text{kg}$), $0.7 \text{ N}/\text{kg}$ (95% CI: $0.2, 1.2 \text{ N}/\text{kg}$) and $0.5 \text{ N}/\text{kg}$ (95% CI: $0.0, 0.9 \text{ N}/\text{kg}$) increase in NHE peak force, respectively. For MG the same $10 \text{ ml}/\text{m}^2$ increase in MV was associated with a $0.5 \text{ N}/\text{kg}$ (95% CI: $-0.9, -0.0 \text{ N}/\text{kg}$) decrease in NHE peak force. Average (\pm standard deviation) values for each metric were: NHE peak force, $4.40 \pm 0.86 \text{ N}/\text{kg}$; ST, $160.0 \pm 23.2 \text{ ml}/\text{m}^2$; BFLH, $137.5 \pm 23.9 \text{ ml}/\text{m}^2$; BFSH, $70.9 \pm 12.3 \text{ ml}/\text{m}^2$; SM, $171.0 \pm 24.2 \text{ ml}/\text{m}^2$; MG, $156.4 \pm 31.0 \text{ ml}/\text{m}^2$; and LG, $90.9 \pm 15.7 \text{ ml}/\text{m}^2$.

CONCLUSIONS: ST, BFLH, and SM muscle volume had a positive relationship to NHE peak force, while the gastrocnemius muscles showed a negative relationship (medial) or no relationship (lateral).

CLINICAL RELEVANCE: NHE is commonly used to increase the eccentric strength of the hamstring muscles; however, all knee flexors including the gastrocnemius muscles may contribute to the exercise, thereby reducing the demand on the hamstrings. The current findings indicate that larger hamstring muscles, specifically the ST, BFLH and SM, are associated with greater NHE peak force, while larger gastrocnemius muscles are not, suggesting the hamstrings are the major contributor to NHE force.

SP0126

ESTABLISHING PREDICTIVE PHYSICAL PERFORMANCE MEASURES FOR GOLF SWING VELOCITY

Gabrielle Flocco, John Ryan Magill

PURPOSE/HYPOTHESIS: Identify the relationship between demographic variables and physical performance measures on driver clubhead speed in collegiate golfers.

NUMBER OF SUBJECTS: Ten male NCAA Division 1 golfers

MATERIALS AND METHODS: Subjects completed a battery of physical performance measures over an 8-month period (8 sessions). Data was collected every six weeks on the following physical performance measures: seated 4lb chest pass distance, 10lb and 30lb lat pull down power, counter-movement jump (CMJ) height, relative strength index (RSI): bench press, squat, and deadlift. Driver clubhead speed was collected by Trackman Systems and was collected as the average miles per hour of five consecutive swings. Statistical analysis was performed using chi-squared automatic interaction detection (CHAID) model.

RESULTS: Individual demographic and performance measures were predictive of clubhead speed. The CHAID analysis successfully created a decision tree predictive model that predicted the average diver clubhead speed for the sample as 110.88 mph. Seated 4lb chest pass was the most discriminative measure and categorized the subjects into three distinct groups: lower swing speed (101.98 mph), moderate swing speed (112.94 mph), and higher swing speed (125.60) groups ($F = 28.43, p < .001$). Subjects' height was predictive of swing speed for the lower swing speed group ($F = 14.04, p < .05$); a height of 165.1 cm or less decreased clubhead speed by 15.25 mph to 86.73 mph. Height greater than 180.34 cm increased clubhead speed by 12.75 mph to 114.725 mph. CMJ height was a discriminator for golfers with moderate clubhead speed ($F = 15.06, p < .05$); a jump less than 9.88" predicted a clubhead speed of 108.20 mph, and a jump greater than 9.88" increased clubhead speed to 115.09 mph. Demographic variables of age and weight were not predictors of clubhead speed.

CONCLUSIONS: Predictive modeling of driver clubhead speed is possible with CHAID analysis. Results indicated an individualized step-wise progression for improving clubhead speed. Increasing chest pass based on optimum cut points of the CHAID model can increase clubhead speed 10.968-23.623mph ($p < .05$). Modifiable performance predictors had a larger influence on clubhead speed than demographic variables, with 4lb chest pass being found as the most discriminative independent predictor.

CLINICAL RELEVANCE: Club head speed has been linked to improved performance in amateur golfers. Current research has found inconsistent findings on the effect of demographic and physical performance variables on the club head speed. The findings of this study indicate that club head speed can be accurately predicted with physical performance measures and demographic variables in collegiate golfers. Establishing the effects of physical performance measures on club head speed will enable future investigations to evaluate the predictive ability of physical performance measures on a larger population. The creation of a decision tree model can lead to an individualized training plan to improve club head speed.

SP0127

CAFFEINE AND ISOLATED AND MULTI-JOINT ACUTE MUSCLE STRENGTH IN ADULT FEMALES: A CASE REPORT ANALYSIS

Nicole Leigh Schroeder, Logan Les Leichtman, Caitlin E. Yauch, Hazel Luque, Suchitra Singh, Jonathon Yeh, Jerrica Poling

BACKGROUND AND PURPOSE: Caffeine is one of the most widely used and studied substances, particularly as it pertains to human performance and its potential to increase strength, power, and velocity. In fact, one meta-analysis revealed a significant increase in acute muscle strength with the use of caffeine. However, this analysis concluded most of the studies involved male participants, so further research into caffeine's effects on female subjects was warranted. This is especially important since there is some evidence to suggest males process caffeine faster than females. Additionally, most studies utilize large muscle groups or multi-joint movements for testing while less is known about caffeine's effects on isolated muscle strength, especially regarding the core or lower abdominal muscles. Therefore, the purpose of this study was to assess female athlete isolated and multi-joint strength before and after caffeine supplementation.

