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The International Journal of Sports Physical Therapy is pleased to publish abstracts from the thirteenth Orthopaedic Summit (OSET) taking place in Boston, September 19-23, 2023. The IJSPT hosted the third annual research forum and reception at OSET, sponsored by ATI Physical Therapy and Hyperice. The abstracts presented in the following pages were selected by the OSET Research Committee and editorial staff of the International Journal of Sports Physical Therapy. After careful review, a total of 20 research abstracts were accepted and presented at OSET 2023. Awards for outstanding abstracts were presented on September 22.

The 2023 abstracts include contemporary orthopaedic and rehabilitation topics across various research designs. Each abstract presents only a brief summary of a research project / presentation and does not permit full assessment of the scientific rigor with which the work was conducted. While the abstracts offer only preliminary results that may require further refinement and future validation, they do serve an important role in sharing new research ideas and rehabilitation advancements. This sharing of ideas helps to encourage dialogue among researchers, clinicians, and educators that will ultimately contribute to the orthopaedic and rehabilitation body of knowledge. We strongly encourage authors to continue pursuing the publication of their research as a full manuscript.

Thank you to all submitting abstracts for consideration. We look forward to another outstanding season of submissions for OSET in 2024.

Phil Page PhD, PT, ATC

Chuck Thigpen PhD, PT, ATC

OSET Research Committee Co-Chairs

Posters from the 2023 meeting can be viewed HERE.

ABSTRACT 1

Effects of Blood Flow Restriction (BFR) on the shoulder's internal and external rotators Post-Activation Potential (PAP) performance using Hand Held Dynamometry (HHD)

Hochrein, A, Keller, K, Stoddard, S, Riemann, BL, Davies, GJ.

Introduction: Subjects use a variety of techniques to enhance performance prior to activity. Research demonstrates BFR can recruit fast twitch muscle fibers sooner due to the metabolic changes that occur in the muscle. (Lambert et. al 2023). This study wanted to determine if using BFR could also be used to enhance muscle performance. Bowman et. al. 2020, Lambert et. al. 2021 performed UE training using BFR and found that low-weight resistance BFR training provided a greater increase in strength and hypertrophy in the Upper Extremity (UE) and distal muscle groups when compared to a control group that did not use BFR. Garbisu-Hualde et. al. found PAP was most beneficial when used with loads that began at 65% of 1 Repetition Maximum (1RM).

Purpose: Perform a prospective RCT using BFR on UE to assess muscle PAP/performance.

Hypothesis: BFR will demonstrate significant increases in PAP/performance on HHD for experimental groups 1 and 2 compared to control group.

Methods: Subjects: 40 (27 females) physically active subjects, ages 18-30, were randomized into the 3 groups. Methods: Resting limb occlusion pressure (LOP) was measured using a doppler ultrasound (Karanasios et. al 2022). Subjects performed a warm-up using the UE ergometer and stretching of the shoulder. HHD measured isometric internal/external rotation (IR/ER) strength of the shoulders for pre/post-testing. Experimental group 1 performed ER/IR using BFR at 50% LOP in the dominant UE using a resistance Theraband for 4 sets of 30/15/15/15 reps at 6-8 on the Omni-Resistance scale. Exp group 2 performed a similar protocol performing 15/8/8/8 reps. Control group did not perform BFR exercises

Statistics: Pre-post within group changes and between group changes for both the control and experimental groups were assessed using repeated measures ANOVA.

Results: There was no statistically significant difference in the change in HHD for shoulder ER on the dominant arm between groups as determined by one-way ANOVA (F(2,37)

= 2.505, p = .095). There was no statistically significant difference in the change in HHD for shoulder IR on the dominant arm between groups as determined by one-way ANOVA (F(2,37) = 1.353, p = .271). There was no statistically significant difference in the change in HHD for shoulder ER on the non-dominant arm between groups as determined by one-way ANOVA (F(2,37) = .257, p = .775). There was no statistically significant difference in the change in HHD for shoulder IR on the non-dominant arm between groups as determined by one-way ANOVA (F(2,37) = 1.490, p = .239).

Discussion: Results did not support the hypothesis, therefore, using BFR for PAP/performance enhancement was not effective within the design of this study.

Summary/clinical application: More research is needed to determine the effectiveness of BFR in facilitating various aspects of human performance.

Presenting author: gdavies@georgiasouthern.edu

ABSTRACT 2

Effects of Blood Flow Restriction on upper extremity to assess neurocognitive performance using Blaze Pods

Keller, K, Hochrein, A, Stoddard, S, Riemann, BL, Davies, GJ

Waters College of Health Professions, Department of Rehab Sciences, Department of Health Sciences & Kinesiology, Georgia Southern University, Savannah, GA.

Introduction: Subjects use a variety of techniques to enhance performance prior to activity. Some of the methods involve static stretching, dynamic stretching, foam rollers, percussion devices, etc. The research demonstrates Blood Flow Restriction (BFR) can recruit fast twitch muscle fibers sooner due to the metabolic changes that occur in the muscle. Therefore, this study wanted to determine if using BFR could also be used to enhance neurocognitive reactive performance. There is limited research on UE testing using BFR with outcomes measuring neurocognitive testing. The neurocognitive Open Kinetic Chain (OKC) and the Closed Kinetic Chain (CKC) Blaze Pod reactive testing have not been used as outcome measures in any published studies to date.

Purpose: Perform a prospective randomized controlled trial using BFR on the upper extremity (UE) to assess neurocognitive reactive performance using the Blaze Pods.

Hypothesis: BFR will demonstrate significant increases in CKC and OKC neurocognitive reactive performance with Blaze Pods for experimental groups 1 and 2 compared to the control group.

Methods: Subjects: 40 (27 females) physically active subjects as per ACSM guidelines, ages 18-30, were randomized into three groups (control, experimental 1, and experimental 2) using randomizer.org. Resting limb occlusion pressure (LOP) was measured using a doppler (5). Order of neurocognitive reactive performance testing was randomized. Subjects performed a warm-up using the UE ergometer and stretching of the shoulder. The Blaze Pods measured neurocognitive reactive performance in Closed and Open Kinetic Chain for pre/post-testing, then rested 5 minutes between testing. Experimental group 1 performed shoulder external rotation (ER)/internal rotation (IR) using BFR at 50% LOP in the dominant UE using a resistance Theraband for 4 sets of 30/15/15/15 repetitions at 6-8 on the Omni-Resistance scale. Experimental group 2 performed a similar protocol with 15/8/8/8 repetitions. Control group did not perform BFR exercises.

Statistics: Pre-post within group changes and between group changes for both the control and experimental groups were assessed using repeated measures ANOVA.

Results: There was no statistically significant difference in the change in average CKC tests between groups as determined by one-way ANOVA (F(2,37) = 1.693, p = .198). There was no statistically significant difference in the change in average OKC tests between groups as determined by one-way ANOVA (F(2,37) = 1.052, p = .359).

Discussion: Results did not support the hypothesis; therefore, using BFR for neurocognitive performance enhancement was not effective within the limitations of the design of this study.

