CBJC 2020
Canadian Bone and Joint Conference

Conference Program – Day 1 Friday June 12, 2020

Session Sponsor:

Western Bone and Joint Institute

Zoom Meeting Room: https://westernuniversity.zoom.us/j/98489615242

Pre-recorded Videos (available post-session): https://vimeo.com/showcase/7216022

12:00 pm ET	**Conference Welcome Address**	**Session Chair: Michele Battié**
Plenary Session A: Phenotyping & Data Registries		**Session Chairs: Michele Battié & Anusha Ratneswaran**
12:10	***Dr. Jeff Lotz,* University of California – San Francisco** ***"Deep phenotyping chronic back pain patients using the biopsychosocial model."*** The NIH Back Pain Consortium (BACPAC) Research Program presents a unique opportunity to broadly characterize a national cohort of cLBP patients with the goal of developing diagnostic algorithms that optimally match patients to treatments. The consortium has reached consensus on an array of questionnaires, clinical assessments, and diagnostic tests that will feed advanced analytic efforts for algorithm development. These efforts are supported by an integrated theoretical model of back pain. A collaborative interventional trial will help establish algorithm validity.	
12:30	***Dr. Gilles Boire,* University of Sherbrooke** ***"The quest for biomarkers in rheumatology"*** Biomarkers are objective variables used to complement clinical evaluation, mostly for diagnostic and prognostic purposes, or to predict or monitor response to treatment. Without such a clinical evaluation, a biomarker may lead to both under- and over-diagnosis. Prognostic biomarkers also have limitations. For example, biomarkers poorly predict patient-related outcomes. Once integrated into clinical practice and used to modify treatment, a biomarker's impact decreases or disappears. Despite their aura of big science, novel biomarkers derived from high-throughput techniques (e.g. microbiome studies) must be as carefully evaluated as more conventional biomarkers.	
12:50	**Danielle Whittier** – *University of Calgary; PhD* "Open-Source Reference Data for Bone Microarchitecture in Adults Measured using Second-Generation HR-pQCT" Introduction: As the application of high resolution peripheral quantitative computer tomography (HR-pQCT) for the study of bone microarchitecture continues to grow, there is a need to establish normative data that can be used as a basis for assessing skeletal health across the lifespan. Normative datasets are available for the first-generation HR-pQCT (XtremeCT, Scanco Medical, 82 µm), but even with cross-calibration efforts these reference datasets are not suitable for second-generation bone microarchitecture properties due to fundamental differences in morphological measurement techniques between scanner generations. This study aims to develop site-, and sex-specific centile curves for bone mineral density, microarchitecture, and micro finite element (µFE) estimated parameters measured using the second-generation HR-pQCT. Methods: A total of 1,236 individuals recruited from Calgary and the surrounding area participated in this study (males: 468 and females: 768). Participants were between the ages of 18 and 95 years, and 86.3% Caucasian. Participants' non-dominant radius and left tibia were scanned using the second-generation HR-pQCT (XtremeCT II, Scanco Medical, 61 µm), and a standard analysis was completed for bone density and microarchitecture parameters. Centile curves were generated using the generalized additive models for location, scale, and shape (GAMLSS) package in R (V3.4.1). Results: Sex-and site-specific centiles have been determined for bone mineral density, microarchitecture parameters, and µFE-estimated failure load (Figure 1). Discussion: These centile curves provide a valuable reference population for others to directly compare results obtained using the second-generation HR-pQCT, and provide an opportunity to explore phenotypic characteristics in the population. It is our intention to make these data widely available to researchers and clinicians through our online web application (www.normative.ca).	
1:00	**Noémi Dahan-Oliel** – *McGill University; Mid-career Researcher* "Registry for children with arthrogryposis: Mapping phenotype with genotype" Background: Arthrogryposis multiplex congenita (AMC) is defined as congenital joint contractures in two or more body areas. The primary underlying cause is fetal akinesia, attributed to genetic and/or environmental factors. Over 400 known genes have been related to AMC with considerable variability in phenotypic expression. Yet, an understanding of the genetic pathways is required to develop gene therapies. Multiple orthopedic interventions are often required, but evidence-based guidelines as to type and timing of treatment are lacking. Originality: To address these important knowledge gaps, a multi-site registry for children with AMC was implemented at four North American pediatric orthopedics hospitals. Objectives: To map the phenotype and genotype of children with AMC by: i) describing the clinical presentation, ii) determining genetic causes of AMC. Methodology: Children presenting with multiple congenital contracture (0-21 years, n=300) will be invited to participate. Primary caregivers and youth are asked to complete standardized questionnaires to assess mobility, self-care, cognition, pain and quality of life. Pregnancy, obstetric and neonatal history is obtained from medical charts to explore risk factors and further describe the phenotype. Next generation sequencing is offered to participants based on prior genetic testing and findings, family history of AMC and atypical clinical presentation. A telehealth consultation with a geneticist is provided when additional information is required to establish the diagnosis. Significance & Impact: Preliminary findings on 19 participants recruited to date will be presented. The systematic collection of clinical and genetic data in a registry provides the opportunity to formulate hypothesis-driven studies on a large, representative sample of children with AMC to promote musculoskeletal research. Finding causative genes provides benefits for diagnosis, individualized treatment, and genetic counselling to families.	

1:10	**Jenna Schulz** – *Western University; PhD* "Reliability of the KIMRISS for rating bone marrow lesion scores after osteotomy" Background: Bone marrow lesions (BMLs) commonly occur in knee osteoarthritis (OA) and are associated with increased risk of cartilage damage and pain. The Knee Inflammation MRI Scoring System (KIMRISS) is a semi-quantitative grading tool used to evaluate measures of inflammation in patients with knee OA, but it's reliability pre and post a surgical intervention has not been determined. Objectives: Investigate inter-rater reliability of KIMRISS BML scores including expert readers and a trainee reader and determine validity of KIMRISS BML scores before and 1-year after medial opening wedge high tibial osteotomy (HTO). Methods: Patients with varus alignment and medial compartment knee OA undergoing unilateral HTO were included. Sagittal 2D turbo spin-echo sequences were acquired at 3-Tesla in both knees pre and 1-year post HTO, after surgical removal of hardware. Femoral BML scores in the medial and lateral compartments were assessed on images blinded to limb and time by masking surgical evidence. Three reviewers independently graded the same 136 scans (34 patients, two limbs, two time points) on a scale of 0-500. Reliability of BML change scores in the medial and lateral compartment of the surgical limb were evaluated by calculating intraclass correlation coefficients (ICC) and Bland-Altman plots with 80% Limits of Agreement (LoA). Results: When combining all three raters, the ICC (95% confidence interval) was 0.74 (0.59, 0.85) for the medial compartment and 0.71 (0.55, 0.83) for the lateral compartment. Paired rater ICCs ranged from 0.56-0.83. The 80% LoA was -3.57 to 5.44 for the medial compartment and -1.57 to 3.47 for the lateral compartment. Paired rater LoA ranged from -5.07 to 7.70. Impact: The KIMRISS can detect differences between femoral BML scores in the surgical limb and is readily learned by a trainee reader. This supports the inter-rater reliability, feasibility and concurrent validity of compartment-specific BML scores.
1:20-1:30	**Health Break – Get up & Stretch!**
1:30-2:50	**Bilingual Poster Sessions:** **Bone** **Session Pre-recorded Videos** (available post-session): https://vimeo.com/showcase/7175382 Sponsored By: Schulich School of Dentistry ~ Courtney Waugh ~ Donated Speaker Honorarium **Spine/OA/Basic Science** **Session Pre-recorded Videos** (available post-session): https://vimeo.com/showcase/7214866 Sponsored By: Schulich Medicine & Dentistry — University of Saskatchewan College of Kinesiology
1:30-2:50	**Special Emphasis Session: MSK Imaging Innovations | MSK Rehab: Wearables & Biomechanics** Session Sponsor: Dalhousie University Faculty of Health **Zoom Meeting Room:** https://westernuniversity.zoom.us/j/95912086874 **Pre-recorded Videos** (available post-session): https://vimeo.com/showcase/7216206

Special Emphasis Session: ***MSK Imaging Innovations*** **Session Chair: David Cooper & Jenna Schulz**

1:30	**Sydney M Robinson** – *Western University; Master's* "Evaluation of scaphoid kinematics using 4-dimensional computed tomography" Background: Traumatic injury of the scapholunate ligament (SLL) can lead to long-term degenerative arthritis. Current diagnostic tools for SLL injuries are radiographs and clinical examinations, which are unable to detect subtle bony movement abnormalities nor dynamic instabilities. Four-dimensional computed tomography (4DCT) can capture abnormal bony movements and allows for quantification of carpal kinematics in real time. The purpose of this study was to use 4DCT as a method of measuring the translation of a scaphoid's centroid during radio-ulnar deviation in situ. Methods: Twelve participants with no history of wrist pain nor injury were recruited and underwent unilateral imaging of the wrist using a 4DCT scanner while performing three cycles of radio-ulnar deviation. Models of the scaphoid and radius in extreme radial and extreme ulnar deviation were made in Materialise Mimics 22.0 and registered to a neutral model using Python. Transformation matrices and a radius-based coordinate system (Matlab) were used to describe the position of the scaphoid's centroid in each kinematic frame relative to the position of the radius in the static frame. Results: The average scaphoid translation was 1.7±1.5 mm dorsal, 5.5±1.4 mm distal, and 2.3±0.9 mm lateral (6.4±1.3 mm total) and showed no statistically significant difference according to sex (p=0.170) nor lunate type (p=0.961). The scaphoid extended from extreme radial to extreme ulnar deviation, which is consistent with the literature. Significance & Impact and Future Studies: These results show that 4DCT can be used to analyze scaphoid motion in vivo in a clinical setting. This data provides a starting point for establishing normal scaphoid motion in healthy subjects, which can be used as a control for comparison with individuals with scapholunate instabilities and to advance the understanding of the complex motion of the carpals. Future studies will examine the effects of SLL injury on scaphoid centroid translation.