CASE DESCRIPTION: Participants included 10 active females of normal BMI (average BMI 24.3) and aged 18-35 (average age 22.3 years) who reported

a history of caffeine use. Participants were recruited from a rural, private midwestern university. After providing informed consent, participants completed a manual muscle test (MMT) for lower abdominal strength, and a 1 repetition maximum (1 RM) for the clean. The MMT was performed using the protocol described in *Kendall's Muscles: Testing and Function with Posture and Pain* while the 1 RM clean was performed as recommended by the National Strength and Conditioning Association in *The Essentials of Strength and Conditioning*. Following baseline testing, participants consumed 5 mg of caffeine per kg of body weight in accordance with a protocol outlined by Filip-Stachnik, 2021. Participants consumed an average of 393.5 mg of caffeine in the form of chewing Militech Energy Gum for 15 minutes. After 15 minutes, testing lower abdominal MMT and 1 RM clean was repeated by the same researcher to improve testing reliability.

OUTCOMES: Data Analysis was performed using SPSS software, version 27 on all subjects. A paired t-test was used to compare participant lower abdominal MMT and 1 RM clean assessments before and after caffeine ingestion. Significance was determined using a two-tailed test with $p \leq 0.05$. The p-value for lower abdominal strength ($p = 0.00$) and 1 RM clean ($p = 0.02$) indicate a significant improvement in strength testing after caffeine consumption.

DISCUSSION: The results of this small study reveal a significant improvement in female athlete acute strength testing for isolated and multi-joint muscle groups 15 minutes after ingesting 5 mg/kg caffeine. Prior studies have called for more research on the effects of caffeine on female athlete strength, especially regarding the length of time needed for females to metabolize caffeine. The results of this study can be used to guide female athlete education regarding the use of caffeine to improve isolated and multi-joint muscle strength.

SP0128

PALMAR COOLING EFFECTS ON VERTICAL JUMP, PEAK KNEE EXTENSION FORCE, AND ENDURANCE: AN INVESTIGATIVE STUDY

Gary Dean Schindler, Victor Dean Anselmo, Minda Caillier, Amber Darge, Emily Christine Frigaard, Cullen Krueger, Olivia S. Motter, Richard Michael Morgan

PURPOSE/HYPOTHESIS: Palm cooling (PC) has been found to have a positive impact on work volume and strength response in resistance training. The research found individuals who received PC between sets had increased work volume, work capacity, strength, and endurance. Previous research has primarily investigated the effects of PC on strength and aerobic capacity; however, research is lacking in regard to palm cooling and power. The purpose of this study was to explore the effects PC has on power, strength, and endurance.

NUMBER OF SUBJECTS: 90

MATERIALS AND METHODS: Ninety participants (1st- and 2nd-year PT students), 46 females and 44 males, completed 3 tests (vertical jump, maximum knee extension peak force, and endurance). Participants were randomly selected to complete the first test day with or without the cooling agent (Game Ready at 50 degrees F) and vice versa on the second day. Two test days occurred with a 3-week separation period in order to avoid a training effect. Vertical jump and knee extension force were analyzed utilizing the Vertec Jump System and a MicroFET dynamometer stabilized to a table. During vertical jump and maximum peak knee extension force measurements, participants completed 2 sets of 3 repetitions with PC for 2.5 minutes before the 1st set and between the 2 sets. Endurance was assessed via the Queens College Step Test (QCST). The QCST consisted of stepping up and down on a 16.25-inch platform in rhythm with a metronome (men = 96 bpm, women = 88 bpm) for 3 minutes. PC was applied during the endurance test with the final heart rate documented.

RESULTS: SPSS was used for repeated measures pairwise comparison analysis. A significant ($p < .001$) reduction in heart rate was found with PC

(77.2 bpm) versus non-palm cooling (N-PC) (82.3 bpm). However, no statistical significance ($t = .147$) was found during the vertical jump between PC (21.6 inches) and N-PC (21.9 inches) and max peak force ($t = .084$) with PC (98.4 lbs.) and N-PC (102.7 lbs.). Overall, no significant difference was identified between PC and N-PC test days within the vertical jump and maximum knee extension force. A statistical difference was noted during QcST ($p < .001$).

CONCLUSIONS: Data collected in this study demonstrate PC may have a significant impact on heart rate during endurance activities and limited effects regarding power and strength. The aerobic findings are consistent with the hypothesis that PC may reduce heart rate during endurance activities. This data suggests PC may improve endurance training outcomes. **CLINICAL RELEVANCE:** Literature has identified PC as an effective tool for improving strength and endurance. Identifying reduced overall heart rate during endurance activities with PC may allow greater training to be completed with endurance athletes. In addition, PC may allow for earlier progression of walking and endurance activities for special patient populations (i.e., cardiac patients) and allow them to participate earlier in daily activities.

