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Virtual Poster Session: **MSK Rehab: Wearables & Biomechanics - Friday June 12, 2020** 1:30 - 2:50pm EDT
https://vimeo.com/showcase/7214426

10| Humberto Omana- Western University; PhD (In progress or completed)

"Dual-Task Balance and Gait in Adults with Diabetes: A Systematic Review"

Background: Individuals with diabetes mellitus (DM) are susceptible to balance, gait and cognitive impairments. Importantly, diabetes affects executive function, a set of cognitive processes critical to everyday cortical function and mobility. Reduced executive function is a risk factor for falls in people with DM. Dual-task testing, the completion of two tasks at once, enables the examination of the cognitive-mobility relationship. A synthesis of the literature on the effects of dual-task testing on the balance and gait of individuals with DM has not been performed.
Objective: To systematically review the literature on the effect of dual-task testing on balance and gait in people with DM.
Methodology: Databases EMBASE, CINAHL, MEDLINE, PsycINFO, Scopus and Web of Science were searched (inception-April 2020). Inclusion criteria: participants were adults with a diagnosis of DM, instrumented dual-task balance and/or gait was assessed, and articles were published in English.
Results: Ten articles met inclusion criteria- three examined dual-task balance and seven dual-task gait. In people with DM with or without peripheral neuropathy, larger sway velocities were reported in comparison to controls during dual-task standing tests. Individuals with DM and peripheral neuropathy had impaired dual-task gait; specifically, reduced pace and rhythm, and increased stride variability compared to controls or people with DM without peripheral neuropathy.
Significance & Impact: The findings support a compromise in the cognitive-mobility relationship of people with DM; especially in those with peripheral neuropathy. Therefore, healthcare professionals working with individuals with DM may look to dual-task testing as a method to discern those at a higher risk for falls. Future research should continue to examine the cognitive-mobility relationship in order to better understand the increased prevalence of falls in this population.

15| Natasha Ivanochko- University of Waterloo; PhD (In progress or completed)

"Effect of Squatting Exposures on Knee Joint Stiffness and Muscle Activity"

Background: Frequent exposure to high flexion postures (>120º knee flexion) is a risk factor for knee osteoarthritis and knee pain.[1,2] There is no consensus on whether the total number of exposures or the duration of the exposures is more detrimental to knee health.
Objective:The goal of the study was to examine how joint stiffness and vastus medialis activity during the deceleration phase of landing are influenced by cyclic and sustained squat exposures. We hypothesized that sustained squatting would cause greater decreases to joint stiffness and vastus medialis activity.
Methodology: Twenty-eight healthy, young participants performed a cyclic and sustained squat. Pre- and post- squat exposures, participants completed countermovement jumps (CMJ). Kinematics, kinetics, and EMG data were collected on the dominant leg. Joint stiffness was calculated as knee moment change over knee angle change between initial contact and peak knee moment. Integrated EMG (iEMG) during deceleration of landing was examined. Two-way mixed factor ANOVAs were used to determine the influence of squat exposure type, and sex on changes in joint stiffness and iEMG.
Results:No significant main effects were found for squat exposure type ($p = .524$) or sex ($p = .093$) for joint stiffness. There was a significant sex main effect for iEMG ($p = .018$), but not a significant squat exposure main effect ($p = .071$). Our study found that females exhibited greater reductions in vastus medialis iEMG than males.
Significance: Brief squat exposures can cause decreases in muscle activity in a healthy young population. This is important as adequate vastus medialis activation during landing is required to prevent knee valgus, a potentially injurious movement pattern. Thus, it highlights the need for future work to investigate how occupational exposures may affect an older population.
References:
1. Coggon et al. (2000). Arth Rheum. 43(7); p.1443-1449
2. Baker et al. (2003). Occup Environ Med. 60; p.794-798

17| Harvi Hart- Western University; Post-Doctoral Fellow

"Walk smarter not harder: Lower cadence is associated with higher knee loads"