Summary and Clinical Application: More research is needed to determine the effectiveness of BFR in facilitating neurocognitive reactive performance.

Presenting author: gdavies@georgiasouthern.edu

ABSTRACT 3

THE REVERSE LUNGE: A DESCRIPTIVE ELECTROMYOGRAPHIC STUDY

Ferguson, M, Krauss, Z, Tran, S, Hoogenboom, B.

Grand Valley State University, Grand Rapids, Michigan

INTRODUCTION: Activation of key lower extremity musculature throughout the reverse lunge movement via surface electromyography (EMG) was studied. Limited studies have examined the reverse lunge compared to other forms of the lunge. The purpose of this study was to describe EMG activation of key lower extremity muscles of bilateral limbs during the reverse lunge movement. A secondary purpose was to describe the phases of both limbs (stationary [stance] and lead [moving]) during the reverse lunge movement.

METHODS: Surface electrodes were placed on target muscles (rectus femoris [RF], biceps femoris [BF], gluteus medius [Gmed], and gluteus maximus [Gmax]) of both lower extremities using standard Seniam placements. Maximum voluntary isometric contractions of each muscle were performed for use in normalizing the EMG data. Verbal cues, a mirror, tape marks on the floor, and a metronome were utilized to normalize the movement across all subjects. Each participant was allowed two practice repetitions of the reverse lunge, on each limb, prior to data collection. EMG data were collected bilaterally during four reverse lunges trials (4 left lead limb, 4 right lead limb), and phases of the lunge were marked during EMG to aid in analysis of phases. Left lead leg lunges were analyzed using Root Mean Squared EMG values and mean maximum and mean average muscle activation throughout the movement were calculated. Descriptive terminology was created to describe the phases of the lunge for the stationary and lead limbs.

RESULTS: Twenty-one healthy, active subjects participated in this study and data from nineteen subjects (10 females, 9 males, mean age 24.05 +/- 1.32 yrs) were analyzed. All values are reported as a percentage of the MVIC (%MVIC). Mean maximum muscle activations in the lead limb during the reverse lunge movement were BF 36.6%, RF 105.67%, GMed 34.29% and GMax 34.88%. The stationary limb mean maximum muscle activations were BF 17.11%, RF 36.16%, GMed 49.2% and GMax 36.61%. Throughout the movement, average muscle activity values in the lead limb were RF 32.41%, BF 10.72%, GMed 11.73%, GMax 12.68% and RF 13.55%, bicep femoris 7.04%, GMed 15.35%, and GMax 14.51% in the stationary limb. All four muscles of the stationary limb and the lead limb RF displayed greatest maximum muscle activations during the rising half of the lunge.

DISCUSSION: Across subjects, only two muscles achieved a strengthening stimulus in their maximum muscular contractions: the lead limb RF (105.67% MVIC) and the stationary limb GMed (49.2% MVIC) all other musculature performed at lower % MVIC's suggesting stabilization or neuromuscular control functions. The rising phase provided greatest maximum activations during concentric contractions. As expected, average muscle activation throughout the movement was less than maximum activation for all muscles of both limbs showing low to moderate activation throughout. There was difficulty making direct comparisons to the literature due to the limited EMG research related to the reverse lunge.

CONCLUSIONS: Operational definitions of the reverse lunge movement were created to describe the phases of the reverse lunge. Only the lead limb RF and stationary limb GMed reached a strengthening stimulus during maximum muscle contractions. These definitions and results may be used both in clinical prescription of the reverse lunge as well as in future research. Future research should compare EMG activation between types of lunges and with the addition of weight.

Presenting author: hoogenbb@gvsu.edu

ABSTRACT 4

THE UNILATERAL HIP BRIDGE ENDURANCE TEST A RELIABILITY AND DESCRIPTIVE STUDY INVOLVING FEMALE COLLEGIATE ATHLETES

Greene C,[1] Butowicz CM,[2,3,4] Brody LT,[1,5] Schuck DE,[6] Brown K,[7] Brumitt J.[1,8]

1. Rocky Mountain University of Health Professions
2. Research & Surveillance Division, Extremity Trauma and Amputation Center of Excellence, Defense Health Agency
3. Department of Rehabilitation, Walter Reed National Military Center
4. Department of Physical Medicine & Rehabilitation, Uniformed University of Health Sciences
5. University of Wisconsin Clinics Research Park
6. Atrium Health Musculoskeletal Institute Orthopedics & Sports Medicine
7. Hutchinson Regional Medical Center
8. School of Physical Therapy, George Fox University

Background: Functional performance tests (FPT) can be used to assess core stability and identify female collegiate athletes at risk for lower extremity injuries. Yet, a lack of consensus exists regarding which FPT best assesses core stability. The unilateral hip bridge endurance test (UHBET) is FPT, which uses a digital inclinometer to assess transverse pelvis displacement and may be well suited to assess core stability in athletic populations. However, the test reliability and descriptive data for collegiate female athletes are unknown.

Purpose: To establish the intra and interrater reliability for left and right sides and the average score for the UHBET using a digital inclinometer for homogenous (Phase I) and heterogenous (Phase II) cohorts of female collegiate athletes. A secondary purpose was to report UHBET descriptive scores for a cohort of female collegiate athletes and if differences exist between levels of competition and sports (Phase III).

Study Design: Descriptive Study

Methods: Phase I established UHBET intra and interrater reliability using a sample of female collegiate athletes (13 lacrosse athletes). A digital inclinometer was strapped across the athlete's pelvis to monitor pelvic neutrality in the transverse plane while the sagittal plane was assessed visually. The test terminated when the pelvis tilted greater than 10 degrees in the transverse plane or failure to maintain neutrality in the sagittal plane. The testing protocol from Phase I was repeated in a heterogenous sample (n=16, volleyball, soccer, cross-country/track & field, basketball, softball, and lacrosse) of female collegiate athletes. Three raters participated in Phases I and II. The raters were the primary investigator ([PI] 37 years of experience as a physical therapist and a certified athletic trainer), the second rater was a certified athletic trainer (nine years of experience), and the third rater was a physical therapist assistant (10 years of experience). The PI was the rater for establishing the intrarater reliability for both samples. In Phase III, the PI, using the same protocol, collected test scores of 192 female collegiate athletes representing nine sports (volleyball, soccer, cross-country, basketball, tennis, lacrosse, track & field, softball, and dance) from five universities (three National Association of Intercollegiate Athletics [NAIA]) and two National Collegiate Athletic Association [NCAA] Division III Universities). ANOVA was conducted to determine differences between sports and the level of competition.

Results: Excellent intrarater reliability was observed for the left and right sides, and the average score (ICC $_{(3,2)}$ = 0.90 or higher) for both the homogenous and heterogeneous cohorts. Excellent interrater reliability was observed for the left and right sides, and the average score (ICC $_{(3,2)}$ = 0.99 or higher) for both cohorts. Mean UHBET scores for female collegiate athletes were: left side = 48.57 sec, right side = 51.80 sec, and average score = 50.74 sec. Cross-country and track and field athletes demonstrated higher mean scores for the left and right sides and average scores ($p < 0.05$) than basketball and soccer athletes.