SP0129

RELIABILITY OF ASSESSING UPPER BODY PULLING PEAK FORCE STRENGTH USING A PROGRESSOR 500 DYNAMOMETER

Katy Eileen Mitchell, Abhinav P. Bhatt, Nicholas Keith Purcell, David Anderson, Nathania Liem, Samantha Shaw, Christina Marie Bickley

PURPOSE/HYPOTHESIS: There is a need to assess functional upper body strength in the climbing community. The Progressor 500 dynamometer by Tindeq was developed to meet this need, however there is limited psychometric evidence supporting its use. This study assessed the reliability of this new device and model with healthy individuals. The purpose of this study was to determine the standard error of the mean (SEM_{Mean}), standard error of measurement (SEM_{Measure}), and the reliability of peak force (PF) assessment: 1) test-retest (with/without upper extremity (UE) repositioning), 2) dominant (D)/non-dominant (ND) and 3) between identical dynamometers.

NUMBER OF SUBJECTS: 50

MATERIALS AND METHODS: Healthy adults (males and females) were recruited from Texas Woman's University. Two dynamometers were suspended from a chin-up bar. Below the dynamometer, a Power Guidance 5-sided hangboard was attached. Participants pulled down with maximum effort using the 4 finger hole in a seated position with the tested shoulder and elbow at 90° of flexion. For set 1, one UE was randomly selected. After a practice trial, three trials were completed. The UE was repositioned only between trials 2 and 3. Next, the protocol was repeated with the opposite arm. Finally, the protocol was repeated with the D arm but using a 2nd (but identical) dynamometer. Data was analyzed using t-tests, Pearson correlations, and linear regression with SPSSv28.

RESULTS: The SEM_{Mean} was 2.32 (ND) and 2.24 (D). The SEM_{Measure} was 1.87kg. (ND) and 1.93kg. (D). For test-retest reliability without repositioning, the average PF was 36.2±16.37kg (ND) and 37.3±15.78kg. (D). There were no significant differences in PF between trials 1 and 2 for either side, $p \geq .336$. There was a significant association between trials 1 and 2 at $r = .987$, $p < .001$ (ND), and $r = .985$, $p < .001$ (D). For test-retest reliability with repositioning, there were no significant differences in PF between trials 2 and 3 for either side, $p \geq .303$. There was a significant association between trials 2 and 3 at $r = .987$, $p < .001$ (ND), and $r = .980$, $p < .001$ (D). When ND vs. D UEs were compared, there were no significant differences in PF at $p = .059$. The correlation between the ND and D averages was $r = .969$, $p < .001$. When comparing identical dynamometers, there was a significant difference in the averages of trials 1 and 2 at $t(49) = 3.997$, $p < .001$. The mean difference between the devices was 2.57kg. (95%CI: 1.28, 3.87).

CONCLUSIONS: This study provides psychometric evidence to support the clinical application as well as future research with the Progressor 500. This study found the device to be a highly reliable, and it maintained its

reliability after arm repositioning. There was a difference found between identical devices, so it is advised to consistently use the same dynamometer within and between sessions.

CLINICAL RELEVANCE: Clinicians looking to test climbers' strength in functional rock-climbing positions may consider using the Progressor 500. Clinicians can use the values presented in this study for comparative purposes as well as use the testing set-up as a clinical model.

SP0130

EFFECTIVENESS OF PHYSICAL THERAPY INTERVENTIONS IN MANAGING ROCK CLIMBING INJURIES: A MIXED-METHOD STUDY

Anna Chleboun, Tarang Kumar Jain

PURPOSE/HYPOTHESIS: Rock climbing, a growing recreational and competitive sport, is associated with a high incidence of specific musculoskeletal injuries due to its unique biomechanical demands. Current literature indicates a gap in comprehensive understanding and application of effective therapeutic and preventative interventions tailored for climbers. The purpose of this study is to identify effective therapeutic modalities and preventative strategies for common musculoskeletal injuries among recreational rock climbers, as perceived by practicing physical therapists. **NUMBER OF SUBJECTS:** Thirty-eight licensed physical therapists participated, each having treated at least one recreational rock climber in the past year. The sample included practitioners with diverse experience levels and practice settings.

MATERIALS AND METHODS: This mixed-method study used a cross-sectional online survey via Qualtrics, with 31 questions on demographics, injury prevalence, and treatment approaches. Quantitative data were analyzed descriptively and inferentially to outline prevalent injuries and treatments. Qualitative data were examined to identify common themes in injury causes, treatment methods, and prevention strategies.

RESULTS: Survey results showed high rates of finger pulley injuries (44%), shoulder dislocations or strains (33%), and shoulder impingement or rotator cuff injuries (23%). Repetitive stress or overuse caused 89.65% of injuries. Key qualitative themes of contributing factors to injuries included poor training load management, leading to overuse injuries, inadequate warm ups, premature return to climbing after an injury, and sudden training intensity increases. Effective rehab involved progressive overload using sport-specific strength measurements, on-the-wall training, and tailored strength and mobility exercise prescriptions. Manual therapy, such as dry needling and soft tissue mobilization, provided short-term relief and long-term gains, supported by taping and patient education. Injury prevention stressed load management, proper warm-up, training logs, and climbing on varied terrain.