1:40	**Puneet K Ranota** – *Western University; Master's* "4DCT To Examine Joint Congruency Following Wrist Fracture" BACKGROUND: Previous studies are limited by their ability to capture dynamic data (3D reconstructions + time). Four-Dimensional Computed Tomography (4DCT) captures joint motion and measures 3D joint space. Previous studies solely focused on the distal radioulnar joint (DRUJ) space and the impact of fracture on surrounding joint mechanics has yet to be examined. OBJECTIVE: To employ 4DCT and examine joint surface area (JSA) at DRUJ and radiocarpal joints following fracture. METHODOLGY: Eleven healthy and eleven distal radius fracture participants were recruited. Patients underwent 1 "static" and 1 "kinematic" scan throughout wrist extension/flexion (GE Revolution 4DCT Scanner, 5°/sec). Semi-automated segmentation was used to create 3D reconstructions of the distal radius and carpal bones (Materialise Mimics). A surface-based registration algorithm (ICP) was used to match the kinematic bone surfaces with the static bone surfaces. A previously developed inter-bone distance algorithm was used to measure JSA at maximum extension, neutral and maximum flexion for each joint (normalized to the individual's total static JSA). Univariate and repeated measures ANOVA were conducted (statistical significance was set at $p<0.05$). RESULTS: The JSA % of the DRUJ was significantly different between healthy and fracture cohorts. The JSA % was significantly different across the range of motion (ROM) in radiocarpal joints for the healthy cohort and only in radioscaphoid joint for the fracture cohort. SIGNIFICANCE: The results showed that joint congruency was affected by health status and changed across ROM. Future work needs to examine the link between altered contact mechanics and osteoarthritis.
1:50	**Sam Papernick** – *Western University; Master's* "Validation of 3D ultrasound for quantifying trochlear knee cartilage loss" Introduction: Osteoarthritis (OA) is the most prevalent chronic health condition in Canada. X-ray imaging and MRI are the current standards for assessing cartilage loss. However, x-ray imaging is unable to provide soft tissue assessments, and MRI is expensive, associated with long waitlists, and is inaccessible to many patients. There is a tremendous clinical need for an objective/imaging-based point-of-care tool to assess OA status, progression, and response to treatment. We propose the use of a handheld mechanical 3D ultrasound (US) device we have developed for quantifying the volume of the femoral articular cartilage (FAC) at the patient's bedside. Objectives: We aim to validate volume measurements of the trochlear FAC using 3D US segmentations against the current standard of MRI in healthy subjects. Methods: Knee images of 25 healthy volunteers were acquired using our 3D US device with accompanying 3.0T MR images. The trochlear FAC was repeatedly manually segmented by 2 raters at 2 time points on MR and 3D US images. 3D US segmentations were registered to MRI using a semi-automated surface-based registration algorithm. Intra- and inter-rater reliabilities were assessed using intraclass correlation coefficient (ICC) values calculated from segmentation volumes. Correlations between MRI and 3D US cartilage volumes were assessed using a Spearman Rank-Order Correlation. Results: 3D US intra-rater ICC were 0.99 ($n = 5$) for both raters while inter-rater ICC was 0.95 ($n = 25$). MRI intra-rater ICC were 0.97 and 0.90 ($n = 5$) for each rater while inter-rater ICC was 0.83 ($n = 25$). Spearman correlation resulted in $\rho = 0.88$ ($p < 0.0001$, $n = 25$). Significance: We have validated a handheld 3D US acquisition device that can be used to acquire volume measurements of the trochlear FAC with higher reliability than MRI in healthy subjects. 3D US has the potential to increase the quality of lives of knee OA patients by reducing the need for MRI in OA clinical trials and future care.
2:00	**Baraa Daher** – *Western University; Master's* "Four-Dimensional Computed Tomography Scans Allow kinematic Visualization and Measurement of Scapulothoracic Joint" Background and Objective: Literature surrounding the characterization of the scapulothoracic joint is limited and controversial. One of the many challenges faced when characterizing scapulothoracic motion is the difficulty in detecting/palpating anatomical landmarks due to skin artifacts. However, these obstacles are circumvented when using a 4-dimensional computed tomography (4DCT) scanner. The objective of this study is to quantitatively evaluate scapular translation during active internal/external rotation using 4DCT scanning. Methods: A single healthy participant with no previous history of shoulder injuries was recruited and underwent dynamic 4DCT imaging of their shoulder. CT scans during motion were performed for eight seconds (producing 25 frames of images). Neutral CT frame and first and last dynamic frames were reconstructed into 3-dimensional models of the scapula and spine. Translations of the trigonum relative to the neutral position of third thoracic (T3) vertebrae and the superior angle relative to its neutral position were calculated. Results: Translation of the scapula was measured for both dynamic frames relative to the neutral frame. In the first frame, the trigonum moved 21mm laterally with respect to the T3, and the superior angle moved 19mm inferiorly with respect to its neutral position. In the last frame, the trigonum moved 19mm medially with respect to the T3, and the superior angle moved 17mm superiorly with respect to its neutral position. Significance and Impact: Preliminary results suggest that the scapula translates with respect to the spine and glides across the thorax during shoulder motion. Understanding the motion of the scapulothoracic joint will improve the engineering design of shoulder implants and surgeries approach.
2:10	**Sara Hakim** – *Western University; Master's* "Modelling Ischemia in Duchenne muscular Dystrophy" Introduction: Duchenne muscular dystrophy (DMD) is a progressive neuromuscular degenerative disorder caused by the absence of dystrophin, which results in a loss of cell membrane integrity. Necrotic fibers are often observed in groups, and it has been previously hypothesized that this may be due to a reduction in regional blood supply. The accumulation of adipose and fibrotic tissue replacing muscle fibers further exacerbate the ischemic condition. Here we aim to develop an imaging protocol to non-invasively and systemically model hemodynamic parameters in DMD. We hypothesize that CT perfusion will help model DMD disease progression by quantifying such changes in the heart, brain, and skeletal muscle. Methods: Two cohorts of DMD mice (n=6) and their respective controls were scanned using CT to collect both longitudinal and acute data at differing time points 4-5 weeks, 8-10 weeks, and 15-20 weeks. These critical periods are associated with disease progression and correspond to pre-fibrotic, fibrotic, and post fibrotic conditions respectively. Wire myography was used to study aortic vascular reactivity, and histological staining (n=3) to validate CT findings. Results: DMD mice have qualitatively shown increased levels of collagen deposition within the brain, and cardiac tissue. Furthermore, wire myography has concluded that DMD mice are less likely to mediate dilatory responses than contractile responses at the 15-20 week time point. Discussion: Currently, there is little knowledge of functional tissue perfusion parameters in DMD patients. This research will be essential in developing therapeutics to restore tissue integrity and function when the natural ability of the tissues for repair is exhausted. Further, it will serve as a non-invasive diagnostic measure to assess disease progression prior to the onset of fatal complications.