Background: Over 50% of people with knee osteoarthritis (OA) do not complete the recommended 7000 steps/day—estimated to be equivalent to the current physical activity recommendations(150 min/week).
Rationale: Surrogate measures of knee load–such as the external knee moments–are larger in people with knee OA and are associated with pain and OA progression. Lower walking cadence is associated with future knee OA progression—presumably due to higher knee loads.
Purpose: To test the association of walking cadence with knee loads, while controlling for gait speed, in patients with medial knee OA.
Methodology: We analyzed gait data from a registry of 691 patients (age 47±9years, BMI 30±5kg/m2) who participated in studies of rehabilitative and surgical interventions for medial knee OA. Using multivariate linear regression, we tested the association of cadence with the knee adduction moment angular impulse, while controlling for gait speed. We also conducted analyses to test the associations of cadence with the first and second peak knee adduction moment, peak knee flexion moment and peak vertical ground reaction force.
Results: While controlling for gait speed, lower cadence was associated with higher knee adduction moment angular impulse (standardized beta=-0.396, $p<0.001$) suggesting a 0.02%BW.Ht.s decrease in impulse for each step per minute increase in cadence (unstandardized beta [95% CI]: -0.020%BW.Hts [-0.027 to -0.015]). Lower cadence was also associated with higher second peak knee adduction moment (standardized beta=-0.176, $p=0.004$) and vertical ground reaction force (standardized beta=-0.173, $p<0.001$).
Significance & Impact: When controlling for gait speed, lower cadence is associated with higher knee load per step in patients with medial knee OA. Given the negative effects of aberrant loading and positive effects of physical activity, the present study supports future prospective studies investigating increasing walking cadence for patients with knee OA.

45| William Anderson- Western University; Masters (In progress or completed)

"Design and 3D Printing of Wireless Load Cells for Biomedical Applications"

Introduction: Load data is an integral part of many biomedical applications as it provides quantitative information about the forces acting on structures. Advancements in automotive pressure sensor technology have enabled an alternative method of monitoring real-time load and strain data. To be effective, the sensor package must be embedded within a deformable enclosure designed to transduce compressive forces. Objective: The objective of this study is to develop customizable, 3D printed load cells capable of measuring a range of compressive loads for use in biomedical applications.
Materials and Methods: A deformable compression enclosure was produced by generating a two-component rectangular structure with four internal cantilever beams. In subsequent designs, the width of the beams was increased from 2 mm to 4 mm at 0.5 mm increments. The two-component enclosure was imported into Abaqus to determine the theoretical load capacity of the package when fabricated in polylactic acid (PLA) and Ti-6Al-4V. To determine the experimental load capacity of the enclosures, the packages were 3D printed in PLA and subjected to compressive deformation applied by an Instron 3343. Results: The theoretical and experimental load capacity of the PLA enclosure ranged from 5 to 12 N. The average percent error between the theoretical and experimental PLA load capacity was 2.62%. The theoretical load capacity of the Ti-6Al-4V enclosure ranged from 210 to 460 N. Discussion and Conclusions: The results of this study show that custom load cell enclosures can be 3D printed to measure specific load values by altering the design of internal features and the materials used in fabrication. In combination with our load sensor, a retasked tire pressure sensor, we will be able to develop a range of wireless telemetric load cells with varying load capacity. The device could be used to measure orthopaedic loads within joint replacements, fracture fixation components, and spinal fusion cages.

49| Faraz Damji- University of British Columbia; Masters (In progress or completed)

"Using the VERT wearable device to examine resultant peak acceleration at the center of mass during impact landing"