CONCLUSIONS: In conclusion, physical therapists are essential in managing and preventing rock climbing injuries. Effective strategies include rest, exercise prescriptions, manual therapy, and load management education. These approaches address immediate injuries and aid long-term prevention and performance. Qualitative insights highlight the need for improved load management and technique training.

CLINICAL RELEVANCE: This study highlights the importance of tailored physical therapy for rock climbing injuries. Emphasizing load management, technique improvement, and comprehensive exercise programs can reduce injuries and enhance recovery. Applying these strategies in practice can elevate sports therapy for climbers with a holistic approach. Future research should examine long-term outcomes of sport-specific rehab protocols and metrics.

SP0131

ISOKINETIC DYNAMOMETRY FOR EXTERNAL AND INTERNAL ROTATION SHOULDER STRENGTH IN YOUTH ATHLETES: A SCOPING REVIEW

Ian Michael Leahy, Erin Marie Miller, Mary Shotwell

PURPOSE/HYPOTHESIS: This review examines existing evidence regarding the utilization of Isokinetic Dynamometry for shoulder strength testing in youth repetitive overhead athletes.

NUMBER OF SUBJECTS: 23 articles meeting the inclusion criteria from 2000 - 2024

MATERIALS AND METHODS: A comprehensive literature search was conducted using PubMed and EBSCO Host databases, covering publications from 2000-2024. Search terms included “isokinetic dynamometry,” “shoulder,” and “youth athlete.” Inclusion criteria focused on youth athletes (<18 years) engaged in organized sports, excluding those with neurological conditions or designated as college or professional athletes. The PRISMA-ScR guidelines were followed.

RESULTS: A total of 23 articles met the inclusion criteria. Volleyball and swimming were the most studied sports, with common testing positions being the seated 90/90 position. Variations in testing speeds and outcome measures, such as peak torque and ER ratios, were identified. Research highlighted the impact of sport-specific movements on shoulder muscle dynamics and the potential for strength imbalances that increase injury risk.

CONCLUSIONS: Isokinetic dynamometry is a valuable tool for assessing shoulder strength in youth overhead athletes. It provides critical insights into muscle strength dynamics, aiding in injury prevention and rehabilitation. However, gaps remain, particularly in understanding normative strength values in younger, skeletally immature athletes. Further research is needed to optimize strength assessment protocols and enhance clinical decision-making for safe return-to-sport practices.

CLINICAL RELEVANCE: Clinicians encounter difficulties in accurately measuring shoulder strength in overhead athletes due to the dynamic nature of the movements. Isokinetic dynamometry (ID) offers dynamic strength assessments that static methods, such as manual muscle testing and handheld dynamometry, cannot provide. Benchmarks exist for shoulder function in adults, but little is known about measurement of shoulder function in the youth throwing athlete. This study provides data ranges and parameters in the youth, overhead athlete and discusses the gaps in the literature with regards to normative shoulder strength values in skeletally immature throwing athletes.

SP0132

BEYOND THE MOUND: COMPARING POST-SEASON PERFORMANCE METRICS IN PITCHERS AND NON-PITCHER JUNIOR COLLEGE BASEBALL PLAYERS

Janna Michelle McGaugh, Charles T. Morrison, Kelci Cope, Zachary L. Hettler, Amy Lam, Meagan Taylor Springer, Benjamin D. Brightwell

PURPOSE/HYPOTHESIS: The use of wearable sensors to monitor performance and injury risk is increasing in popularity in competitive athletics. Identifying relationships between easily implementable field tests and instrumented performance metrics can provide athletic programs with potentially useful information for improving athletes' performance and reducing injury risk. This study's purpose was to understand relationships between instrumented assessments and field tests and identify performance asymmetries. We hypothesize that upper extremity peak acceleration and peak velocity during the Closed Kinetic Chain Upper Extremity Strength Test (CKCUEST) is correlated with vertical jump height and isometric mid-thigh pull (MTP) strength. Additionally, we hypothesize that peak accelerations and velocities would be different between pitchers and non-pitchers.

NUMBER OF SUBJECTS: 27 junior college baseball players (13 pitchers), aged (18.8 ± 0.7 years), BMI (25.5 ± 2.0 Kg/m²) participated.

MATERIALS AND METHODS: Performance tests included the CKCUEST, isometric MTP measured on a dynamometer, and the Vertical Jump height estimated with flight time. Inertial measurement units fixed to athletes' wrists during the CKCUEST measured peak acceleration and peak velocity of the dominant (DUE) and non-dominant (NDUE) upper extremities. Normality was assessed with the Shapiro-Wilk test. Differences in the performance of pitchers and non-pitchers were assessed with independent samples t-tests. Pearson product-moment correlations with

Bonferroni corrections were used to evaluate associations among kinematic variables and field tests.

RESULTS: Vertical jump height (28.7±3.9 in.) was significantly correlated with peak velocity of the DUE (r = 0.9) and NDUE (r = 0.8) and peak acceleration of the DUE (r = 0.7) and NDUE (r = 0.7) during the CKCUEST. Mid-thigh pull (406.4±83.1 lb.) was significantly associated with peak acceleration of the DUE (r=0.7). Performance on the CKCUEST was similar between groups [pitchers 24±4; non-pitchers 25±4; p=0.64]. Peak velocity of the NDUE was slower in pitchers (722.0±98.1°/s) than non-pitchers (834.3±110.0°/s; p= 0.03). No significant difference in upper extremity kinematic values were identified. Vertical jump height and MTP performance were not significantly different between pitchers and non-pitchers.

