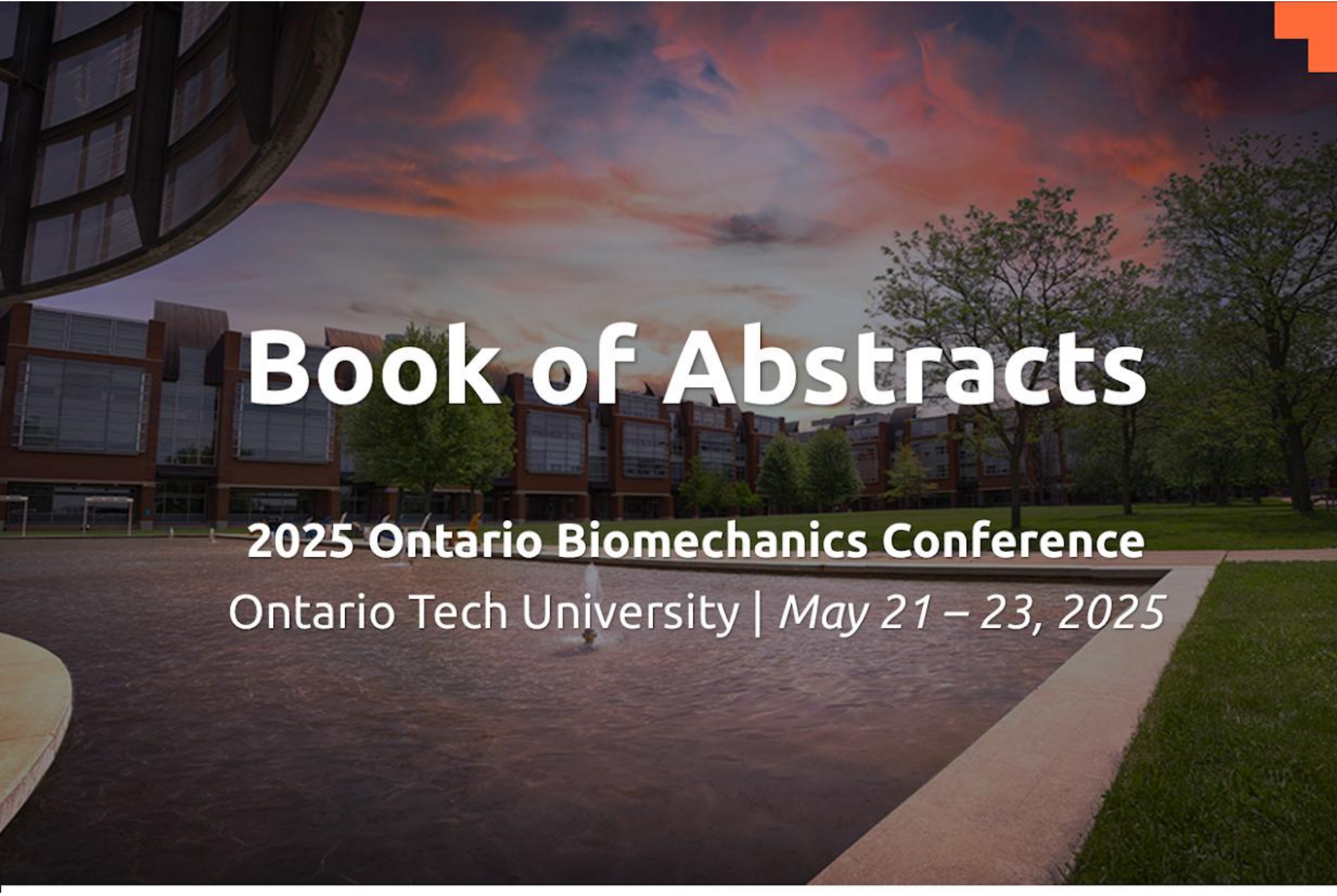

Book of Abstracts

2025 Ontario Biomechanics Conference

Ontario Tech University | *May 21 – 23, 2025*

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Podium Session 1

Thursday, May 22 (8:45am-9:45am)

Business and Information Technology Building (BIT) 2080

Co-chairs: Jessa Davidson (University of Waterloo) &

Katherine Wiebe (Carleton University)

8:45am-8:55am	**Ryan Chhiba** *McMaster University*	Distributed Loads Alter Internal Finger Loading
8:55am-9:05am	**Komal Azeem** *Queen's University*	Integrating Marker-Less Motion Capture with OpenSim For Musculoskeletal Modelling
9:05am-9:15am	**Claudia M. Town** *University of Waterloo*	Head Kinematic Responses Following Seated Translational Perturbations
9:15am-9:25am	**Pratham Singh** *University of Toronto*	Biomechanical Assessment of a Two-Foot Vertical Jump Following Anterior Cruciate Ligament Reconstruction
9:25am-9:35am	**Gillian Slade** *Ontario Tech University*	Determining Effective Durations in Lifting and Lowering Tasks
9:35am-9:45am	**Aliza R. Siebenaller** *University of Guelph*	Asymmetrical Thoracic and Lumbar Paraspinal Muscle Degeneration Affect Spinal Curvature in an Unexpected Way