Sport is evolving into a more competitive industry, leaving athletes prone to injuries. Monitoring athletes using wearable technology provides a way to potentially manage training and competition loads with the goal of reducing injuries. One such technology is the VERT, a commercially available discrete wearable device that measures vertical displacement from the center of mass. While several studies have examined the accuracy of the VERT's measures of jump height and jump count, the landing impact parameter has not yet been investigated. Landing impact refers to the resultant peak acceleration at the center of mass during a landing from a jump. The objective of this research study was to explore the potential utility of the VERT as a load monitoring tool in elite volleyball players. This was done by examining the accuracy of the VERT landing impact values in university volleyball players. We hypothesized that the VERT landing impact values would fall within 10% of those derived from a research-grade accelerometer, the Shimmer3 inertial measurement unit. Methodology for this study included recruiting 14 players, having each perform 10 jumps while wearing both devices. The results showed that VERT landing impacts were variable (limits of agreement of -84.13% and 52.37%) and had a propensity to be lower (mean bias of -15.88%) when compared to the Shimmer. In conclusion, the validity of the VERT device's landing impact values is generally poor, with respect to Shimmer. The findings of this study are useful for high performance teams – athletes, coaching staff, and medical staff – with an interest in assessing jump load via an inexpensive, simple and efficient method. As well, this research is important for clinicians who hope to provide better care for injured athletes by allowing them to remain physically active while promoting recovery, and thereby return to sport safely.

53| Dominique Cava- Western University; PhD (In progress or completed)

"First Step Toward a Knee OA Patient-Specific Neuromusculoskeletal Model"

Aberrant mechanical loading is a major risk factor for knee osteoarthritis (OA), but cannot be directly measured in the intact knee. Computational neuromusculoskeletal models offer a means to estimate the magnitude and distribution of knee loads. Patient-specific models may be vital for understanding knee OA progression and treatments, but must first be validated with experimentally recorded results. The purpose of this study was to compare muscular activations computed by an electromyography (EMG)-informed neuromusculoskeletal model to experimentally measured muscle activations.
Kinematic, kinetic, and EMG data from one patient's limb were collected during gait. A generic OpenSim model was scaled to the patient's anthropometrics, whose kinematic and kinetic data were provided as inputs to an inverse dynamics analysis. With these data, a patient-specific EMG-informed neuromusculoskeletal model was created in CEINMS. The model can estimate excitation patterns for musculotendon units from which EMGs cannot be experimentally measured and can adjust EMG linear envelopes that may be subject to measurement errors and uncertainties, while simultaneously ensuring dynamical consistency in the predicted joint moments. Computed muscle activations were compared to corresponding experimentally-measured EMG activations.
The root mean square error (RMSE) and maximum error (ME) between the computed and experimentally measured activations for all muscles were 6.5% and 11.6%, respectively. Results for each muscle group were: quadriceps (RMSE=5.0%, ME=12.1%), hamstrings (RMSE=10.9%, ME=7.7%), gastrocnemius (RMSE=5.9%, ME=14.6%) and tibialis anterior (RMSE=3.2%, ME=8.7%).
Errors between the computed and experimentally measured muscle activations are low, supporting the validity of the model. These preliminary results are encouraging and represent the first step in developing a knee OA patient-specific EMG-informed neuromusculoskeletal model.

67| Vaughan K Murphy- WearME Lab; Masters (In progress or completed)

"Characterizing a Woven Biomimetic Actuator for Wearable Therapeutic Devices"

Context: Post-stroke symptoms, such as upper limb paralysis, limit the mobility of patients, and require them to undergo rehabilitation therapy. This therapy is time-intensive, limiting the number of patients therapists can see. Wearable robotic devices can help with this, but currently-available devices are large, bulky, and confined to clinicians' offices. Scope and Objectives: To miniaturize these devices and enable portable, at-home care, alternatives must be explored to replace the large motors typically used. Twisted, coiled nylon actuators (TCAs) are smart material actuators that contract when heated, and are able to produce large relative strains and forces while being light and soft; however, they have low gross force output, and little work has been done to incorporate them into soft wearable devices, limiting their use. This work investigated the use of TCAs in a biomimetic woven textile mesh, characterizing its stroke and force production to determine its actuation capacity. Methods: To do this, TCAs were assembled into a biomimetic bi-pennate structure and woven into a nylon wool mesh. The mesh was loaded and heated, with the produced stroke recorded at each temperature. It was then attached to a load cell and heated, with the produced force recorded at each temperature. Results: Generalized equations relating the stroke and force production of the woven mesh to its temperature were found, allowing for scaling based on the number of active TCAs. The mesh was able to produce strokes of up to 12.2% and forces of up to 11.28 N, with both scaling linearly with the number of active TCAs. Significance: These results indicate that the mesh is comparable to, or better than, alternatives found in the literature, while being flexible, linearly scaling, and able to be incorporated in textiles. The designed mesh is a desirable alternative to motors in wearable devices, and will allow for the design of novel assistive devices that can overcome current shortcomings.