CONCLUSIONS: Our hypotheses were partially supported as upper extremity peak accelerations and velocities during the CKCUEST were significantly associated with vertical jump height, and peak acceleration of the dominant arm was associated with MTP. Only peak velocity of the non-dominant arm was significantly slower for pitchers compared to non-pitchers

CLINICAL RELEVANCE: Performance testing can identify changes in physical performance post-training. Instrumented testing offers a more sensitive method to detect kinematic impairments. Decreased peak velocity in the nondominant arm of pitchers during the CKCUEST may indicate the presence of compensatory overuse or fatigue in the dominant arm. Addressing these imbalances in the transition period could optimize performance and reduce injury risk for the spring season.

SP0133

IMPORTANCE OF MAXIMAL FORCE AND POWER OUTPUT FOR MODULATING LANDING FORCES

Zachary Lorbeck, Charles Nathan Vannatta, Ward Dobbs, Salvador Jaime, Becky Lynn Heinert, Thomas Kernozeck

PURPOSE/HYPOTHESIS: Augmented feedback training with and without a dual-task condition may be effective in improving drop landing (DL) performance, but some athletes demonstrate minimal improvement. Strength, power, and low landing vertical ground reaction force (vGRF) have been identified as factors that mitigate ligamentous knee injury risk but the role of force production capacity in attenuating vGRF during DL has not been characterized. Our purpose was to evaluate differences in force production and jump performance between those who responded to augmented feedback in DL training and those who did not.

NUMBER OF SUBJECTS: 45 female collegiate basketball (12) and volleyball (33) athletes (height 1.73±0.12m; weight 71.5±10.7kg)

MATERIALS AND METHODS: Athletes completed an augmented feedback DL training session followed by an isometric midhigh pull (IMTP) and a countermovement jump (CMJ). DL was performed from a 50 cm box onto two force plates (2000 Hz) where they completed 6 pretest DL, followed by 6 DL with augmented feedback, followed by 6 posttest DL. Next, 3 CMJ were performed on force plates (1000 Hz) while holding a polyvinyl pipe in a back squat position. CMJ mean propulsive force (PF), braking force (BF), propulsive impulse (PIMP), and braking impulse (BIMP) were calculated and normalized to body weight (kg). 2-3 IMTP were performed on the force plates with a 1-inch pipe at the mid-thigh position. Athletes were grouped into tertiles based on the percentage change in peak vGRF during the augmented feedback DL training, where the top third was identified as the “responders (RS)” and the bottom third as the “non-responders (NRS)”. Independent t-tests examined differences in performance variables between groups. A repeated measures ANOVA (alpha=.05) compared the effects of augmented feedback training on vGRF between the RS and NRS groups from pre to post.

RESULTS: Overall, RS reduced vGRF by 40.5% while the NRS reduced vGRF by 10.6%. There was a 27.2% reduction of vGRF between the pretest test and posttest (12.1 N/kg and 6.8 N/kg) for both groups (p<0.001). An interaction was found between the groups (RS and NRS) and time (pre to post), showing the RS had a greater decrease in vGRF (23.7 N/kg) than the NRS

(4.9 N/kg) with augmented feedback training. RS had a greater IMTP peak force (13.9%), BF (9.9%), PF (8.9%), and PIMP (10.6%) ($p < 0.05$). BIMP did not differ (5.6%). Effect sizes for the IMTP, BF, PF, and PIMP were medium-large (0.65–0.93), while BIMP was small (0.35).

CONCLUSIONS: RS improved more with augmented feedback training in DL than the NRS and demonstrated greater IMTP force, PF, BF, and PIMP. These performance variables may give athletes a greater capacity to alter vGRF. Thus, athletes may need sufficient force and power production to augment vGRF during DL.

CLINICAL RELEVANCE: The IMTP and CMJ may provide helpful metrics to assess underlying capacity for force production and facilitate evaluation and training of jump landing. Sports medicine providers may have to target strength and power before working on the ability to absorb forces during deceleration activities and specific training to each of these areas may be necessary.

SP0134

EFFECTS OF BLAZE PODS TRAINING ON SIMPLE AND COMPLEX REACTION TIMES OF DIVISION I ATHLETES

Jake Dominic Kocovsky, Gary Dean Schindler

PURPOSE/HYPOTHESIS: Traditional methods using proprioception and hand-eye coordination training techniques were developed to improve the mind-muscle connection and reaction time. However, little research has been conducted on the effects of different training methods on Simple Reaction Time (SRT) and Complex Reaction Time (CRT). Blaze Pods (BP) flash reflexive technology is a modality that utilizes various patterns of light flashes, while recording their subjects' times, to train an agility-saturated athlete and improve their overall reaction. The purpose of this research was to investigate the effectiveness of BP in improving reaction time for both SRT and CRT compared to proprioceptive training. The hypothesis is Blaze Pod training will show significant improvements in SRT and CRT compared to the proprioception training and control groups.