2:20	**Gregory Hong** – *Western University; PhD* "MRI Artifact Reduction Near 3D-Printed Porous Metal Scaffolds" Background: Infection is the most common reason for early revision (within 5 years of primary surgery) of both hip and knee replacements. The gold standard treatment of infection is to implant a temporary antibiotic impregnated cement spacer in a 2-stage revision. Originality, Rationale, and/or Scope: We aim to maintain the benefits of a 2-stage revision in a single surgery through a 3D printed porous metal scaffold that can be filled with antibiotics and deployed as a permanent replacement for the failed solid implant. The porosity will also reduce metal artifacts, leading directly to better monitoring of the infection. Objectives: Our objective is to characterize the signal loss and magnetic susceptibility of titanium scaffolds of varying porosities to quantify image artifact. Methodology: 5 gyroid-based scaffolds were 3D printed in titanium with nominal porosities between 60% and 90% in cylinders of 17 mm diameter and 40 mm length. The cylinders are placed in a fiducial phantom that establishes a co-registration between scan and simulation. Field maps were calculated from the difference in phase accumulation between two gradient-echo scans. The scaffold's effective susceptibility was measured by comparing the scanned field maps against simulated field maps of a cylinder assigned susceptibility values ranging from water to titanium (-9 to 182 ppm). Results: The susceptibility estimates give a highly correlated (R2 = 0.9993) linear relationship with a 100% porosity value of χ = -9.9 ppm, comparable to the expected value of pure water (χ = -9.06 ppm). Significance & Impact and/or Future Studies: We have shown that artifact size and effective susceptibility are strongly correlated with porosity. The reduced artifact around porous implants is promising for MR imaging as lowering effective densities reduces the artifact size to within millimeters of the scaffold, which may allow for quantitative imaging techniques to track antibiotic elution.
2:30	**Discussion & Session Wrap up**

Session Sponsor:

Canadian MSK Rehabilitation Research Network

Zoom Meeting Room: https://westernuniversity.zoom.us/j/98815224579

Pre-recorded Videos (available post-session): https://vimeo.com/showcase/7216014

Special Emphasis Session: ***MSK Rehab: Wearables & Biomechanics***	**Session Chair: Michael Hunt, Cheryl Kozey & Harvi Hart**
1:30	**Introduction by Cheryl Kozey & Michael Hunt**
1:40	**Monica Russell** – *University of Calgary; Undergrad* "Axillary crutch length effects on upper extremity kinematics" Background: Crutch-assisted gait results in repetitive weight-bearing through the upper extremities (UE). This can result in secondary UE pain and injury. If this occurs, it can worsen disability in a person with impaired ambulation ability. Proper crutch fitting may be important to mitigate the risk of UE injury. Originality: There have been no studies assessing the impact of axillary crutch length on UE kinematics. Objective: To analyze scapular, elbow, and wrist kinematics during axillary crutch-assisted gait when crutches are fit appropriately and inappropriately. Methodology: Fifteen able-bodied adult males (mean age: 26) were fit with crutches using standard guidelines, and crutches that were 5 cm longer and 5 cm shorter than standard-fit crutches. Subjects performed 15 gait cycles with each crutch length. A 12-camera motion capture system was used to determine UE and crutch kinematics. Statistical parametric mapping analyses were performed. Results: Crutches that were too long increased scapular downward rotation ($p<0.01$) throughout the gait cycle. Crutches that were too short increased elbow extension ($p=0.02$) during crutch advancement and increased ulnar deviation of the wrist ($p<0.01$) throughout the gait cycle. Significance: Crutches that are too long increase scapular downward rotation. Increased scapular downward rotation has been associated with neural tension phenomena and may explain why 50% of short-term crutch users report paresthesiae or numbness. The increased elbow extension noted when using shorter crutches may increase triceps-based pain, which has also been reported in 5% of crutch users. There have been case reports of proximal ulna and wrist injuries with crutch use, and shorter crutches may increase these risks. Appropriate crutch fitting may be imperative to reduce the risk of UE injury with short- and long-term crutch use.
1:50	**Philip Boyer** – *Sunnybrook; PhD* "Physiotherapy Activity Out-Of-Distribution Detection" Background: When tracking at-home physiotherapy exercise adherence in "real-world" patient scenarios, subjects may perform unrelated activities (e.g. taking a drink) in addition to their prescribed exercises. Training a Machine Learning (ML) algorithm on all possible human actions for activity recognition is impractical and supervised ML algorithms do not accurately classify Out-of-Distribution (OOD) activities. Methods to address the OOD problem exist for image classification, but have not yet been applied to time series activity recognition. Hypothesis: OOD samples can be accurately detected in a physiotherapy activity dataset using ML (AUROC $\geq$ 0.95). Methodology: Our team has collected a novel inertial dataset (SPARS9x) captured by smart watches worn by 20 healthy subjects as they performed supervised shoulder physiotherapy exercises (in-distribution), followed by a minimum three hours of data as they engaged in unstructured activities (OOD). The dataset was analyzed using "classical" algorithms on engineered features (One-Class State Vector Machine (OCSVM), K-Nearest Neighbour (KNN), and K-Means), and deep learning approaches (thresholding based on SoftMax "confidence"; confidence calibration via entropy regularization; confidence calibration via temperature scaling and input perturbations (ODIN); and extending the SoftMax layer for prediction of an unknown class (OpenMax). Results: Simple and rapid OOD-detection techniques such as KNN using engineered features were found to outperform deep learning techniques on this time series dataset of physiotherapy exercise inertial data. KNN OOD prediction performed best in cross-validation, achieving mean Areas under the Receiver Operating Characteristic Curve (AUROC) of 0.97. Conclusion: Accurate detection of OOD-activities in physiotherapy inertial data is possible with ML.

2:00	**Robert M Kanko** – *Queen's University; Master's* "Running Kinematics Measured Using Markerless Motion Capture" Background: Marker-based motion capture systems are well-accepted but are resource intensive, susceptible to marker placement errors, and cannot be used in real-world environments such as outdoors. Markerless motion capture eliminates these barriers and could improve our understanding of motor task performance in real-world conditions. Theia3D is a deep-learning based markerless motion capture software with this potential. Objective: To compare kinematics obtained using Theia3D markerless motion capture and marker-based motion capture during running. Methodology: 27 adults (15F; mean age: 23) performed treadmill running at a self-selected speed (mean 2.4 m/s) during simultaneous video (8 cameras) and marker-based (7 cameras) motion capture. Markers were tracked and video data were processed in Theia3D to obtain 3D pose estimates, and both datasets were analyzed concurrently in Visual3D. Root-mean-square differences (RMSD) quantified system differences for joint positions and angles. Intraclass correlation coefficients (ICCA-1) were calculated for joint angles. Results: Differences between corresponding joints had RMSD of (mean(SD)): ankle 21(3) mm; knee 19(8) mm; hip 27(7) mm; shoulder 22(6) mm; elbow 25(5) mm; wrist 12(3) mm); movement of markers relative to underlying bone have similar magnitudes [1]. Lower limb sagittal joint angles had very strong correlations (0.9-0.99) and small RMSD (ankle=6.5°, knee=3.5°, hip=7.1°) between systems. Correlations (0.2-0.5) and RMSD (ankle=8.0°, knee=5.7 °, hip=4.8°) showed lower agreement in the frontal plane. Both systems measured similar joint angle patterns, but the markerless system showed greater consistency. Significance: These results indicate that 3D joint positions and sagittal plane lower limb kinematics can be accurately measured using Theia3D markerless motion capture, significantly reducing the barriers to collecting kinematic data of running.
2:10	**Jesse M Charlton** – *University of British Columbia; PhD* "Knee-biomechanics during gait are reliable between two laboratories" Background: Multi-centre gait biomechanics studies provide opportunities to greatly increase sample size, yet differences between centres may introduce error in the data. Previous research showed that the variance of lower body gait biomechanics can range widely between laboratories. Rationale: Due to limited reporting of reliability statistics in earlier work, little is known about relative reliability and measurement error metrics that are needed when interpreting multi-centre studies. Purpose: Assess the inter-laboratory and inter-rater reliability of knee biomechanics during gait. Methodology: 12 healthy adults attended sessions at 2 independent motion capture laboratories (inter-laboratory). A different researcher (inter-rater) at each lab acquired stance-phase knee joint biomechanics using common methods. Relative reliability (ICC: intraclass correlation coefficient), measurement error (SEM: standardized error of the measurement), and the minimum difference to be considered real (MDD: 95% minimum detectable difference) were quantified. Results: Joint angle and moments exhibited ICCs >0.83, except for the knee adduction moment late stance peak (ICC=0.69). Sagittal plane knee angles (peak flexion and extension) exhibited SEMs and MDDs ≤2º and ≤5.3º, respectively. The knee adduction moment (%BW*HT) at early and late peak, and at midstance exhibited SEM of <0.31 and MDD of <0.85. Meanwhile, the knee adduction moment impulse (%BW*HT*s) showed an SEM of 0.09 and MDD of 0.26. Lastly, the peak knee flexion moment (%BW*HT) showed an SEM of 0.54 and an MDD of 1.51. Significance: These results suggest knee biomechanics are reliable between laboratories. Moreover, our findings are similar or better than previously reported reliability, even when compared to within-laboratory studies. Though our findings are limited to the laboratories involved, they provide reliability statistics that other groups can compare to or use when designing multi-centre studies.
2:20	**Jose G Colli-Alfaro** – *Western University; PhD* "User-Independent Hand Gesture Recognition Using Sensor Fusion Techniques" Background: Stroke is the third leading cause of disability. 80% of stroke survivors are affected by upper limb hemiparesis, thus requiring extensive rehabilitation sessions to regain motor functions. It has been proven that targeting the motor impairments while using wearable mechatronic devices as a robot assisted therapy can improve the rehabilitation outcomes. However, despite the increased progress on control methods for wearable mechatronic devices, the need for a more natural interface that allows for better human—machine interaction remains. Objective: To develop a user-independent gesture classification method based on a sensor fusion technique that combines electromyography (EMG) and kinematic data. Methodology: The Myo Armband was used to measure muscle activity and motion data from healthy subjects. Participants were asked to perform 10 types of gestures in 4 different arm positions while using the Myo on their dominant limb. Data from 22 participants were used to classify the gestures using 4 different classification methods. Then, each classification method was trained using the EMG and kinematic data from each participant. The following classification methods were tested: the particle adaptive classifier (PAC), the adaptive least-squares support vectors machines, the bilinear model-based classifier, and multilayer perceptron (MLP) networks. Finally, a 5-fold cross-validation method was used to test the efficacy of each classification method. Results: Overall classification accuracies in the range of 33.11%–72.1% were obtained. However, following the optimization of the gesture datasets, the overall classification accuracies increased to the range of 45.5%–84.5%. Significance: These results suggest that by using the proposed sensor fusion approach, it is possible to achieve a more natural human machine interface that allows a better interaction with wearable mechatronic devices during robot assisted therapies.
2:30	**Lauren C Benson** – *University of Calgary; Post-Doc Fellow* "A Wearables-Based Lower Limb Asymmetry Metric to Monitor Rehabilitation" Background: Lower limb asymmetry is used to monitor rehabilitation progress. Rationale: A correlation between ground reaction force (GRF) and tibial acceleration (TA) suggests TA may be used to identify lower limb asymmetries. Objectives: To identify the agreement between GRF and TA-based lower limb asymmetries, and to examine asymmetries among those with a previous severe knee injury. Methodology: Part 1 - Nineteen adults [11F, 8M; 26.8 (5.5) years; 171.6 (8.2) cm; 74.1 (12.4) kg; dominant leg: 18 right, 1 left] performed three countermovement jumps (CMJ) and three squat jumps (SJ) with at least 30 seconds of rest between each jump. A triaxial accelerometer was fastened to the anterior-medial aspect of the tibia and each foot landed on a separate force plate. The peak axial GRF and TA during landing was identified. Lower limb asymmetry was calculated as the difference between the dominant and nondominant leg peaks divided by the maximum peak and expressed as a percentage, with a positive value indicating a greater dominant leg peak. The agreement between the GRF- and TA-based lower limb asymmetries was determined by intraclass correlation coefficient (ICC(3,k)). Part 2 - Twenty-four adults with a history of severe knee injury [14F, 10M; 26.8 (2.9) years; 173.0 (9.6) cm; 82.3 (14.1) kg; injured leg: 19 right, 5 left] performed ten CMJ and ten SJ with at least 30 seconds of rest between each jump. TA-based lower limb asymmetries were calculated as above such that a positive value indicated a greater non-injured leg peak. Results: The agreement between GRF- and TA-based lower limb asymmetries was good for the CMJ (ICC(3,k) = 0.800) and moderate for the SJ (ICC(3,k) = 0.719). Lower limb asymmetries for those with a previous severe knee injury ranged from -25% to 68% (CMJ) and from -33% to 46% (SJ). Significance & Impact: TA may be used to identify lower limb asymmetries, leading to a low-cost and portable method for monitoring rehabilitation progress.