72| Alec Bass- Université de Montréal; PhD (In progress or completed)

"PROPOSING AN ALGORITHM TO SAFELY DOSE WALKING WITH ROBOTIC EXOSKELETONS"

CONTEXT : Manual wheelchair users with a chronic and complete spinal cord injury (MWUsci) often develop severe bone loss in their lower extremities (L/E) as a result of mechanical unloading and vascular dysfunction below the level of injury. Engaging them in a walking program with a wearable robotic exoskeleton (EXO) may be a promising intervention to increase L/E mechanical loading, improve bone health and probably reduce L/E fracture risk. Yet, L/E fractures can occur during EXO walking programs. Low bone mineral density (BMD) is associated with an increased risk for fractures. RATIONALE: The optimal balance between the need for L/E mechanical loading and the increased risk of L/E fragility fracture during EXO walking programs among MWUsci is unknown. PURPOSE: To present a recently developed clinical decision support algorithm and to initiate dialogue in preparation for a Delphi-based consensus to refine the algorithm based on empirical evidence. METHODS: The clinical decision support algorithm was developed using a literature overview and expert opinions of physical medicine and rehabilitation professionals. RESULTS: Total hip BMD, measured by dual-energy X-ray absorptiometry, was used to assign each MWUsci to one of three intensities of an EXO walking program: low (T-score ≤ -2.5): first session = maximum of 300 steps, number of steps progress up to 10% every week; moderate (-2.5 < T-score < -1.0): first session = maximum of 400 steps, number of steps progress up to 15% every week; or high (T-score ≥ -1.0 SD): first session = maximum of 500 steps, number of steps progress up to 20% every week. Thus far, 11 MWUsci (low = 3, moderate = 2, high = 6) have completed their intensity-specific EXO walking programs (1-3 days/week for 16 weeks) and remained fracture free. SIGNIFICANCE: The proposed clinical decision support algorithm is a first step in raising awareness of L/E fracture risk during EXO walking programs and calls stakeholders to engage in its refinement.

81| Carson J Halliwell- Dalhousie University; Masters (In progress or completed)

"Pathomechanics of Femoroacetabular Impingement Using Challenged Walking"

Femoroacetabular impingement (FAI) is a proliferative musculoskeletal diagnosis in young adults. Inconsistent findings during level ground walking between FAI and control populations have led authors to speculate whether traditional level ground walking is enough to elicit significant biomechanical alterations. The purpose of the current study was to investigate the effect of challenged walking on gait mechanics in individuals with FAI compared to age matched controls.Seven patients with a clinical diagnosis of FAI and seven controls were recruited to participate. All participants underwent gait analysis, using an 8-camera motion capture system, with full body passive reflective markers and synchronized with an instrumented treadmill during level, incline and decline walking (treadmill set to □5o and □10o). Surface electromyography was normalized to percent maximum voluntary isometric contraction. A 2-way mixed methods ANOVA assessed for within and between group differences for sagittal plane hip range or motion (SROM), peak and mean activation of the gluteus maximus (Gmax). Effect sizes (ES) were calculated using the mean change between level ground and each incline/decline condition between groups, then interpreted using Cohen's d. Significant main effects for condition were found for all biomechanical and neuromuscular variables (p = <0.05). Exploratory analyses revealed moderate to large ES for SROM at 5o (ES = 0.56) and 10o degree (ES = 0.84) inclines, peak hip extension (ES = 1.12) at 10o incline, peak hip flexion (ES = 0.78) at 10o decline, and peak (ES = 0.72) and mean (ES = 0.74) Gmax activation at 10o incline between FAI and controls. Moderate to large ES suggest that challenged walking may elicit significant biomechanical and neuromuscular alterations between individuals with FAI and asymptomatic controls and support further investigation with larger samples and increased statistical power.