NUMBER OF SUBJECTS: 17

MATERIALS AND METHODS: Seventeen Division I male FB athletes participated in this study. Participants were randomly selected into a BP group ($n = 6$), Proprioception (PG) group ($n = 5$), or Control (CG) group ($n = 6$). Prior to the pre-testing, the arm span (AS) was measured which assisted in reliable and consistent BP positioning. For the pre-SRT and CRT, three different patterns were completed with the average of three trials being recorded as the final number. During post-SRT and CRT, identical setups and patterns were used to ensure reliability and equal comparison between test times. BP and PG groups completed 6 exercise sessions. Three exercises were completed (3 sets x 30 seconds) during each session. Proprioception training progressed in difficulty per session including foam, medicine ball throws, and cervical movements. CG maintained their current activity level.

RESULTS: Data were analyzed via SPSS software utilizing t-test and one-way ANOVA. Comparisons were made between and within groups regarding pre- and post-training SRT and CRT. Statistically significant SRT improvements were noted in the BP, PG, and CG groups; however, only the BP group was found to have significantly improved CRT ($p < .05$). No significance was found within groups regarding SRT and CRT.

CONCLUSIONS: This study demonstrated statistically significant SRT improvements in the BP, PG, and CG groups; however, only the BP group was found to have significantly improved CRT ($p < .05$). No significance was found within groups regarding SRT and CRT. Training consisting of only 6 sessions and a smaller sample size may have limited this study. Further research is warranted to determine if differences exist between BP and proprioceptive training regarding SRT and CRT and if differences exist in injury prevalence.

CLINICAL RELEVANCE: Limited research exists regarding training to improve simple and complex reaction time. Utilizing Blaze Pods may help agility-saturated athletes improve their reaction times and ultimate performance. Identifying alternative strategies for neurocognitive stimulus may

improve speed, agility, and reaction time. Therefore, improving function and optimum athletic performance while possibly reducing the incidence of injury.

SP0135

SEX DIFFERENCES IN PSYCHOLOGICAL READINESS TO RETURN TO SPORT AMONG ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION ATHLETES

Makayla Lawrence, Adam Nicholas Finck, Aaron Krych, Christopher V. Nagelli

PURPOSE/HYPOTHESIS: To compare sex differences in psychological readiness to return to sport among athletes with an anterior cruciate ligament reconstruction (ACL) surgery. Secondly, we wanted to understand if there were any interactions between sex and meeting a previously validated Anterior Cruciate Ligament Return to Sport After Injury (ACL-RSI) cut-off score which had fair to good predictive ability for return-to-sport outcomes. We hypothesize that female athletes will report significantly lower ACL-RSI scores than males and there would be a significant interaction between sex and reaching the 60 points or above cut-off score on the ACL-RSI.

NUMBER OF SUBJECTS: 74 athletes (45 females and 29 males; 20.2 ± 7.8 years old; 8.7 ± 2.3 months post-ACL)

MATERIALS AND METHODS: A retrospective chart review study was performed for patients who had undergone a primary ACLR. At the time of the athlete's return to sport testing, we collected their demographic information, ACL-RSI score, and time from their ACLR procedure. We stratified the data by sex (male or female) or if they did or did not meet the ACL-RSI score of 60 points or above. A two-way analysis of variance (ANOVA) on ACL-RSI scores determined if there was an interaction between sex and reaching this previously validated ACL-RSI cut-off score of 60 points ($p < 0.05$). Post-hoc t-tests were conducted if a significant main effect or interaction were found.

RESULTS: There were 25 female and 22 male athletes who met the ACL-RSI cut-off of 60 points and above, and 20 female and 7 male athletes who scored below 60 points on the ACL-RSI scale. There was no significant main effect of sex ($p = 0.94$) on ACL-RSI scores (males: 74.8 ± 25.7 ; females: 66.8 ± 19.2). There was a significant interaction between sex and whether an athlete met the ACL-RSI cut-off score of 60 points or above ($p = 0.003$). Post-hoc testing determined that within the group who did not meet the ACL-RSI cut-off score, there were significant ($p = 0.01$) differences between male and female athletes ACL-RSI scores (males: 36.1 ± 19.2 ; females: 48.7 ± 9.4). However, there was no significant difference ($p = 0.08$) in ACL-RSI scores between the male and female athletes who met the ACL-RSI cut-off score (males: 87.1 ± 19.4 ; females: 81.3 ± 10.7).

CONCLUSIONS: While we did not find a significant difference in ACL-RSI scores between male and female athletes, the female athletes still reported lower average ACL-RSI scores. This study is still ongoing, and we hypothesize that including more patients will distinguish these groups. The significant interaction between sex and meeting the ACL-RSI cut-off scores suggests that sex is a key factor when considering the psychological impact of an ACL injury.

CLINICAL RELEVANCE: It is critical we identify athletes who are at greatest risk for adapting a lower psychological readiness to return to sport to develop rehabilitation strategies to improve an athlete's psychological health and confidence in their knee.

SP0136

ASSESSING AGREEMENT OF HIP MUSCLE STRENGTH MEASUREMENTS WITH HAND-HELD AND ISOKINETIC DYNAMOMETRY

Dilina Weerapperuma Desilva, Taryn Dal Degan, Parker A. Scott, Joseph James Eischen, Mario Hevesi, Chad E. Cherny, Christopher V. Nagelli

PURPOSE/HYPOTHESIS: This study aims to elucidate the reliability of the hand-held dynamometer (HHD) for isometric hip abduction strength

compared to the gold standard, isokinetic dynamometer (IKD). We hypothesize that a HHD is a valid measurement of isometric hip abduction strength and can be a useful substitute for an IKD.