Conclusions: The UHBET using a digital inclinometer to assess core stability has excellent intra and interrater reliability in a homogeneous and heterogeneous group of female collegiate athletes. This study established descriptive data for UHBET in a heterogenous sample of collegiate female athletes and reported that cross-country and track and field athletes have higher UHBET mean scores for the left and right sides and average scores compared to basketball and soccer athletes. One explanation for this difference is that cross-country and track and field athletes may do more core training than the other athletes, but this is speculative. To determine if that is the case, future research would be needed.

Level of Evidence: 3

Presenting Author: charlesgreene86@gmail.com

ABSTRACT 5

A NOVEL TOOL FOR ASSESSING PRONE PLANK ENDURANCE A DESCRIPTIVE STUDY OF NAIA & NCAA DIVISION III FEMALE COLLEGIATE ATHLETES

Greene C,[1] Butowicz CM,[2,3,4] Brody LT,[1,5] Schuck DE,[6] Brumitt J[1,7]

1. Rocky Mountain University of Health Professions
2. Research & Surveillance Division, Extremity Trauma and Amputation Center of Excellence, Defense Health Agency
3. Department of Rehabilitation, Walter Reed National Military Medical Center
4. Department of Physical Medicine & Rehabilitation, Uniformed Services of the Health Science
5. University of Wisconsin Clinics Research Park
6. Atrium Health Musculoskeletal Institute Orthopedics & Sports Medicine
7. School of Physical Therapy, George Fox University

Background: The prone plank endurance test (PPET) is reported to assess core stability with good to excellent intraclass correlation coefficient (ICC) reliability of 0.78-0.97. The range of reliability may be due to how pelvic neutrality during the test is determined and/or the number of attempts one is allowed to reestablish neutrality. To address this limitation, a prone plank measuring device (PPMD, patent pending) was created to provide objective information about the subject's pelvic neutral starting position. The reliability of this test using the PPMD is unknown.

Purpose: Establish the minimum detectable change ($MDC_{95\%}$) and the intra and interrater reliability of the PPET using the PPMD (Phase I). Report PPET descriptive scores using the PPMD in a group of female collegiate athletes and determine if differences in PPET hold times exist among various sports and levels of competition (Phase II).

Study Design: Descriptive Study

Methods: In Phase I, three raters consisting of the primary investigator (PI) with 37 years of experience as a physical therapist and a certified athletic trainer and two first-year physical therapy students tested 13 healthy active physical therapy students (8 males; mean (SD) age: 24.92 $\pm$ 2.32 years and mean (SD) exercise/wk 3.92 $\pm$ 0.86 *hours*) who were recruited from a midwestern university to perform the PPET using the PPMD on two separate occasions with 24-48 hours between testing sessions. The intrarater reliability and $MDC_{95\%}$ were calculated from the data collected from the PI. The PPMD is a device made of PVC pipes with a crossbar that moves up and down along uprights. Once the subject assumed the PPET position, the rater visually determined pelvic neutrality, and the PPDM crossbar was applied to the posterior pelvis. The subject held this starting position as long as possible. The test terminated when the subject disengaged from the PPMD's crossbar. In Phase II of the study, the PI collected PPET scores from 191 female collegiate athletes (mean (SD) age 19.48 $\pm$ 1.43 years, mean (SD) height 166.92 $\pm$ 7.60 cm, and mean (SD) weight 67.30 $\pm$ 12.77 kg) representing nine sports (volleyball, soccer, cross-country, basketball, tennis, lacrosse, track & field, softball, and dance) from five universities (three National Association of Intercollegiate Athletics [NAIA]) and two National Collegiate Athletic Association ([NCAA] Division III universities) using the PPMD protocol. An analysis of variance was conducted to determine if differences existed among sports, and an independent t-test was conducted to determine if differences existed among levels of competition.

Results: The $MDC_{95\%}$ was 5.33 sec for the PPET using the PPMD. An excellent intra and interrater reliability was found for the PPET using the PPMD ($ICC_{(3,1)}$ = 0.99 and $ICC_{(3,2)}$ = 0.99, respectively). The mean PPET time for collegiate female athletes was 72.19 $\pm$ 28.45 sec. The mean PPET hold time was longer for track and field athletes than basketball athletes (mean difference 25.40 sec, p = 0.013) and softball athletes (mean difference = 26.66 sec, p = 0.028).

Conclusions: The PPET using the PPMD to assess core stability has excellent intra and interrater reliability. This study established descriptive data for the PPET using the PPMD for female collegiate athletes and determined if differences existed between female athletes in different sports. Also, this study reported longer PPET hold times in track and field athletes compared with their basketball and softball counterparts. It is possible that track and field athletes perform training exercises designed to increase the muscular endurance of the core; however, this is speculative. Future research is warranted to evaluate training habits for different sports.

Level of Evidence: 3

Presenting Author: charlesgreene86@gmail.com

ABSTRACT 6

ULTRASOUND-GUIDED DRY NEEDLING: AN EFFECTIVE TREATMENT FOR CHRONIC REGIONAL PAIN SYNDROME – A SCOPING REVIEW

Foret W[1], Page P[2]

1. Moreau Physical Therapy, Baton Rouge, LA
2. FranU DPT Program, Baton Rouge, LA

Background: Chronic Regional Pain Syndrome (CRPS) is a complex condition characterized by persistent pain,

abnormal pain signaling, altered blood flow, temperature changes, muscle dysfunction, skin abnormalities, inflammation and autonomic dysfunction.[1-8] Ultrasound imaging is used for diagnosing and treating soft tissue injuries, providing real-time visualization of musculoskeletal structures. By combining ultrasound guidance with dry needling, clinicians can precisely visualize target muscles, trigger points, and surrounding tissues, minimizing the risk and enhancing precision and effectiveness of treatments.

Purpose: Ultrasound imaging can be used to reveal abnormalities such as muscle edema, tenosynovial inflammation, and fibrosis often present in CRPS affected limbs.[1-8] By identifying these structural changes, healthcare professionals can make more accurate diagnoses and safely develop personalized treatment plans tailored to each patient's specific needs. This review explored studies that utilized ultrasound guided dry needling to identify pathological myofascial patterns in tissue and effectively treat the dysfunction in patients with CRPS.

Study Design: Scoping review.

Methods: This scoping review was performed in May of 2023 using the following databases: CINAHL, Medline, SPORTDiscus, Academic Search, E-Journals, and Google Scholar. Boolean search terms included: "CRPS" OR "chronic regional pain syndrome" AND "ultrasound guided dry needling." Inclusion criteria were studies that utilized USGDN on patients with CRPS. Exclusion criteria were (1) abstracts without full text (2) literature reviews or Level 5 studies (3) studies that did not include patients with CRPS.