102| Michaela CM Khan- University of British Columbia; PhD (In progress or completed)

"Acute Achilles Tendon Rupture: A 15-Year Follow-Up"

Background: It is unknown if deficits in the involved limb following acute Achilles tendon rupture (AATR) persist in the long-term or how outcomes change over time. Further, we lack long-term data comparing operative and non-operative treatment options. The purpose of the present study was to investigate side-to-side differences, describe changes over time, and compare those treated operatively and non-operatively.
Methods: This study included 31 participants (12 operative, 19 non-operative) at an average of 15±1 years post-AATR from a previous randomized controlled trial that compared operative and non-operative treatment. Outcomes from the initial trial were re-assessed, including plantarflexion and dorsiflexion isokinetic strength and range of motion, calf circumference, and the Leppilahti score. Dependent and independent t-tests were used for between-limb and between-group comparisons, respectively. Changes over time from the initial trial to present study were evaluated using a one-way repeated measures ANOVA.
Results: In the involved compared to the uninvolved limb, plantarflexion strength was weaker at 240°/s, dorsiflexion strength was higher at 30°/s, plantarflexion range of motion was larger, dorsiflexion range of motion was smaller, and calf circumference was smaller. Good results were achieved on the Leppilahti score. Over time, plantarflexion strength increased while ankle range of motion decreased. A between-group difference favouring the operative group was observed in dorsiflexion strength at 30°/s, though results were highly variable.
Significance: Many side-to-side differences persist in those who sustain an AATR, though some changes from the initial trial to 15 years post-rupture were observed. Outcomes favouring operative treatment were limited and should be interpreted with caution. Deficits identified at this stage in the healing process may help streamline treatment and rehabilitation protocols to optimize recovery.

104| Antoine Frasie- Université Laval; PhD (In progress or completed)

"A protocol for out-of-the-lab assessment of shoulder abductors fatigue."

Background: Work-related shoulder musculoskeletal disorders are a major problem as it affects workers' quality of life and leads to absenteeism. The lack of quantitative measurement tools available to identify muscle fatigue development associated with physical work demands at the upper extremity is challenging for injury prevention. Previous work has shown that a drop in the electromyogram (EMG) power spectrum median frequency (MDF) is correlated with muscle fatigue. The behavior of this fatigue marker as a function of contraction level in real-life activities is not known.
Originality: Our team is developing a wearable system for worker monitoring (EMG and inertial sensors). Covid-19 restrictions forced us to simplify our test protocol (initially designed for in-the-lab measurements) and to collect at home using a portable set-up, temporarily loaned by our team.
Objectives: to characterize the fatigue-associated drop in MDF of shoulder abductors at different levels of voluntary contraction in a home setting.
Methodology: Data collection will be performed by ten participants, at home, under supervision from an experimenter via a videoconference software. They will receive at their doorstep a briefcase with a sanitized sensor kit. They will position four EMG sensors (Delsys Inc., USA) on their middle deltoid and upper trapezius, bilaterally and a tape mark for 90° of abduction on the wall. They will test three 90° static abduction MVC (5s contraction/ 30s rest) while pulling up against an electronic dynamometer (Medup, Canada) strapped between their dominant forearm and foot. They will then perform 3 static and 3 dynamic submaximal contractions (15, 30, 50 % MVC; container filled with water according to individual force; 5 min rest between conditions). One-way ANOVA will identify if MDF changes with levels of muscle contraction.
Significance: This protocol illustrates the advantages of using wearable sensors to assess physical demands outside of the laboratory.