2:40	**Annemarie F Laudanski –** *University of Waterloo; PhD* "IMU-based lower extremity kinematics validation in high knee flexion" Background: Repetitive exposure to high flexion postures, where the knee flexion angle >120°, is a known factor in the initiation and progression of knee osteoarthritis (OA)1,2. Wearable sensors (IMUs) may present a viable means for the measurement of such exposures in occupational settings where they are commonly adopted in order to evaluate their potential association with increased OA risk. Objectives: IMU-based joint kinematics for the hip, knee, and ankle were compared to those synchronously collected using gold-standard laboratory-based motion capture in high flexion postures to determine their suitability for accurate measurement of lower limb joint angles of childcare workers. Methodology: 20 participants were recruited to perform 6 childcare inspired high knee flexion postures: heels-up and flatfoot squatting as well as dorsiflexed, plantarflexed, single-arm supported, and double arm supported kneeling. Participants were instrumented with inertial and optical motion capture on the right lower extremities and pelvis. Joint constraints were exploited to calculate the IMU-based joint angles2,3 and estimates were compared to gold-standard optical-based kinematics through root mean squared error (RMSE) and coefficient of multiple correlation (CMC) analyses. RMSE represents the average error of estimates compared to the gold standard in degrees while CMC represents a measure of similarity between waveforms. Results: CMC analysis revealed very good similarity in all postures for the hip and ankle and excellent similarity for the knee. Mean RMSEs were found to be 6.48°, 2.20°, and 2.79° for hip, knee, and ankle respectively. Conclusion: The proposed system may provide an accurate means of measuring lower-limb kinematics in occupational settings and advance the study of posture related OA risk.
2:50-3:00	**Health Break – Get up & Stretch!**
3:00-4:15	**Special Emphasis Session: Joint Arthroplasty | Bone | MSK Rehab Strategies**

Session Sponsor:

CaNMOR ACTIVE FOR LIFE!

Zoom Meeting Room: https://westernuniversity.zoom.us/j/99052979947

Pre-recorded Videos (available post-session): https://vimeo.com/showcase/7216002

Special Emphasis Session: *Joint Arthroplasty* Session **Chair: Daniel Langohr & Adam Paish**

3:00	**Jacob M Reeves** – *Western University; Post-Doc Fellow* "Indentation Depth as an Objective Alternative to Surgeon 'Thumb Testing" Intro: During shoulder arthroplasty, surgeons must choose the optimal humeral component type and size for each patient. Metaphyseal bone quality is important for achieving primary implant fixation; however, the typical 'thumb test' to gauge bone quality lacks the objectivity needed to be referenced between surgeons. The purposes of this investigation were: (i) to determine the correlation strength between a probe's indentation depth and the quality of a bone surrogate; as well as (ii) to assess how changing the indenter tip shape and impact energy would affect these relationships. Methods: A spring-loaded indenter was developed. Four tip shapes (needle, tapered, flat and radiused cylinders) and four spring energies (0.13J – 0.76J) were assessed by indenting five cellular foam bone surrogates of varying density (0.12g/cm3 – 0.32g/cm3). Each tip-spring combination was tested five times/block. The indentation depth was measured and correlated to apparent density and compressive stiffness; and the distance between the shallowest and deepest mean indentations was quantified. Results: Indentation depth plateaued as the density and stiffness increased, particularly for indentation tips with larger footprints and weak springs. Removing the densest block, which exceeded the physiologically expected range, the correlation strength was excellent for both density and compressive stiffness, regardless of tip shape (needle: r2 = 0.71 – 0.94; flat cylinder r2 = 0.66 – 0.96; radiused cylinder r2 = 0.83 – 0.93; tapered r2 = 0.77 – 0.93). The needle tip created the largest range between the shallowest and deepest mean indentation depths, followed by the tapered, flat and radiused cylinder tips. Conclusion: The exceptional correlation strength found suggests that indentation depth could provide objective evidence of bone quality intraoperatively. Though the needle tip impacted between 0.30 – 0.76J seems the most promising, further tests in human tissue are needed.
3:10	**Amir Tavakoli** – *Western University; Master's* "The Effect of Angulation on Stress Shielding in Total Shoulder Arthroplasty" BACKGROUND: Total shoulder arthroplasty (TSA) is a treatment for end-stage glenohumeral arthritis [1]. Using high stiffness uncemented stems causes stress shielding and induces bone resorption of up to 63% of patients following TSA [2]. Shorter length stems with smaller global dimensions have been studied to lessen stress shielding [3], however the effect of humeral short stem varus-valgus positioning on bone stress is not known. Therefore, the purpose of this study was to quantify the effect of humeral short stem varus-valgus angulation on bone stresses after TSA. METHODOLOGY: Three dimensional models of eight male cadaveric humeri (age:68±6 yrs) were created from CT data using MIMICS (Materialise, Belgium). The resulting models were virtually reconstructed using a short stem humeral implant (Exactech Preserve) in three orientations; i) centered within the humeral canal (STD), ii) valgus angulated (VAL), or iii) varus angulated (VAR). Bone was meshed using a custom technique which produced identical bone meshes permitting the direct element-to-element comparison of bone stress [4]. Cortical bone was assigned an elastic modulus of 20 GPa and a Poisson's ratio of 0.3. Trabecular bone was assigned varying stiffness based on CT attenuation [5]. A joint reaction force of 45˚ and 75˚ of abduction was applied [6]. Changes in bone stress, as well as the expected bone response based on change in strain energy density (ΔSED) was then compared for all implant positions [7]. RESULTS: Both varus and valgus positioning altered both the cortical and trabecular bone stresses from the intact states. Valgus positioning had the greatest negative effect in the lateral quadrant for both cortical and trabecular bone, producing greater stress shielding than both the standard and varus positioned implant. Overall, the varus and standard positions produced values that most closely mimicked the intact state.