Results/Discussion: Thirteen- Level 4 case studies were selected. Several case studies[1,3-9] utilized ultrasound guided dry needling to achieve uniform reversal and complete resolution of disability in 150 patients presenting in various phases of CRPS over the last 12 years. In a multi modality case study,[7] stellate ganglion block (SGB) and continuous brachial plexus block (CBPB) were useful in pain management, however neither procedure had an effect on motor impairment; dry needling was found to effectively manage motor and sensorimotor impairment. Various outcome measures were utilized[1-8]: Numeric Pain Rating Scale; range of motion; edema; grip strength; Disability of Arm, Shoulder and Hand; painDETECT; Patient Health Questionnaire.

Conclusion: Ultrasound guided dry needling may be an effective treatment in managing pain and sensorimotor impairment in patients with CRPS, however due to the low level of evidence this topic warrants further study.

Presenting author: wforet@moreaupt.com

ABSTRACT 7

TOTAL KNEE ARTHROPLASTY AND THE SCREW HOME MECHANISM OF THE KNEE: A SCOPING REVIEW

Rankin D, Page P

Ochsner Therapy and Wellness, New Orleans, LA

DPT Program, Franciscan Missionaries of Our Lady University, Baton Rouge LA

Background: Total Knee Arthroplasty (TKA) is a common surgical procedure used to treat knee osteoarthritis (OA). Different surgical approaches are used, such as posterior cruciate retaining, posterior stabilized, and medial pivot implants. While these methods have successful outcomes and survivorship, these procedures will affect the kinematics and kinetics of the tibiofemoral joint. In particular, the 'screw-home' mechanism may be affected by different approaches.

Purpose: The purpose was to conduct a scoping review on the influence of TKA on the screw-home mechanism of the tibiofemoral joint.

Study Design: Scoping Review

Methods: A systematic search was conducted in CINAHL, MEDLINE, and SPORTDiscus databases in June 2023 to identify studies that investigated the screw-home mechanism after TKA. Articles that were not in English, conducted in vitro, or did not include biomechanical analysis of the knee during gait or ADLs were excluded. After performing the database search, duplicates were removed and articles were filtered for inclusion criteria, then screened by their titles and abstracts. Two reviewers evaluated each article for inclusion/exclusion criteria. Inclusion and exclusion were tracked using the PRISMA-2020 process. Potential articles were retrieved and imported into Zotero for reference management.

Results: The initial search resulted in 20 studies of which 5 met inclusion/exclusion criteria and were used for the final analysis. Based on the studies analyzed, external rotation of the tibia was limited no matter the design of the TKA prosthesis.

Discussion/Conclusion: Key findings include that a TKA prosthesis interferes with the natural screw home mechanism of the knee and normal knee kinematics. The findings of this review showed that patients who undergo a TKA demonstrate deficits in reproducing the natural screw home mechanism of the knee.

Presenting author: danielle.rankin@ochsner.org

ABSTRACT 8

Evaluating Functional Performance Tests In Those With Non-arthritic Intra-articular Hip Pain: An International Consensus Statement

RobRoy L Martin. PT, PhD[1,2], Amir Takla[3,4,5,6], Ashley Campbell[7,8], Ashley Disantis[1,9], David Kohlrieser[10], Keelan Enseki[11], Liran Lifshitz[12], Louise Grant[13], Mario Bizzini[14], Mike Voight[7,8], Mark Ryan[15], Ryan McGovern[16],Timothy Tyler[17],Yael Steinfeld[18], Yongni Zhang, PT[19]

1. Department of Physical Therapy, Rangos School of Health Sciences, Duquesne University, Pittsburgh, PA, USA
2. UPMC Center for Sports Medicine, PA, USA
3. Swinburne University of Technology – Hawthorn Campus, Health Science, Hawthorn, VIC, Australia
4. Australian Sports Physiotherapy – Ivanhoe, 3079, Australia
5. Hip Arthroscopy Australia, Melbourne, Richmond, VIC 3121, Australia
6. The university of Melbourne -parkville, Melbourne AUS

7. Physical Therapy, Nashville Hip Institute at TOA, Nashville, TN 37203, USA
8. Physical Therapy, Belmont University, Nashville, TN 37212-3757, USA
9. UPMC Children's Hospital of Pittsburgh, Pittsburgh, PA USA
10. Orthopedic One, Physical Therapy, Upper Arlington, OH, USA.
11. University of Pittsburgh Medical Center, Rehabilitation Institute, Freddie Fu Center for Sports Medicine, Pittsburgh, PA, USA
12. Medical Director, The Israel Football Association, Ramat Gan, Israel
13. Physiotherapy, PhysioCure, Leeds, UK
14. Human Performance Lab, Schulthess Klinik, Zurich, Switzerland
15. The Steadman Clinic, Steadman Philippon Research Institute, Vail, Colorado
16. Texas Health Sports Medicine, Sports Medicine Research, Allen, TX 15013, USA
17. Physiotherapy, Pro Sports Physical Therapy, New York, USA
18. Faculty of Medicine, Tel Aviv Sourasky Medical Center, Tel Aviv, Israel.
19. Duquesne- China Health Institute, Rangos School of Health Sciences, Duquesne University, Pittsburgh, PA, USA

Background: Non-arthritic intra-articular hip pain can be caused by a variety pathologies and lead to impairments in range of motion, strength, balance, and neuromuscular control. Although functional performance tests may offer valuable information, no clear consensus exists regarding the optimal tests for this patient population.

Purpose: Establish expert consensus on the selection and application of functional performance tests for patients with non-arthritic intra-articular hip pain.

Study Design: Qualitative study

Methods: 14 expert physical therapists from the International Society for Hip Arthroscopy participated in a modified Delphi technique. These panelists participated in three rounds of questions and related discussions to reach full consensus on the application and selection of functional performance tests.

Results: The panel agreed that functional performance tests should be utilized at initial evaluation, re-evaluations, and discharge, as well as a criterion for returning to sports. Tests should be used as multimodal measures of neuromuscular control, strength, range of motion, and balance. Tests should be applied in a graded fashion, depending on the patient's characteristics. Clinicians should select functional performance tests with objective scoring criteria and prioritize using tests with supporting psychometric evidence. A list of recommended functional performance tests with varying intensity levels was generated. Low-intensity functional performance tests encompass controlled speed in a single plane with no impact. Medium-intensity functional performance tests involve controlled speed in multiple planes with low impact. High-intensity functional performance tests include higher speeds in multiple planes with higher impact and agility requirements. Sport-specific movement tests should mimic the patient's particular activity or sport.

Conclusion: This international consensus statement provides recommendations for clinicians regarding selection and utilization of functional performance tests for those with non-arthritic intra-articular hip pain. These recommendations hope to encourage greater consistency and standardization among clinicians during a physical therapy assessment.