DISTRIBUTED LOADS ALTER INTERNAL FINGER LOADING

Ryan Chhiba[1], Daanish M. Mulla[2], Peter J. Keir[1]*
[1]Department of Kinesiology, McMaster University, Hamilton, ON
[2]School of Kinesiology & Health Science, York University, Toronto, ON

Introduction: Our hands can be used in a near infinite number of ways, resulting in complex forces acting simultaneously on multiple surfaces of the hand and fingers. Historically, biomechanical models have not fully considered how forces are distributed over multiple areas of contact [1]. Accounting for distributed loads across the hands is the next step in understanding internal loading. Pressure mapping systems provide data that can refine calculations of internal tissue loads beyond previous models which have been limited to a single specific point of force application [2]. The effect of complex loading profiles with multiple points of force application have yet to be explored. The purpose of this study was to examine the effects of distributed finger and hand loads on net finger joint moments and predicted muscle activations during multiple finger pressing and power gripping tasks.

Methods: Motion capture, pressure, and forces were collected on 26 right-handed participants (13M, 13F). Pressure and centre of pressure were measured across 17 regions of the hand (TekScan, Boston, MA, USA). Two maximum voluntary grips were performed. Participants completed three trials of five 10 s static finger tasks: i) digits 2 & 3 press (15 N), ii) digits 2, 3, & 4 press (20 N), iii) digits 2, 3, 4 & 5 press (25 N), along with power grips at iv) 20% MVG and v) 40% MVG. Joint moments and muscle activations were computed using OpenSim. Pressure maps were used to represent external load distribution in two ways: (1) at each segment centre of mass (CoM); (2) at each segment centre of pressure (CoP). Additionally, a more traditional approach was used by evenly dividing the force to a single point (SP) force on each fingertip. To account for data non-normality and non-continuity, equivalence testing was used to compare internal loads between the models.

Results: CoM-CoP moments and activations were equivalent ($p = 0.1$). During the two and three finger presses, SP proximal interphalangeal moments were significantly larger than CoM and CoP in the middle and ring fingers, respectively ($p < 0.01$). SP metacarpophalangeal moments of the thumb and middle finger were largest during power grip ($p < 0.01$). FDS and FDP activations of the ring and little fingers were largest with SP ($p = 0.01$). Muscle activations of wrist and extensors during power gripping were also greater in SP versus CoM and CoP ($p < 0.01$).

Discussion and Conclusions: These findings indicate that internal loads are sensitive to how external forces are represented in computational models. Distributed load profiles increase fidelity of forces acting on the hand. Pressure mapping provides a means to determine realistic force profiles across the hand. Along with improved force representation, other considerations modelling specific parameters such as anthropometric scaling, muscle strength scaling, and reserve actuator use will affect model outputs. These important and necessary modelling parameters require further investigation as they play large roles in accounting for individual characteristics and improving model fidelity.

References: [1] Hicks J et al. (2015). *Journal of Biomechanical Engineering*, *137*: 020905-02090524. [2] Vigouroux L et al. (2009). *Journal of Biomechanics.* 42: 1772-1777.

INTEGRATING MARKER-LESS MOTION CAPTURE WITH OPENSIM FOR MUSCULOSKELETAL MODELLING

Komal Azeem[1], Pouya Amiri[1]

[1]School of Kinesiology and Health Studies, Queen's University, Kingston, ON

Introduction: Marker-based motion capture has long been the gold standard for recording human movement. However, they are time-consuming, require attachment of physical markers, extensive postprocessing, and expertise in operation. Recent advances in artificial intelligence have led to the development of marker-less motion capture technologies with comparable performance and much easier usability [1]. They eliminate the need for physical markers, arduous post-processing, and require minimal expertise, making them suitable for large-scale data collection and clinical applications. While they can be used to determine kinematics of the motion, marker-less motion capture system have not been yet integrated with musculoskeletal (MSK) modelling software necessary to estimate internal muscle and articular contact forces during motion [2]. Thus, the objective of this research was to develop a pipeline to convert the output from the Theia3D marker-less motion capture software into a compatible format for analysis in OpenSim.