3:20	**Jason Lockhart** – *Western University; Master's* "Screw Placement and Acromial Stress After Reverse Shoulder Arthroplasty" Introduction: Acromial fractures are a significant complication after reverse shoulder arthroplasty, and have been reported in up to 7% of patients. This study aims to determine if glenoid baseplate screw position, angle, or proximity to the scapular spine influences acromial stress. Methods: Scapula models were created using CT data from eight cadaveric shoulders (74±19yrs), and glenoid fixation was virtually performed for diverging (15°) and perpendicular (0°) screw angles, superior and posterior screw absence, and if the scapular spine was penetrated the screw was both left in the spine and withdrawn from it. The force acting on the glenoid baseplate was determined for nine abduction angles (0-120°) in the scaption plane of elevation. Finite element analysis was performed in Abaqus to determine max principal stress in the scapular spine and a RM-ANOVA was performed. Results: A perpendicular screw angle significantly increased scapular spine stress by 6.5% (2.2 ± 0.6 MPa, p=0.036) compared to a divergent angle. Exclusion of the superior and posterior screws did not significantly affect acromial stress. When the scapular spine was penetrated with a divergent screw angle, removal of the screw from the scapular spine significantly increased stress to 38 ± 6 MPa compared to 33 ± 5 MPa with screw retention (p=0.044). The scapular spine was not penetrated while using a perpendicular angle in this study. An insignificant peak in scapular spine stress was seen in line with the screw shaft. Discussion: These results suggest that a divergent screw angle may decrease the risk of acromial fracture by decreasing scapular spine stress. If a divergent angle is used and the scapular spine is penetrated, then the screw should be left in place in order to avoid increasing scapular spine stress. Scapular spine stress may be increased in line with the screw shaft, suggesting avoiding the scapular spine all together may be beneficial, further research is needed to confirm this.
3:30	**Hana Marmura** – *Western University; PhD* "Surgeons' Perspectives on Changing Practice for ACL Reconstructions" Background: Anterior cruciate ligament reconstructions (ACLR) are common orthopaedic surgeries. Randomized clinical trials are being conducted to improve the process of ACLR and patient outcomes but will not provide benefits to patients if surgeons do not change their practice accordingly. Purpose: To determine the reduction in graft failure risk that would cause orthopaedic surgeons to consider adopting a new surgical intervention for ACLR. Methods: A survey was administered to the ACL Study Group, an international group of orthopaedic surgeons. Using nine scenario-based questions, surgeons were asked to consider making three types of changes; new graft type, new surgical technique, or added extra-articular procedure. Surgeons also had to consider the patients' risk of graft failure: 20% (high), 10% (moderate), or 5% (low). Surgeons indicated a new risk of graft failure, compared to the initial risk, that would influence them to change practice in each scenario. The relative risk reduction (RRR) was calculated. Results: A response rate of 68% was obtained, with a total of 104 usable responses (96% male, aged 53 ± 2 years). A mean RRR in ACLR graft failure of 51.4 ± 1.4% was required to influence practice change across all scenarios. There was no difference in the RRR required for the high, moderate and low risk patient profiles. The RRR required to change graft type was significantly higher compared to changing surgical technique (52.8 ± 2.3% and 50.5 ± 2.4% respectively, $p < 0.05$). Significance: This study indicates the magnitude of risk reduction a new surgical intervention must produce before orthopaedic surgeons will consider its adoption. Clinical trials investigating ACLR may need to show a minimum reduction in graft failure of 51% to cause a change in surgical practice. Studies that show clinically relevant results meeting this threshold should develop knowledge translation strategies to increase awareness and bridge the gap between evidence and practice.
3:40	**Liam Montgomery** – *Western University; Master's* "Characterizing Force Contributions of Soft Tissues in the post-TKR Knee" One common treatment of knee osteoarthritis is total knee replacement (TKR) surgery. This involves replacing the bony anatomy of the joint with metal prosthetics with a goal of providing the patient a pain-free knee. A key factor in achieving normal knee function is good ligament balancing which stabilizes the joint. Satisfaction rates following TKR (84%) remain less than those for other joint replacement surgeries. One reason is joint instability. This can be caused by poor ligament balancing. Therefore, there is a need to better understand the relationship between these factors. The objective of this study is to characterize soft tissues in the knee based on in situ experiments to be later incorporated into a hybrid experimental-computational knee model. Results from previous cadaveric knee tests using 14 specimens were analyzed to determine force contributions from the following ligament sets: the posterior cruciate ligament (PCL), all medial-side ligaments, and all lateral-side ligaments. The tests included passive flexion/extension with simple compressive loads of 100N and 200N. Average force contributions were determined in extension and flexion. The force exerted by the PCL in extension during 200N and 100N were 51+/-39N, and 36+/-22N, respectively. The corresponding forces in flexion were 20+/-17N, and 10 +/-10N. The forces exerted by medial ligaments in extension were 127 +/-76N and 131+/-76N with 200N and 100N loads which decreased to 39+/-34N and 49+/-41N in flexion. With the knee in extension, the lateral soft tissues exerted 76 +/-50 N and 64+/-45N and exerted 18+/27N and 15+/15N in flexion. This agrees with literature that states that ligaments are most stretched in extension. The wide range of values demonstrates the need for subject specific models. Our hybrid knee model will allow us to easily and repetitively test various TKR implant and alignment types using a joint motion simulator giving us a better understanding of post-TKR knee kinematics.
3:50	**Lawrence F Torkan** – *Queen's University; Master's* "A Biomechanical Assessment of Pullout Forces for Three Cemented Femoral Stems" Total hip arthroplasty (THA) is a procedure used to treat end-stage osteoarthritis of the hip. Cemented fixation involves using poly(methyl methacrylate) cement to secure the stem in the femur and to offset instability due to osteopenia in older patients. Cemented femoral components achieve stability through subsidence of the stem within cement, which causes compression at both prosthesis-cement and cement-bone interfaces. Tensile forces on the hip can disrupt the implant causing aseptic loosening. Three femoral stem-types were obtained and implanted into nine synthetic femur surrogates and were compressively loaded for seven days. The mean maximum forces for the pullout of C-Stem, Exeter, and CPT are as follows: initial test, 8381N, 5417N, and 1738N, respectively; re-impacted, 669N, 876N, and 594N, respectively; re-impacted/loaded, 2160N, 1337N, 725N, respectively. Analyses confirmed a significant difference (P=0.0001) between groups and between all comparisons (P<0.004) for the initial test. For the re-impacted condition, no significant difference existed between groups (P=0.387). The re-impacted/loaded condition showed a significant difference between all groups (P=0.009). A similar relationship to that of the initial condition was found between stems in the re-impacted/loaded condition, which outlines the importance of subsidence following loading for maximizing the stem's retention in a cemented system. Although this was the first study to assess cemented stem pullout force following compression loading, future pullout studies would benefit from loading for longer periods of time and using higher compression loads closer to that experienced by the hip during dynamic motion. Exeter maintains fixation and offers a pullout force that may allow for a relatively uncomplicated revision that improves both functional outcomes and patient quality of life.
4:00	**Discussion & Session Wrap up**

Session Sponsor:

Schulich School of Dentistry

Zoom Meeting Room: https://westernuniversity.zoom.us/j/97274355472

Pre-recorded Videos (available post-session): https://vimeo.com/showcase/7215994

Special Emphasis Session: ***Bone*** **Chair: Matthew Grol & Santiago Cobos**

3:00	**Yuwen Zheng** – *University of Saskatchewan; PhD* "Lower Bone Area and Strength in Children and Youth with Type 1 Diabetes" Background & Objective: Greater fracture risk in children and youth with type 1 diabetes (DM1) may relate to weaker bones; however, evidence is limited. The study objective was to compare bone properties and estimated bone strength between children with and without DM1. Methodology: We compared bone properties between 49 children and youth with DM1 (28F) and 170 typically developing peers (88F) (aged 6-15yrs). We used peripheral quantitative computed tomography to measure bone outcomes (area, content, density, and estimated bone strength) at distal and shaft sites of the radius and tibia, and muscle cross-sectional area at the forearm and lower leg. We compared bone outcomes between children with DM1 and their peers using MANCOVA followed by pairwise comparisons. We adjusted radius comparison for sex, maturity, forearm muscle area and body mass and tibia comparison for sex, maturity and body mass. Significance was set at $p<.05$. Results: Adjusted bone outcomes differed between children and youth with DM1 and their peers at the radius and tibia (Pillai's trace = 0.18 and 0.25, $p<.01$, respectively). At the radial shaft, children and youth with DM1 had a 7% lower total bone area, 8% lower cortical bone area, and 8% higher cortical bone density ($p<.05$). At the tibial shaft, children and youth with DM1 had an 7% lower total bone area, 9% lower cortical bone area, 5% lower cortical bone content, and 6% lower bone strength, and a 4% higher cortical bone density ($p<.05$). Conclusion, Significance & Future Studies: Children and youth with DM1 have deficits in bone area, content and strength, but a higher cortical bone density compared to their peers without DM1. Further studies are warranted to explore underlying mechanisms and develop interventions to optimize bone strength development in children with DM1.
3:10	**Daniel R Martel** – *University of Waterloo; PhD* "The Role of Cortical Bone Fracture Toughness on Femoral Neck Bone Strength" Despite the predominant use of Bone Mineral Density (BMD) to assess hip fracture risk, many who suffer hip fractures don't have low BMD (Stone 2003). Therefore, despite the strong association between bone strength and BMD (Dall'Ara 2013), other factors may play an important role in bone strength. One such factor is bone collagen and its degradation, which affects cortical bone fracture toughness (Willett 2019). However, the relationship of fracture toughness on proximal femur bone strength has not been directly investigated. Therefore, the goal of this study was to investigate the relationship between cortical bone fracture toughness and bone strength.DXA scans were performed on five matched-pairs of fresh-frozen cadaveric femurs (10 femurs), extracting femoral neck aBMD. Right femurs underwent simulated hip impacts until failure to determine bone strength. From the left femurs, single edge notch bending (SENB) specimens were extracted from the inferior femoral neck and underwent high displacement rate (40 mm/s) fracture toughness tests while high-speed microscopy-enabled videography captured crack propagation. These data were used to calculate fracture toughness (JIc). Multi-variate regressions were used to investigate factors that predict bone strength (age, aBMD, and JIc). A moderate relationship was found for bone strength and JIc ($R2=0.432, p=0.14$), with further analysis revealing JIc+age as the best model ($R2=0.869, p=0.07$), equivalent to aBMD+age ($R2=0.866, p=0.07$). As a major contributor to fracture toughness, collagen may be an integral component of bones strength, as suggested by these findings, via fracture toughness. To this end, further analyses of cortical bone collagen, including hydrothermal isometric tensions testing and high performance liquid chromatography will be conducted to extract detailed information on collagen network integrity and content, allowing us to more directly assess the relationship between cortical bone collagen and bone strength.
3:20	**Mayu Nagao** – *Western University; Post-Doc Fellow* "Loss of Nucleoside Transporter ENT1 Slows Incisor Eruption in Mice" Background & Originality: Equilibrative nucleoside transporter 1 (ENT1) transfers nucleosides, such as adenosine, across plasma membranes. We reported previously that mice lacking ENT1 (ENT1-KO) exhibit ectopic calcification of spinal tissues, sternocostal articulations, and the mandibular symphysis. Objectives: The current study aims to investigate the role of ENT1 in dental and periodontal tissues using the ENT1-KO mouse model. Methodology: Heads from ENT1-KO and wild-type (WT) mice at 3 and 6 months-of-age were scanned using micro-CT to evaluate the morphology and densities of teeth and adjacent tissues. Representative samples were decalcified and processed for histological assessment. Rates of eruption of mandibular incisors were measured at 2 months-of-age using a tooth notch assay. Connective tissue fibroblasts isolated from ENT1-KO and WT mice were assayed in vitro for differences in cell adhesion and cell-mediated matrix contraction. Results: No hypercementosis or ectopic calcification of the periodontal ligament was detected in ENT1-KO mice. Micro-CT analysis revealed generally normal dental morphology in mice lacking ENT1. However, mineralization of enamel was greater toward the apical end of ENT1-KO incisors. Moreover, pulp chambers of ENT1-KO incisors were smaller in diameter than those of WT mice. These differences are consistent with a slower rate of eruption in ENT1-KO mice. This was confirmed by measurement of eruption rates in vivo. Although no difference was detected between adhesion of ENT1-KO and WT fibroblasts in vitro, the ability of ENT1-KO fibroblasts to contract collagen gels was significantly less than that of WT cells. Significance: These results demonstrate that loss of the adenosine transporter ENT1 slows the rate of incisor eruption. This effect may be mediated by a defect in the ability of ENT1-KO fibroblasts to generate tension. These findings are consistent with a role for adenosine in the regulation of tooth eruption.

3:30	**Hamed Alizadeh Sardroud** – *University of Saskatchewan; PhD* "In vivo study of force-shielding effects on hyaline cartilage regeneration in 3D-bioprinted hybrid constructs" Efforts in hyaline cartilage regeneration have focused on using hydrogels as biomaterials. Cells embedded within hydrogel feel high mechanical loadings when implanted into joints, and this leads to the upregulation of collagen type I and fibrocartilage formation instead of hyaline cartilage. Here, we investigate using 3D-bioprinted alginate/polycaprolactone hybrid constructs to shield cells from high mechanical loading. Potential force-shielding can be investigated by implanting hybrid constructs into joints and observing cellular responses loading forces. 3D-bioprinted hybrid and alginate hydrogel (control group) constructs containing cells from the chondrogenic line ATDC5 were implanted into punched defects in the joints of pigs. A pilot two week study of implanting scaffolds ensured the maintenance of implants within the defects without any need for covering with Platelet Rich Plasma. Afterward, 3D-bioprinted hybrid and alginate hydrogel-only constructs were implanted into the joints of 10 pigs. The pigs were euthanized after 1 or 3 months, and constructs and surrounding tissues were harvested for synchrotron-based phase contrast imaging, and then processed for histological and immunostaining analyses. Synchrotron imaging, a novel diagnostic tool for cartilage studies, visualized the implanted constructs and surrounding tissues. Further 3D volume rendering will allow us to analyze biomaterial and cartilage changes qualitatively and quantitatively. Gross observation of the defects showed an increase in new tissue filling the defects between 1 and 3 months. However, further analyses are needed to specify the type and amount of regenerated tissues. Specifically, the amount of collagen type I and II secretion within the force-shielded hybrid and hydrogel-only constructs will be compared by immunostaining of sectioned samples. The findings of this research will help towards the clinical application of hybrid constructs for osteoarthritis treatment.
3:40	**Matthew S Chapelski** –*University of Saskatchewan; Master's* "Are the bone health benefits observed in young recreational gymnasts still present in adolescence?" Background: Recreational gymnasts 4-8 years of age have greater bone strength at the wrist; however, it is unknown if these benefits persist into adolescence. Originality: Long-term impact of recreational gymnastics in young childhood is unknown. Purpose: Are the observed improvements in bone health in young children maintained into adolescence? Methodology: 39 recreational gymnasts (19 F) and 32 physically active controls (19 F), were assessed for anthropometrics, physical activity (PA) and peripheral quantitative computed tomography (pQCT) scans and in childhood (7.2±1.3 years) and in adolescence (14.2±1.3 years). PA was assessed using the Netherlands Physical Activity Questionnaire (NPAQ) and the Physical Activity Questionnaire for Adolescents (PAQ-A). pQCT scans were obtained on the non-dominant radius and tibia (4% and 66% the limb length respectively). Group means were compared using t-tests and adjusted means using multivariate analysis of covariance (controlling for sex, age, biological age, height, weight and PA). Results: No significant differences were found in any anthropomorphic or PA variables (p>.05), except for weight which was greater in gymnasts at adolescence (p=.020). During childhood gymnasts had significantly greater estimated bone strength at the wrist (p=.046). The only significant difference in bone parameters during adolescence was found at the distal radius, with gymnast demonstrating greater values (p=.015). Significance: The higher bone strength index at the wrist observed in young recreational gymnasts was no longer apparent in adolescence. However total bone content was higher in adolescence. These findings suggest impact loading activities need to be maintained during childhood and adolescence.
3:50	**Discussion & Session Wrap up**

Session Sponsor:

Canadian MSK Rehabilitation Research Network

Zoom Meeting Room: https://westernuniversity.zoom.us/j/98815224579

Pre-recorded Videos (available post-session): https://vimeo.com/showcase/7216008

Special Emphasis Session: *MSK Rehab Strategies* for Now and the Future	**Session Chair: Laurent Bouyer, Mike Szekeres & Codie Primeau**
3:00	**Introduction by Mike Szekeres & Laurent Bouyer**
3:10	**Suelen M Goes** – *University of Saskatchewan; Post-Doc Fellow* "Patient-driven COVID-19 accommodations in the Nordic walking intervention" Background: Exercise interventions may help to alleviate social isolation, loneliness, and inactivity in older adults during COVID-19 pandemic. Purpose: To identify needs and address them by co-designing and establishing COVID-19 accommodations for the patient-oriented Nordic walking intervention. Methods: We invited eight patient-advisors (peer-trainers or participants) of the Nordic walking intervention for individuals with osteoporosis, hyperkyphosis, or history of vertebral fracture. Patient-advisors first completed a survey to identify needs and options for the accommodations. We held two web-based meetings to discuss and co-design accommodations. Patient-advisors prioritized needs using an iterative engagement process. We then co-designed the accommodation plan. Findings: The common needs included: (1) to maintain the three weekly Nordic walking intervention sessions; (2) to offer one group-session per week to secure social interaction while maintaining social distancing and exercise safety; (3) to assure all participants will be able to manage remote communication platforms; and (4) to assess new and former Nordic walking participants' physical activity level, functional performance, and quality of life during COVID-19 restrictions. We established a hybrid Nordic walking intervention delivery, including one small-group outdoor session per week while following COVID-19 guidelines in Saskatchewan (limit of 10 people, at least 2-meter physical distancing, and no shared equipment). The other two weekly sessions will be delivered remotely by updating exercise manual, creating new videos, and establishing group video-calls. Significance/Impact: The patient-driven process, identified needs, and co-designed accommodations to the Nordic walking intervention will secure safe and feasible continuation of the intervention and address concerns of social isolation, loneliness and inactivity during COVID-19 pandemic faced by the individuals at risk of osteoporotic fracture.