Presenting author: ensekr@upmc.edu

ABSTRACT 9

Electromyographic Analysis Of The Gluteus Medius (GMed) During Varied Positions Of The Hip And Knee

Ashley Disantis[1,2], Yongni Zhang, PT[3], RobRoy L Martin. PT, PhD[1,4]

1. Department of Physical Therapy, Rangos School of Health Sciences, Duquesne University, Pittsburgh, PA, USA
2. UPMC Children's Hospital of Pittsburgh, Pittsburgh, PA USA
3. Duquesne- China Health Institute, Rangos School of Health Sciences, Duquesne University, Pittsburgh, PA, USA
4. UPMC Center for Sports Medicine, PA, USA

Background: The gluteus medius (GMed) is the largest hip abductor and therefore a critical muscle for normal stability of the hip and pelvis during weightbearing functional activity. While Kendall describes manual muscle testing (MMT) in a partially shortened position, the best position to elicit GMed muscle activity and force production has not been studied.

Purpose: To determine if varying the position of the hip (flexion/extension and rotation) or knee (flexion/extension) affects muscle recruitment measured with electromyographic (EMG) or strength measured with a handheld dynamometer (HHD). It was hypothesized that EMG and strength/force production would be greatest in hip extension with hip external rotation and knee flexion.

Study Design: Cross-sectional study

Methods: EMG electrodes were placed on the GMed. EMG and HHD data was collected in six positions: 1) hip flexion-hip internal rotation-knee extension; 2) hip flexion-hip internal rotation-knee flexion; 3) hip extension-hip external rotation-knee extension; 4) hip extension-hip external rotation-knee flexion; 5) hip neutral-knee extension; 6) hip natural-knee flexion. All test positions were performed in mid-range hip abduction. Three maximal voluntary isometric contractions were performed in each position with average EMG and HHD output used for analysis.

Results: 15 subjects with a lower extremity pathology participated. Subjects had an average age of 23.6 (2.4) years with 66% female. A one-way ANOVA did not find a significant difference between the six test positions in regards to GMed muscle recruitment utilizing EMG ($p = 0.39$) or GMed strength with HHD ($p = 0.76$).

Conclusion: The hypothesis of this study was not supported. Varying the position of the knee and hip to alter the muscle length of the GMed during MMT did not significantly effect muscle recruitment or muscle strength.

Presenting author: martinr280@duq.edu

ABSTRACT 10

Evidence Of Test-retest Reliability And Responsiveness For The Simplified Chinese Lower Extremity Functional Scale In Subjects With Lower Extremity Musculoskeletal Injuries

Yongni Zhang, PT[1], RobRoy L Martin. PT, PhD[2,3]

1. Duquesne-China , Rangos School of Health Sciences, Duquesne University, Pittsburgh, PA, USA
2. Department of Physical Therapy, Duquesne University, PA, USA
3. UPMC Center for Sports Medicine, PA, USA

Background: Evidence is needed to define the reliability and responsiveness of the Simplified Chinese Lower Extremity Functional Scale (SC-LEFS) with information that allows the interpretation of score changes over time in younger patients with a variety of lower extremity injuries.

Purpose: To define minimal detectable change (MDC) and substantial clinical benefit (SCB) values for the SC-LEFS in patients with a variety of lower extremity musculoskeletal injuries.

Study Design: Longitudinal prospective study

Methods: Patients 18-50 years of age referred to physical therapy with a lower extremity musculoskeletal injury completed the SC-LEFS at initial assessment and after 4-weeks of physical therapy. Subjects also completed a categorical rating of functional change (ranging from greatly worse to much improved) at 4-weeks follow-up. Based on self-report after 4-weeks of physical therapy, subjects were classified into “stable/no change”, “improved” and “not improved” groups.

Results: 763 subjects participated, with 342 (44.8%) female, 421 (54.2%) male and a mean age of 32.9 (SD 9.4) years. Using the “stable” group (N=40), the ICC was determined to be 0.98 (95% CI, 0.97; 0.99), with a MDC_{95} of 5.1 points. The “improved” and “not improve” groups consisted of 497 and 266 subjects, respectively. ROC analysis found a SCB change score of 9.5 points could differentiate those “improved” from those “not improved” with a sensitivity of 0.68 (95% CI, 0.64; 0.71), specificity of 0.71 (95% CI, 0.67; 0.74), and area under the curve (AUC) of 0.81 (95% CI, 0.73; 0.89; $p<0.01$).

Conclusion: This study offers evidence of test-retest reliability and responsiveness with MDC and SCB values for the SC-LEFS in Chinese-speaking patients 18-50 years of age with a variety of lower extremity injuries. Values for MDC and SCB will allow clinicians to interpret changes in score on the SC-LEFS after 4-weeks of physical therapy.

Presenting author: martinr280@duq.edu

ABSTRACT 11

Assessing The Reliability And Validity Of A Visual Analog Scale For Rating The Single Leg Squat Test In Individuals With Lower Extremity Injuries

Yongni Zhang, PT[1], Yifan Liu, PT[1], Xinwei Huang PT[1], Zhichen Pan, PT [1], Christopher R. Carcia, PT, PhD[2] , RobRoy L Martin. PT, PhD[3,4]

1. Duquesne-China , Rangos School of Health Sciences, Duquesne University, Pittsburgh, PA, USA
2. Department of Kinesiology, Colorado Mesa University
3. Department of Physical Therapy, Duquesne University, PA, USA
4. UPMC Center for Sports Medicine, PA, USA

Background: The single leg squat test (SLST) is commonly used for visual movement assessment in those with lower extremity injuries. While current methods utilize ordinal rating scoring, adopting a visual analog scale (VAS) may offer potential advantages associated with the continuous data collected.

Purpose: To determine the interrater reliability and validity of a VAS for rating the SLST in individuals with lower extremity injuries.

Study Design: Cross-sectional study

Methods: 29 subjects with lower extremity injuries participated in this study. Reliability was evaluated by two physical therapists (32 years and 8 years of experience) using a VAS to assess the SLST in three segments: trunk deviation, hip adduction, and lower extremity internal rotation. Intra-class correlation coefficients (ICC 2,1) assessed interrater reliability between the two raters. Validity was assessed by comparing VAS scores obtained from visual assessment to 3-D motion analysis for each subject.

Results: 18(62%) females and 11(38%) males with a mean age of 23.1 years (SD=3.2) were included. Interrater reliability was good for trunk deviation (ICC2,1 = 0.84) and hip adduction (ICC2,1 = 0.78), and excellent for lower extremity internal rotation (ICC2,1 = 0.93). The minimal detectable difference (MDD_{95}) values were 3.6 cm, 2.4 cm, and 2.8 cm, respectively. Agreement between visual assessment and 3-D motion analysis was substantial to moderate (weighted kappa =0.51- 0.65) in the three segments.

Conclusion: This study offered evidence of reliability and validity for using a VAS to rate the SLST. Established MDD values allow for score interpretation between raters. These findings potentially provide a more sensitive, precise, and detailed approach for evaluating individuals with lower extremity injuries on the SLST compared to the previously used ordinal rating scoring. The continuous data collected may allow for defining minimal clinically important difference (MCID) and substantial clinical benefit (SCB) values in future research.