NUMBER OF SUBJECTS: 33

MATERIALS AND METHODS: Healthy adults without acute hip pain were recruited for this comparative validity study. All testing was conducted at our Sports Medicine outpatient facility by one of two researchers. Participants were assessed for peak force values for isometric hip abduction using a HHD and peak torque values for isometric hip abduction using an IKD in random order, with a five-minute break between tests. After a standardized warm-up, both HHD and IKD measurements were taken, and the data was analyzed to compare the validity of HHD against the gold-standard IKD. We calculated intra-class correlation coefficients to assess reliability and used Bland-Altman plots to evaluate the agreement between the two hip strength testing devices.

RESULTS: We tested 33 healthy adults (18 males/15 females, 19-52 years old). The ICC values for peak hip abduction torque when comparing the HHD to the gold-standard IKC demonstrated poor reliability with values of 0.4258 and 0.4042 for left and right limbs, respectively. However, the ICC values for average hip abduction torque when comparing the HHD to the gold-standard IKC demonstrated moderate reliability with values of 0.6426 and 0.6285 for left and right limbs, respectively. Bland-Altman plots demonstrated agreement between the two testing methods, and on average for peak hip abduction strength, the HHD hip abduction strength values are 35 Newton-meters lower than the IKD, for either limb.

CONCLUSIONS: While comparing peak hip abduction strength using the HHD with the IKD demonstrated poor reliability, average hip abduction strength demonstrated moderate reliability. These results may have implications for rehabilitation settings that cannot access the gold-standard IKD, but desire an alternative, more accessible method to measure average hip abduction strength. Further research is required to assess the influence on reliability of different set-ups of hip abduction strength testing with a HHD or an IKD.

CLINICAL RELEVANCE: The clinical relevance of this study was to validate the HHD as a reliable and cost-effective alternative to the gold-standard IKD for assessing isometric hip strength. By demonstrating that the HHD provides comparable measurements to the IKD, the study could make objective muscle strength assessment more accessible to clinicians who lack access to expensive and time-consuming IKD equipment. This could enhance the ability of clinicians to track strength changes over time, compare patient results to normative values, and provide more accurate and efficient care in a variety of clinical settings.

SP0137

RETURN TO FUNCTION OF A 30 YO WITH ANKYLOSING SPONDYLITIS FOLLOWING TOTAL HIP ARTHROPLASTY

Michael Zlotnick, Molly Anne Malloy

BACKGROUND AND PURPOSE: Ankylosing spondylitis (AS) is a rheumatological inflammatory disease with a worldwide prevalence rate of 0.1-1.4% with increased prevalence in younger male populations. Primary research of effective physical therapy (PT) treatments for AS focus on management of the spine. Patients with AS also have musculoskeletal impairments affecting the hips (25 to 50% prevalence of hip involvement) and 5-25% of these patients have at least one total hip arthroplasty (THA). There are minimal PT guidelines for effective management of patients following hip surgery who also have underlying AS. This case provides a rehabilitation guideline for effective PT management following hip arthroplasty in a 30 year old with underlying AS.

CASE DESCRIPTION: A 30 year old male patient (pt) presented to outpatient PT using direct access 2 months following left THA. He was diagnosed with AS 6 years prior and had been taking Humira to manage hip and back symptoms and had not been sent to prior PT. The pt reported playing recreational hockey in high school and bike riding for exercise but had

not performed regular exercise since his AS diagnosis. He was diagnosed with degeneration of the pelvic region which was thought to be caused by AS and then had a THA. The patient presented to physical therapy with decreased Range of Motion (ROM) hip flexion (50°), hip extension (10°), internal rotation (0°), abduction (20°) as total ROM, limited knee extension at heel strike, decreased hip/core strength and ADL compensations (sitting, stairs, gait and transfers). A PT prescription was obtained and the pt was seen for 25 visits over a 4 month period to address his limited ROM, strength, balance, gait and functional limitations.

OUTCOMES: The pt demonstrated increased hip ROM of flexion (50° to 90°), abduction (20° to 50°), extension (10° to 20°) and improved hip strength in abduction, flexion, and external rotation. Functionally his improved ROM and strength allowed for upright posture with sitting and driving. The Lower Extremity Functional Scale Measurement (LEFS) improved by the Minimally Clinically Important Difference (MCID) from 58 to 74. Functional improvements included 30 second chair rise from unable to perform to 9 repetitions, community ambulation improved from walking with significant gait deviations and discomfort, to hiking 3 miles with minimal difficulty. After 4 months of PT he is able to ride an upright stationary bike and perform a general mobility and strengthening program on his own.

DISCUSSION: Minimal research has been completed providing guidelines for PT following THA with individuals with underlying AS. This case provides a guideline for incorporating manual therapy and ROM/strength interventions to improve general function and return to ADLs for a 30yo following THA with underlying AS. Even with underlying conditions such as AS these patients, even following a joint replacement, can return to recreational activity as this patient did.

SP0138

REHABILITATION OUTCOMES FOLLOWING ACHILLES RECONSTRUCTION COMPLICATIONS AND REVISION IN A HIKER: A CASE REPORT.

DaRell Springer, Megan W. Moran, Robert E. Metzger Jr.