3:20	**Rochelle C Furtado** – *Western University; PhD* "Preoperative patient education for orthopaedic patients: a scoping review" Background: Healthcare providers have shifted towards educating patients prior to surgery on strategies that accelerate the recovery of postoperative function. This is known as Preoperative Readiness Education Programs for Surgery (PREPS). In the field of orthopaedic surgery, there is an uncertainty on the consensus of the content and effects of PREPS on surgical outcomes, given that prior systematic reviews have been inconclusive and no clear framework for PREPS exists. Purpose: The aims of this scoping review were: 1) explore the effects of PREPS on all processes and outcomes in the field of orthopaedic surgery, 2) describe the nature of the PREPS and determine potential gaps in the literature. Methodology: Framework by Arksey and O'Malley, with the suggestions by Levac, Colguhoun, and O'Brien. Relevant peer-reviewed articles were identified in a search of several online databases. Inclusion criteria: 1) studies that addressed PREPS in an orthopaedic surgery or 2) provided descriptions or evaluations of a PREPS program including its frameworks, content, delivery or outcomes. Results: 54 articles were included in the review. 13/54 studies used a framework to guide intervention. PREPS positively influences anxiety, length of stay, falls risk, self-efficacy, empowerment, patient knowledge and satisfaction, quality of life, days to mobilize and decreases blood pressure, cortisol levels, and dislocation postop. PREPS has no effect on sleep disturbance, muscle strength, and range of motion. Future Directions: Researchers need to use a theoretical framework to guide PREPS and more work is required for upper limb and spine subspecialties, before we can be conclusive of our findings. Due to COVID-19, the push for telehealth rises and researchers are urged to administer PREPS on web-based platforms to limit the number of in-clinic visits.
3:30	**Douglas Gross** – *University of Alberta; Senior-Career Investigator* "Implementation of remote rehabilitation services by WCB-Alberta due to Covid-19" Background / Context: The Coronavirus Disease (Covid-19) pandemic resulted in dramatic changes to avoid virus spread. Following provincial legislation, the Workers' Compensation Board of Alberta (WCBA) stopped in-person rehabilitation services on March 23, 2020. Previous research on conversational rehabilitation strategies (i.e., functional and motivational interviewing, case conferences) allowed WCBA to rapidly transition to remote service delivery. On April 1, training began for rehabilitation providers on virtual functional assessments and the first workers were remotely assessed on April 3. All treatment programs then transitioned to remote delivery. Originality, Rationale, and/or Scope: We are studying WCBA's implementation of remote delivery of rehabilitation services in response to Covid-19. Purpose / Objectives: We will examine WCBA's remote delivery of rehabilitation services and describe rehabilitation program outcomes, stakeholder satisfaction, adverse effects, or unwanted consequences such as appeals. Methodology: A population-based descriptive study is being conducted, with data extracted from the WCBA database. This database is augmented by clinical data from rehabilitation providers. We will use data on workers assessed between Jan. 1 and May 31, 2020. Analysis will include descriptive statistics to characterize the use of remote services. Analyses will be performed on the entire dataset, then separately for the various assessment and treatment programs. Results / Findings: Full results will be available at the conference. We will present the number of injured workers undergoing work assessment and rehabilitation programs using remote services in April 2020. Significance & Impact and/or Future Studies: The unique circumstances created by the Covid-19 pandemic warrant research to document the transition to remote services. It appears that widescale remote rehabilitation services has been successful, with no adverse effects reported.
3:40	**Marianne Gagnon** – *McGill University; Master's* "Home exercise program for arthrogryposis: Is telerehabilitation feasible?" Background: Arthrogryposis multiplex congenita (AMC) is characterized by joint contractures and muscle weakness limiting daily activities. Youth with AMC requires frequent physical therapeutic follow-ups to limit recurrence of contractures and maintain range of motion (ROM) and muscle strength but access to care is limited due to geographical distance with specialized health care centres. Rationale: Telerehabilitation may offer a potential solution to deliver frequent follow-ups in AMC but feasibility needs to be established. Objectives: To evaluate the feasibility of telerehabilitation to provide a home exercise program (HEP) for youth with AMC and to assess its effectiveness. Methodology: Youth with AMC were recruited at a tertiary pediatric care center. Clinicians used the Goal Attainment Scale (GAS) to identify individualized goals to develop a 12-week HEP. Follow-ups every three weeks were provided to adjust the HEP. Participants completed baseline and post-HEP physical activity (PAQ-A), functional (PODCI) and pain (APPT) questionnaires. Withdrawal rates, compliance to the HEP and to the follow-ups were collected. Wilcoxon signed rank test was used to evaluate the feasibility and effectiveness of the HEP. Results: Of the 11 youth that were recruited, seven youth (5 males, mean=16.3 years) from four provinces completed the HEP. Among 47 appointments scheduled, five had to be rescheduled in less than 24 hours. Participants performed their HEP 2.1±0.5 X/week, and reported good satisfaction towards the approach. Five participants achieved their goals (mean GAS T-score= 74.8, threshold=50). No significant changes were observed in questionnaires, but two participants had significant clinical improvements in PODCI (from 50 to 68 and 73 points). Significance and impact: Preliminary results demonstrate the feasibility and effectiveness of using telerehabilitation to provide frequent follow-ups to youth with AMC. Recruitment and retention procedures need to be improved.
3:50	**Anu M Räisänen** – *University of Calgary; Post-Doc Fellow* "Development of the online SHRED Osteoarthritis program" Context: Intra-articular knee injury is a significant risk factor for post-traumatic osteoarthritis (PTOA). Some persons with a knee injury compound their risk of PTOA by developing added risk factors, including muscle weakness. Scope: Neuromuscular training is an effective tool for primary injury prevention and OA rehabilitation, however there is paucity of evidence regarding its role in secondary prevention of OA. Objective: To develop an exercise program to mitigate modifiable risk factors of PTOA. Methodology: A four-step intervention development process: 1) Summarizing clinical experience, existing evidence and exercise training principles; 2) Consulting experts (n=9) through one-to-one interviews; 3) Intervention pilot testing with end-user representatives (n=7); 4) Adapting the program for online delivery. Results: Based on the first step the SHRED Osteoarthritis program was develop to comprise an 8-minute warm-up, 47-minute circuit through 8 exercise stations (squats, single-leg exercises, lunges, balance, jumping and landing, trunk, hamstrings, hip adductors) with 4-5 progressions and a 5-minute cool down. After expert feedback, the balance exercises were moved to the warm-up and to a new component of dynamic exercises (5 minutes) that was added following the circuit, the hip adductor station became an adductor/abductor station, and 25 of 29 exercise progressions were revised. Based on pilot testing, the single-leg, jumping and landing and trunk exercises were revised as they did not progress as intended or participants experienced pain. Additionally, the adductor/abductor strength station was converted back to an adductor strength station as the combination with hip abductor exercises was perceived as too easy. Finally, 13 exercise progressions were revised to eliminate exercise equipment in order to facilitate online delivery. Future studies: A pilot RCT to assess the feasibility and efficacy of the SHRED Osteoarthritis program will be conducted.
4:00	**Discussion & Session Wrap up**
4:10-4:20	**Health Break – Get up and stretch!**

Session Sponsor:

Western Bone and Joint Institute

Zoom Meeting Room: https://westernuniversity.zoom.us/j/93443356516

Pre-recorded Videos (available post-session): https://vimeo.com/showcase/7216033

Plenary Session B: Infection & Inflammation	**Session Chair: David Holdsworth & Holly Philpott**
4:20	***Dr. Bassam A Masri,* University of British Columbia** ***"From Two Stage to One Stage Exchange Arthroplasty of the Knee"*** Abstract not available
4:40	***Dr. Christian Hedrich*, Liverpool** ***"Chronic nonbacterial osteomyelitis (CNO)"*** Chronic non-bacterial osteomyelitis (CNO) is an autoinflammatory bone disorder that results from imbalanced cytokine expression from innate immune cells. Though the exact molecular pathophysiology of CNO/CRMO remains somewhat unclear, defects in the TLR4/ MAPK/ inflammasome signaling cascade result in an imbalance between pro- and anti-inflammatory cytokine expressions in monocytes from CNO patients. The current understanding of CNO, its clinical presentations and treatment options will be discussed.
5:00	**Diane Gregory** – *Wilfred Laurier University; Post-Doc Fellow* "Can Inflammation Alter Mechanics of Intervertebral Extracellular Matrix?" Background: Low back pain (LBP) is one of the most common conditions affecting up to 80% of the global population [1]. One of the main causes of this condition is intervertebral disc (IVD) degeneration [2]. IVD degeneration is a multifaceted condition in which both inflammatory environment and mechanical loading can play crucial roles. In this study, we cultured annulus fibrosus (AF) cells of Sprague Dawley rats in type I collagen, as a three-dimensional in vitro model material, and studied the effect of two inflammatory stimulants on mechanical properties of the resultant constructs. Purpose: The main purpose of this study is to understand the interplay between inflammation and mechanical integrity in IVDs using a 3D collagen model. Methodology: AF cells were isolated from IVD tissues of Sprague Dawley rat tails. High Concentration type I collagen was chosen as the 3D extracellular matrix. To induce noninfectious inflammation, bovine decorin and lipopolysaccharide (LPS) were used. Uniaxial tensile tests were performed using the Biotester (CellScale) on cells+collagen constructs. Results: AF cells were viable and proliferated in collagen and induced a robust and reproducible contraction on collagen matrices which was distinctly clear after 24 hours. This contraction was affected by inflammatory stimulant type. LPS negatively affected the contraction while decorin had no effect. Specifically, LPS decreased the strength and elongation to failure in the cells+collagen constructs. Significance & Impact: There is currently limited knowledge about the interplay of inflammation and mechanics at the cellular level in the disc. Our findings not only show that type I collagen can be a suitable model material for these studies, but also demonstrates that inflammatory stimuli can directly affect the mechanics at this level.
5:10	**Joanne Tang** – *Western University; Master's* "Non-invasive imaging of systemic inflammation in Duchenne muscular dystrophy" Duchenne muscular dystrophy (DMD) is a neuromuscular degenerative disease, characterized by chronic inflammation, progressive muscle and cognitive degeneration until cardiac/respiratory failure at age 20. While there's no known cure, experimental muscle-regenerative therapies can minimize symptoms and prolong ambulation. As muscle regenerative therapies may impair cardiac function, invasive muscle biopsies—current DMD-prognosis gold standard—are unsuitable therapeutic outcome assessors, as they are both painful and localized to specific muscle segments, despite DMD being a systemic disease. As inflammation levels correlate with disease-severity in DMD murine hind-limbs, this study aimed to develop an imaging protocol to non-invasively model DMD progression, without individual tissue isolation, by quantifying inflammation changes. Dynamic PET and biodistribution/autoradiography of DMD and wild-type (WT) mice were acquired using 18F-FEPPA—tracer targeting translocator protein(TSPO) overexpressed on microglial and macrophages. Each mouse's brain, heart, and skeletal muscles were collected for quantification and TSPO-colocalization via immunohistochemistry. DMD mice demonstrated elevated TSPO-PET tracer in heart, skeletal muscle and brain compared to WT, which co-localized with autoradiography and IHCs findings. Biodistributions showed heightened 18F-FEPPA uptake in different tissues. Preliminary PET imaging data showed concurrent inflammation levels in cardiac and skeletal muscles of DMD, which progresses with disease severity. Being the first to model DMD via a whole-body in-vivo system, illustrates the advantage of 18F-FEPPA PET as a useful tool to non-invasively detect DMD progression simultaneously in multiple affected organs, increasing the possibility to propose early intervention prior to severe muscular or cardiac damage. Also offering a novel approach to assess treatment efficacy, which may now include anti-inflammatory therapies.
5:20	**Tina Khazaee** – *Western University; Master's* "Characterization of Drug Elution in Orthopaedic Infection using Micro-CT" Background: Infection is a growing problem in orthopaedic surgery, and is now the number one reason for early revision of hip and knee replacements in Canada. Rational: Local delivery of antibiotics is an important, common component of therapy. However, the exact drug elution mechanism is not yet fully understood. In this study, we developed a quantitative, longitudinal, non-destructive, micro-CT technique to characterize the diffusion of small-molecules in a tissue-equivalent phantom. Objective: Our objective is to use a radio-opaque molecule (Iohexol; molecular weight (MW) 821 Da) as a surrogate for small-molecule antibiotics (e.g., Vancomycin; MW 1449 Da). We characterized the Iohexol diffusion from three finite, carrier sources into an agar, tissue-equivalent, sink. Methodology: A single-phase diffusion experiment was performed to validate our micro-CT method. A two-part phantom was consisted of an inner, cylindrical, agar core (diameter = 1.7cm, length = 4.0cm) loaded with 30 mg ml-1 Iohexol, directly communicating with an outer annulus of pure agar (diameter = 7.0cm, length = 5.0cm). Image acquisition was performed with a pre-clinical micro-CT system (GE eXplore SpeCZT; 90 KVP, 40 mA, 16ms exposure and 900 views). A 5-minute short-scan protocol was used; scans were repeated at regular intervals for up to 25 days. Projections were reconstructed, corrected for beam hardening and scaled in Hounsfield units. We then applied the validated method to evaluate diffusion in two-phases, using calcium-sulphate matrices (i.e., Stimulan® and Plaster of Paris) as core carriers. Two-dimensional radial diffusion and cumulative release amount were used to calculate diffusion coefficients in single-phase and two-phase, respectively. Results: Iohexol diffusion coefficient was calculated as 2.6 ×10-10 m2 s-1, 0.46 ×10-10 m2 s-1, 0.85 ×10-10 m2 s-1 through agar, Stimulan®, and Plaster of Paris. This technique can be used to measure elution kinetics in novel porous implants.

5:30	**Bilingual Poster Sessions 2:** **Infection & Inflammation** **Session Pre-recorded Videos** (available post-session): https://vimeo.com/showcase/7214276 Sponsored By: ~ Christian Hedrich ~ Donated Speaker Honorarium Western Bone and Joint Institute **Remote Virtual Technologies & Care** **Session Pre-recorded Videos** (available post-session): https://vimeo.com/showcase/7214857 Sponsored By: Western Engineering Western HealthSciences **MSK Rehab Wearables & Biomechanics** **Session Pre-recorded Videos** (available post-session): https://vimeo.com/showcase/7214426 Sponsored By: McCAIG INSTITUTE FOR BONE AND JOINT HEALTH Canadian MSK Rehabilitation Research Network **MSK Imaging** **Session Pre-recorded Videos** (available post-session): https://vimeo.com/showcase/7214814 Sponsored By: Western Engineering School of Biomedical Engineering University of Saskatchewan College of Medicine **MSK Rehab Strategies for Now & the Future** **Session Pre-recorded Videos** (available post-session): https://vimeo.com/showcase/7214828 Sponsored By: CaNMOR ACTIVE FOR LIFE! Dalhousie University Faculty of Health

Session Sponsor:

Canadian MSK Rehabilitation Research Network

Zoom Meeting Room: https://westernuniversity.zoom.us/j/97792838196

	Plenary Keynote: MSK Remote Virtual Innovations & Care	**Session Chair: Tom Appleton**
6:30	***Dr. David Hunter, University of Sydney (Australia)*** ***"Remotely Delivered Interventions for Osteoarthritis"*** Osteoarthritis is a leading source of disability in our community. With increasing electronic literacy and the need for scalable interventions remotely delivered care is of expanding interest. This has become more critical during the COVID_19 pandemic, where patients and providers are being told to socially distance and to shift their care to remote delivery to protect patients and staff from infection. This is having an impact on traditional ways of delivering and receiving care. As a consequence of home isolation, people with osteoarthritis related disability may become less fit, more depressed/ anxious, more socially isolated and gain weight, all of which may further compound their underlying reason for chronic pain and disability. It is critical at times like this to promote access to appropriate health care to ensure patients with osteoarthritis have their burden and disability minimised. There are a multitude of remotely delivered resources targeting education, exercise, weight management, psychological, sleep and pain management that can be utilised if patients and the providers are aware of their existence. The purpose of this presentation is to promote knowledge of remotely delivered resources and our experience in rolling out these interventions in trials and clinical practice.	
6:50	***Day 1 Wrap Up***	**Session Chair: Dan Langohr**