Presenting author: zhangy4@duq.edu

ABSTRACT 12

The Test-retest Reliability And Validity Of The Star Performer®

Yongni Zhang, PT[1], Yifan Liu, PT[1], Shangtao PT[1], Jiayou Wang, PT[1], Lina Jian, PT [1] , Kelton D. Mehls, PhD[2], Scott Abbott, PhD[3], RobRoy L Martin. PT, PhD[3,4]

1. Duquesne-China , Rangos School of Health Sciences, Duquesne University, Pittsburgh, PA, USA
2. Athletic Training, Duquesne University, PA, USA
3. Director of R&D ,GDE Technologies,LLC, PA, USA
4. Department of Physical Therapy, Duquesne University, PA, USA
5. UPMC Center for Sports Medicine, PA, USA

Background: The Star excursion balance test (SEBT) is well recognized as a reliable, valid, and responsive assessment tool. However, the SEBT is time consuming and inconvenient to perform. The **Star Performer®** is a new device developed to improve the efficiency in collecting information with the SEBT.

Purpose: To investigate the test-retest reliability of **Star Performer®** and compare its validity to traditional SEBT methods.

Study Design: Cross-sectional study

Methods: 25 subjects with lower extremity injuries performed the SEBT twice, with approximately 7 days between tests. The **Star Performer®** device and a tape measure were used to record three test trials in each of the eight-test directions with the average reach distance being used for analysis. Test-retest reliability was evaluated by calculating the intra-class correlation coefficients ($ICC_{2,1}$) between the average reaching distance for each SEBT direction across the two testing sessions. To assess the validity of the **Star Performer®** device, the averaged reaching distance obtained by the device was compared to measurements obtained from the standard methods.

Results: 17 females (68%) and 8 males (32%) with a mean age of 23.6 years (SD=3.9) participated. The **Star Performer®** demonstrated high test-retest reliability, with $ICC_{2,1}$ value ranging from 0.84 to 0.93 for the eight SEBT directions. The minimal detectable change at the 95% confidence level (MDC_{95}) ranged from 6.43 cm to 14.02 cm for the eight directions. The Pearson correlation coefficients between the **Star Performer®** and tape measure recordings ranged from 0.90 to 0.94 for the eight directions.

Conclusion: This study provides evidence supporting the validity and test-retest reliability of **Star Performer©** in SEBT assessments. Obtained MDC values allow clinicians to interpret scores changes over time. These findings suggested that the **Star Performer®** offers a precise and efficient approach to evaluate SEBT performance in individuals with lower extremity injuries.

Presenting author: zhangy4@duq.edu

ABSTRACT 13

A COMPARISON OF PATIENT EXPERIENCE, OUTCOMES, AND UTILIZATION BETWEEN TELEHEALTH, CLINIC, AND HYBRID PHYSICAL THERAPY PATIENTS

Denninger T[1,2], Lutz AD[1,3], Shanley E[1,3], Thipgen CA[1,3]

ATI Physical Therapy[1], South College[2], SC SmartState Center for Effectiveness Research in Orthopaedics (CERTortho)[3]

Background: The COVID-19 pandemic necessitated reduced barriers for policy and reimbursement enabling widespread adoption of telehealth physical therapy (PT) services. To date, there has been minimal reporting of the care parameters, outcomes, and patient experience associated with telehealth PT relative to clinic-delivered PT services.

Purpose: The purpose of this study was to compare patient experience and outcome measures and course of care metrics between care delivery cohorts.

Study Design: Retrospective cohort.

Methods: A convenience sample of non-surgical patient episodes from a national outpatient PT provider between January 2020 and June 2021 (clinic=219,057, telehealth=603, hybrid=2,292; age 51±19, 59% female, BMI 29±7). Patient data, including pre- and post- body region-specific patient reported outcomes (PROs), visit metrics with treatment delivery, patient satisfaction, net promoter score (NPS), and demographic information, were obtained for patients that completed a PT episode between January 2020 and June 2021. NPS is a commonly-used, single item survey that gauges the likelihood a patient will recommend a product or service. Physical therapy episodes were classified as clinic-only, telehealth-only, or hybrid (including both clinic and telehealth treatments). Patients self-selected to treatment group based upon need and personal choice. Telehealth visits were typically 45-60 minutes and similar in makeup to clinic visits aside from proximity and manual interventions. Initial disability was stratified by PRO and divided into quartiles in a standardized direction (1=high, 4=low disability). The RA residual was calculated as actual PRO change - RA predicted PRO change. Two-way (treatment delivery x disability quartile) analyses of variance (ANOVAs) were used to compare visits and RA residual. Patient satisfaction and NPS were measured and analyzed by each care delivery method. Tukey's post hoc testing was performed when significant interaction effects were observed (α=0.05).

Results: Significant main and interaction effects for treatment delivery and disability quartile were observed for visits; while only significant main effects for disability quartile was observed for RA residual. Initial PROs were 57.8±20.6 (clinic), 55.6±20.9 (telehealth), and 54.5±20.7 (hybrid); PRO change was 13.7±17.2 (clinic), 14.3±16.3 (telehealth), and 15.3±18.5 (hybrid); and visits were 12.7±7.6 (clinic), 10.9±7.8 (telehealth), and 17.0±11.1 (hybrid). Mean differences (95%CI) in visits relative to clinic were +1.6(1.1,2.7; telehealth) and +4.0(3.9,4.3; hybrid). No clinically important differences were observed in RA residual. Patient experience was nearly equal between groups with NPS (clinic 80% [n=14684], telehealth 79% [n=87], hybrid 80% [n=282]) and patient satisfaction (all 91%).

Discussion/Conclusion: Patients who experienced physical therapy through various means of delivery demonstrated compared outcomes and satisfaction with different numbers of treatment sessions. These findings are pragmatic and reflect the impact of patient choice to access and

consume care in a real clinical environment. There may be important personal preference and expectation factors that influence patient's choice that should be examined in future studies.

Presenting Author: Thomas.Denninger@ATIPT.com

ABSTRACT 14

PATIENT EXPERIENCE ASSOCIATED WITH OUTCOME IMPROVEMENT AND COURSE OF CARE METRICS

Lutz AD[1,2], Denninger TR[1,3], Shanley E[1,2], Thipgen CA[1,2]

ATI Physical Therapy[1], SC SmartState Center for Effectiveness Research in Orthopaedics (CERTOrtho)[2], South College[3]

Background: The Net Promoter Score (NPS), a well-researched measure of consumer loyalty and experience, has not been thoroughly evaluated in the healthcare literature. Research suggests the NPS may best be utilized in healthcare settings where patients have a choice of providers (e.g., physical therapy (PT)). Accordingly, PT organizations have increasingly deployed the NPS following care as a complementary measure of patient experience to other outcomes more routinely collected (e.g., patient reported outcomes [PROs]).

Purpose: The purpose of this study was to assess the relationship between the post-care NPS and care episode metrics including attended visits and change in Penn Shoulder Score (PSS; unadjusted [UA] and risk-adjusted [RA] residual) in patients that received post-operatively PT following rotator cuff repair (RCR).