BACKGROUND AND PURPOSE: Following complications with an Achilles repair, the free composite fasciocutaneous anterolateral thigh (ALT) flap with rolled fascia lata (RFL) for reconstruction is recommended. While studies suggest it is possible to regain power in the Achillies following this procedure, there is limited evidence on rehabilitation outcomes. The aim of this study is to look at rehabilitation outcomes in a hiker 7 months post-op ALT flap with RFL for Achilles reconstruction.

CASE DESCRIPTION: The patient is a 34-year-old male hiker with a history of bilateral triple arthrodesis and Achilles lengthening procedure for non-traumatic injuries; the left (L) was done in 2021 and the right (R) in 2022. In 2023, he tore his L Achilles and had a repair that failed due to infection. The patient presented to physical therapy 11 weeks post-op L free ALT flap with RFL for Achilles reconstruction. He was partial weight bearing with strength and range of motion (ROM) deficits. His goal was to return to hiking and to lift 100 pounds for work duties. The rehabilitation progression was based on time, strength, ROM, and pain. The Achilles accounts for up to 10x bodyweight during activities. To assess plantarflexion (PF) strength, the Tindeq isometric dynamometer was used in both knee flexion at 90 degrees and 0 degrees. The weight bearing lunge test (WBLT) was used as a reliable test for dorsiflexion (DF) in closed chain, as deficits reduce power with jumping. The Y-Balance Test (YBT) was used to assess dynamic balance, as decreased anterior reach has been associated with non-contact injuries. The Lower Extremity Functional Scale was used to assess functional status.

OUTCOMES: At 7-months post-op, the patient reported walking 22k steps on uneven surfaces in a day, tracked via his iPhone and walking 45 minutes prior to taking a break. He was able to lift 120 pounds with his co-worker, necessary for work duties. He demonstrated 89% symmetry with the anterior reach on the YBT. For the WBLT, 74% symmetry was obtained. He scored 53/80 on the LEFS. At 90 degrees of knee flexion PF

strength was nearly symmetrical but had deficits with knee straight at 79% symmetry. While the patient increased strength, he was unable to perform a single leg heel raise. Ambulating downstairs and walking downhill remained difficult.

DISCUSSION: This report examines the rehabilitation outcomes in a patient post-op free ALT flap with RFL for Achilles reconstruction, in an active person that requires a high level of strength, balance, and endurance. It demonstrates one patient's time frame to return to long distance walking on uneven terrain and lift heavy items following this procedure. This may be helpful for future clinicians' understanding of expected outcomes, as there is limited evidence available on the topic. Note that the patient's surgical history can influence both the symmetry outcomes and overall activity progression. Longer term studies are recommended to understand how those who undergo this surgery continue to progress with ability to run, cut, and jump for participation in sport.

SP0139

ISOKINETIC QUADRICEPS STRENGTH AT SLOWER SPEEDS FOLLOWING ACL-R INFLUENCES HOP PERFORMANCE IN ADOLESCENTS

Zachary Alan Blaydes, Joseph Patrick Hannon, Andres Burbano, Jeffery Nepple

PURPOSE/HYPOTHESIS: Isokinetic strength testing (ISKT) remains the gold standard for assessing quadricep strength following anterior cruciate ligament reconstruction (ACLR) but current literature demonstrates much variability in the testing speeds utilized. Speeds ranging from 60 to 300 degrees per/second have been reported with little consensus of what the most appropriate testing parameters are. Additionally, discrepancy in pass rates between ISKT and hop tests have consistently been reported in

the literature. The purpose of this study was to examine the influence of different ISKT speeds on functional hop test distances.

NUMBER OF SUBJECTS: We assessed 100 adolescent ACLR patients (49 males, 51 females; mean age: 15.1 ± 2.0 years, mean BMI: 23.8 ± 5.2 kg/m²) using a standardized Return-to-Play (RTP) assessment.

MATERIALS AND METHODS: Participants completed RTP assessments which included ISKT (Isokinetic Strength Test) at 60, 180 and 300 degrees/second and the single leg hop (SHOP), triple hop (THOP), and Cross-over hop (CHOP). Isokinetic data was normalized and recorded and Nm/Kg. Hop data was normalized and reported as a percentage of each subject's leg length. Multiple linear regressions were completed to assess for the influence of the three ISKT tests (60, 180, 300) on performance on each hop test (SHOP, THOP, CHOP). Analysis was performed separately for both the involved and uninvolved limb.

RESULTS: Linear regression demonstrated that only isokinetic testing at 60°/sec significantly contributed to the linear regression model for single, triple, and cross over hop normalized distances. This finding was consistent for both the involved (single hop: $R^2=.544$, $P<.001$, triple hop: $R^2=.574$, $P<.001$, cross over hop: $R^2=.498$, $P<.002$) and uninvolved (single hop: $R^2=.436$, $P=.015$, triple hop: $R^2=.516$, $P<.001$, cross over hop: $R^2=.466$, $P<.001$) limb.

CONCLUSIONS: In this cohort of patient's normalized quadriceps strength at 60 degrees per second most strongly influenced hop test distance on SHOP, THOP, and CHOP.

CLINICAL RELEVANCE: These findings seem to indicate that restoring strength at slower speeds may be most influential in improving hop distance on both the involved and uninvolved limb in adolescents following ACLR.