Study Design: Retrospective Cohort

Materials and Methods: A sample of convenience (776 PT patient episodes) related to post operative RCR with available post care NPS, initial and final PSS, and requisite risk-adjustment variables (i.e., age, sex, BMI, payer, health history, clinic state, chronicity, initial PSS, initial VR12 Mental & Physical Component Scores) were available. Analyses of Covariance (ANCOVAs) compared UA PSS change, RA residual PSS, and attended visits by response classification (i.e., Promoter [9-10], Passive [7-8], Detractor [0-6]), controlling for chronicity, sex, age, and initial PSS quartile. Estimated marginal means (EMM) described outcome and visit metrics between levels of NPS classification, averaged over remaining control variables.

Results: Post-care NPS demonstrated significant differences (P<0.001) between Detractors and Promoters for each dependent variable. Detractors averaged significantly lower RA residual (-4.1; CI -10.4,2.1 vs 8.2; 6.6,9.8), UA change (37.2; 30.5,43.9 vs 49.8; 48.0,51.5), and visits (20.0; 15.2,24.9; 30.3; 28.9,31.7) than Promoters. Passives were not statistically different from Detractors and Promoters for the PSS measures but were consistent with Promoters for attended visits.

Discussion/Conclusion: Patients classified as 'Promoters' demonstrated significantly better PROs and attended significantly more visits than patients classified as 'Detractors'. While we are unable to establish a causal link, the clear differences in visits and PROs between the rating cohorts indicate that better experience is associated with a longer, comprehensive plan of care that yields better outcomes.

Presenting Author: Adam.Lutz@ATIPT.com

ABSTRACT 15

Comparing Kinematic Sequencing in Pitcher & Quarterbacks

Authors: Phil Page[a*], Andre Labbe[b]

[a]Franciscan University DPT Program, Baton Rouge LA

[b]Tulane University Medical School Dept of Orthopedics

Background: Overhead throwing involves a kinematic sequence of events from the contralateral foot to the hand. After 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.

Purpose: The purpose of this study was to evaluate the kinematic sequencing in pitchers and quarterbacks during throwing, including hip-shoulder separation.

Methods: 11 right-handed male quarterbacks (n=6) and pitchers (n=5) between high school and college level participated in a biomechanical throwing analysis before their respective season. The Noraxon Ultium 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: left 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%).

Conclusion: Understanding the different biomechanics of throwing athletes may assist in rehabilitation and performance. Pitchers demonstrated higher ROM, velocity, and hip-shoulder separation. Future research should include larger sample sizes, kinetic analysis, and different throws.

Presenting author: alabbe@tulane.edu

ABSTRACT 16

Instrumented Analysis of Scapular Kinematics: A Scoping Review

Authors: Phil Page[a], PhD PT ATC; Logan Seal[b], DPT

[a]Franciscan University DPT Program, Baton Rouge LA
[b]Baton Rouge Orthopedic Clinic, Baton Rouge LA

Background: Although controversial, scapular dyskinesis is typically assessed clinically through observational methods. Instrumented measurement of scapular kinematics can provide objective quantification of angular movements simultaneously in 3 planes of movement. While the most representative measure of scapular kinematics would involve invasive placement of bone pins into the scapula, the "gold standard" for assessing kinematics relies on reflective markers and high-speed cameras in a lab setting. Electromagnetic sensors have been validated as another method of quantifying scapular kinematics; more recently, inertial motion units (IMUs) have been used in biomechanical studies for movement analysis. In addition to angular data, IMUs can provide velocity and acceleration data, often wirelessly. IMUs may provide clinicians more practical and accessible methods of objective measurement of human movement.

Purpose: The purpose of this scoping review was to identify and describe studies assessing scapular kinematics with IMUs that reported data on range of motion (ROM), validity, or reliability.

Methods: Four electronic databases (CINAHL, EMBASE, MEDLINE, and SPORTDiscus) were systematically searched in July 2023 for search terms (scapul* AND (kinematic* OR biomechanic*) AND (marker OR sensor OR inertia* OR IMU). Included studies evaluated scapular kinematics using IMUs on ROM, validity, or reliability. Cadaveric and biomechanical modeling studies were excluded, as well as conference proceedings, dissertations and case reports. PRISMA-2020 guidelines were followed.

Results: 15 studies were included; 8 evaluated reliability while 4 evaluated validity against the "gold standard" camera and reflectors placed on the acromion. The median number of subjects in each study was 23. Four different IMU systems were used: MTS XSens (6); InertiaCube3 (6); MoLab (2); and Showmotion (1). All but one study used 3 or 4 sensors; typically using the "ISEO" protocol placement including the sternum, scapular spine, lateral humerus and forearm. Most studies evaluated elevation in the sagittal plane (flexion) and frontal plane (abduction), while 4 studies evaluated functional tasks. The average scapular ROM (internal/external rotation, upward/downward rotation, and anterior/posterior tilt) was typically non-linear and varied widely across studies, as well as between flexion and abduction movements. Similarly, the intraclass correlation coefficients (ICCs) ranged from –0.2 to 0.9 while the standard error of the measure (SEM) ranged from 1.8º to 3.9º.

Discussion: Most authors used biomechanical terminology; however, they were not always clear in defining movement, often using terms different than clinicians ("protraction" is clinically defined as scapular internal rotation). Average scapular motion during elevation was previously quantified with bone pin placement by Ludewig et al. as 2º of external rotation, 21º of posterior tilt and 37º of upward rotation. Values obtained through IMUs were sometimes reported in excess. (44º of transverse rotation; 65º of frontal rotation; 15º of sagittal tilt). These differences may be due to skin artifacts, different sensing systems and placement, or incorrect reporting.

Conclusion: The literature is not consistent in reporting scapular kinematics using IMUs, thus limiting the clinical utility of their use in assessing scapular motion. More research is needed to assess the validity and reliability of IMU use in quantifying scapular kinematics in healthy and patient populations.

Presenting author: lseal@broortho.com

ABSTRACT 17

Pathomechanical Analysis of Movement: A Clinical Decision-Making Algorithm for Gait Analysis

Phil Page, PT, PhD, ATC, CSCS, FACSM
Franciscan Missionaries of Our Lady University DPT Program, Baton Rouge LA

As experts in mobility and locomotion, physical therapists (PTs) examine and evaluate the "human movement system." The movement system functions through the interaction of the musculoskeletal, cardiopulmonary, nervous, and integumentary systems. Biomechanical analysis can provide PTs with quantitative and detailed insights into the interactions of the human movement system in various muscles and joints, across multiple planes and phases of movement. Deviations from 'normal' movement can help identify potential impairments or compensations leading to dysfunction.

The component systems of human movement are usually evaluated "statically" for impairments (range of motion, strength, flexibility, etc); however, common activities such as squatting, throwing, or walking should be analyzed "dynamically" through observational or instrumented methods during movement. While instrumented analysis is not commonly available to PTs, technology is rapidly evolving to bring objective data to clinicians through inexpensive and convenient measurement devices. For example, wireless inertial motion units (IMUs) and marker-less motion capture devices can provide kinematic data in real-time through readily available mobile devices.

Dysfunctional movement can be quantified by comparing a patient's movement pattern with "normal" kinematic and kinetic variables. Clinicians may benefit from a systematic approach of analyzing objective movement data using an algorithm to identify dysfunction and potential impairments. PTs can then combine their clinical examination and patient history with pathomechanical measures, thereby facilitating clinical decision-making to determine appropriate and timely interventions. This presentation describes the development and use of a clinical decision-making algorithm using kinematic parameters of gait analysis to differentiate possible impairments and inform potential interventions.

Presenting author: Phillip.Page@franu.edu

ABSTRACT 18

Humeral Torsion Assessment using Musculoskeletal Ultrasound: A Scoping Review

Abby Trahan SPT, Hannah Vicknair SPT, Phil Page PT, PhD, ATC

Franciscan Missionaries of Our Lady University, Baton Rouge LA

Background: Humeral torsion is defined as the angle formed between the proximal and distal articular axis of the humerus. Torsion is typically quantified through MRI or CT, but musculoskeletal ultrasound (MSKUS) has been used in several studies to quantify humeral torsion in overhead athletes. The purpose of this study was to systematically synthesize the literature describing the use of MSKUS to quantify humeral torsion in overhead athletes in order to evaluate the validity and reliability of the techniques used.

Methods: A systematic scoping review was performed in February 2023 following PRISMA guidelines for scoping reviews. Studies included the use of MSKUS to image and quantify humeral torsion in overhead athletes, and English, full-text articles that were published in peer-reviewed journals.

Results: 46 articles were screened for inclusion and 10 were chosen. All studies used MSKUS to align proximal humeral tuberosities while using a goniometer or digital inclinometer to measure external rotation at 90° abduction. The average humeral retro-torsion on the throwing arm was approximately 12.44° compared to "normal" 7°. The intraclass correlation coefficients (ICC) for intra- and inter-observer reliability were good (0.83-0.1.0). Using 2 examiners resulted in higher reliability.

Conclusion: MSKUS was used to align proximal humeral tuberosities while using a goniometer or digital inclinometer to measure external rotation at 90° abduction with either 1 or 2 observers. The patient position was consistent throughout all studies and all techniques utilized. This review found that quantifying humeral torsion with MSKUS is reliable and valid for clinical practice. The two examiner method provided slightly higher reliability.

Presenting author: AbbyTrahan@franu.edu

ABSTRACT 19

Does Localized Intermittent Pneumatic Compression Change Soft Tissue Pain and Stiffness?

Authors: Phil Page PhD PT ATC, Hannah Vicknair SPT, Lillian Doskey SPT

Franciscan University DPT Program, Baton Rouge LA

Background: Intermittent pneumatic compression (IPC) is a popular modality for recovery after physical activity or during injury rehabilitation. Previous research supports its use in reducing pain and swelling. Graded circumferential pressure is applied to the entire limb with an inflatable bladder or cuff using an external compression device. A new IPC device, the Normatec Go (Hyperice, Burlington MA) was designed to provide localized compression to the calf muscles without a tethered external compression device. While researchers have validated the use of traditional Normatec compression boots, no studies have evaluated the Normatec Go device.

Purpose: The purpose of this study was to pilot test an experimental protocol on healthy subjects to evaluate the effects of the Normatec Go on pain, swelling, and muscle stiffness and damping.

Methods: A convenience sample of 22 young healthy subjects received 30 minutes of compression simultaneously to both lower legs with the Normatec Go (setting 4) for 30 minutes. Subjects were tested before and after the intervention for pain pressure threshold (PPT) using a digital pain algometer (Wagner FPX, Greenwich CT), girth at 15cm inferior to the knee crease, and muscle stiffness and damping using the PACT sense (Impact Biosystems, Boston MA) muscle scanner. Reliability of the PACT was examined using 3 consecutive pre-treatment measures to determine the intraclass correlation (ICC). Dependent t-tests were used to analyze pre- and post-test differences (significance set at $p<0.05$) and Cohen's d effect sizes were calculated. An *a priori* power analysis (G Power; $\alpha=0.05$, power=0.8, effect size = 0.5) indicated 34 subjects were needed to avoid a Type 2 error. Each subject was tested on both calves, resulting in a sample of 44.

Results: Test-retest reliability of the PACT sense device was excellent to good (0.91 for stiffness and 0.86 for damping). Stiffness ($p=0.04$), damping ($p=0.001$), and girth ($p=0.01$) were significantly different after the intervention; there was no difference in PPT. Cohen's d effect sizes for the intervention were trivial to small, except for muscle damping, which was moderate at $d=0.4$. There were no adverse effects.

Discussion: The protocol was feasible and safe. The Normatec Go IPC reduced muscle stiffness, damping, and girth immediately after use in healthy subjects. While statistically different, the differences were likely not clinically meaningful.

Conclusion: Normatec Go IPC temporarily enhanced the viscoelastic properties of the calf muscle in healthy subjects. Further testing in muscle recovery is warranted in subjects after physical exertion or injury.

Presenting author: HannahVicknair@franu.edu

ABSTRACT 20

PRE- AND POST-TOTAL HIP ARTHROPLASTY GAIT ANALYSIS IN A PATIENT WITH A 4-LEVEL ACDF AND T1-SACRUM SPINAL FUSION

Katherine Peaslee, PT, DPT, OCS, Phil Page, PhD, PT, ATC, CSCS

Doctor of Physical Therapy Program, Franciscan Missionaries of Our Lady University, Baton Rouge, Louisiana, USA

Background: Several research studies have performed gait analyses on patients pre- and post- total hip arthroplasty (THA), but historically patients with concomitant neurologic and orthopedic comorbidities are excluded from these research trials. By presenting this case study, we aim to illustrate the kinetic and kinematic variables in a patient pre- and post-THA with increased medical complexity.

Clinical Case: An 85-year-old man underwent a right anterior approach total hip arthroplasty in September 2022. The patient's recent past medical history includes a CVA with residual R quadriceps, gluteus medius, and anterior

tibialis weakness in December 2020, a 4-level anterior cervical discectomy and fusion (ACDF) in September of 2020, and a T1-sacrum fusion in December of 2020. The patient performed two gait analyses using the Noraxon IMU-based body model and Digitsole insoles for analysis of temporal, spatial, and joint angle data: the first was 5 months pre-THA and the second was 3 months post-THA. The patient demonstrated improvements in limb-to-limb symmetry in percentage of time in stance phase, percentage of time in loading response, percentage of time in single leg support, percentage of time in pre-swing, stride time, step time, cadence, length of gait line, center of pressure parameters, dynamic hip ROM (in stance and swing phase), knee flexion ROM, contralateral hip abduction during stance phase, bilateral knee abduction ROM (in stance and swing phase), and bilateral ankle dorsiflexion ROM during stance phase of gait.

Conclusion: This is one of the first cases demonstrating the changes in kinetic and kinematic variables after total hip replacement in a patient with orthopedic and neurologic comorbidities.The clinical significance in this case is that our medically complex patient post-THA demonstrated similar improvements in gait as otherwise healthy patients post-THA.

Presenting author: Katherine.Peaslee@franu.edu