Methods: One healthy participant's movement was captured during a running trial using 8 Sony cameras with a sampling rate of 119.88Hz (Sony Electronics Inc., USA). Synchronized videos were processed using Theia3D marker-less software. The output was a .c3d file that included the 4×4 matrices of each body segment's pose during movement. A subroutine was developed in Python to convert the Theia3D outputs into body joint angles consistent with the OpenSim Gait2392 MSK model. This process was as follows: (1) matrices were extracted from the Theia3D .c3d file using EZC3D library in Python; (2) segment angles were obtained from matrices using Rototrans from the pyomeca library and converted to the joint angles, defined according to the MSK model; (3) plots were generated to visualize and validate joint angles during the movement; and (4) the joint angles were written to a .mot file, compatible with the OpenSim model. In total, there were 17 angles corresponding to the degrees of freedom of the OpenSim Gait2392 model. To scale the generic MSK model to match our participant's size, one frame of the .mot file was used. The segments' joint centres the Theia3D model and OpenSim model were compared to determine the scaling factors.

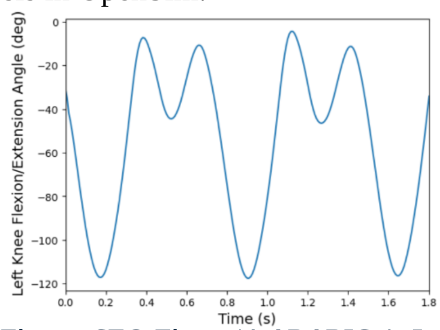

Figure SEQ Figure * ARABIC 1: Left knee flexion angle during running

Results: Figure 1 shows the knee flexion angle during the trial. Figure 2 demonstrates the scaled model with virtual markers attached to joint centers for scaling.

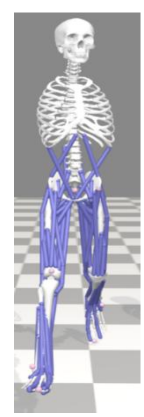

Figure 2. Scaled OpenSim MSK model with markers on joint

Discussion: We successfully developed a pipeline to run a MSK model in OpenSim using Theia3D's data. Our future work will use the marker-less data to perform inverse dynamics and muscle force analysis during motion.

References:

[1] D'Souza S., et al. (2024). A comparison of lower body gait kinematics and kinetics between Theia3D markerless and marker-based models in healthy subjects and clinical patients. *Scientific reports*, *14*(1), 29154.

[2] Seth, A., et al. (2018). OpenSim: Simulating musculoskeletal dynamics and neuromuscular control to study human and animal movement. *PLoS computational biology*, *14*(7)

HEAD KINEMATIC RESPONSES FOLLOWING SEATED TRANSLATIONAL PERTURBATIONS

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Department of Kinesiology and Health Sciences, University of Waterloo, Waterloo, ON

Introduction: Current laboratory approaches to perturb the head and neck mainly consist of load-dropping and quick release methods [1]. However, these methods adopt a direct loading scenario, despite many sport impacts involving inertial loading (e.g. direct impact to the torso that indirectly load the head/neck system). Alternatively, seated perturbations using a translating surface are an indirect loading approach that utilizes inertial loading principles. This method has primarily been used in the motor vehicle accident (MVA) domain to simulate high perturbation magnitudes representative of vehicle collisions [2]. Therefore, the objectives of this study were to characterize head/neck responses during a seated translation perturbation at lower magnitudes and determine the influence of perturbation magnitude (acceleration (acc) and peak velocity (vel)) and direction.

Methods: Participants (n = 19, 9M + 10F) were instrumented with rigid body clusters on their trunks and heads (Certus Optotrak, NDI, Waterloo, ON, Canada), and secured in a chair fixed to the perturbation platform. Perturbations (perts) ranged in magnitude (acc: 1-3m/s^2, vel: 0.5-0.95m/s, deceleration: 5m/s^2, displacement: 0.3m) and were elicited in two directions (front and backwards). Participants were exposed to 60 perts – three blocks of 20 (each magnitude and direction once). Peak head angular displacement (PAD), peak resultant angular acceleration (PAA), and peak resultant linear acceleration (PLA) were calculated for the acceleration and deceleration phases of the perts. Two-way repeated measures ANOVAs were completed for each phase and variable to determine the effect of magnitude and direction.

Results: For brevity, only the acceleration phase of the perturbation is presented. There were significant magnitude x direction interaction effects, and main effects of magnitude for all variables ($p<0.05$). A significant main effect of direction was noted only for PLA characterized by greater values for backward perts. PAD differed between low and high vel perts (~5°) but was not influenced by acc. In contrast, PLA and PAA were highly dependent on acc magnitude.

Discussion and Conclusions: While the kinematic responses we observed were lower than reported in the MVA literature, there were similarities in that specific characteristics of the perturbation pulse (i.e., acceleration and velocity) had nuanced influences on head kinematics. Interestingly, back (compared to forward) perts lead to significantly greater PLA (a finding contradictory to the literature). This may be explained by experimental differences, such as duration of acceleration pulse, seat rigidity, and/or seatbelt design. Overall, these data provide insights that may assist in adopting this perturbation paradigm at lower magnitudes.

References:

[1] Le Flao E et al. (2018). Assessing head/neck dynamic response to head perturbation: A systematic review. Sports Medicine 48; p. 2641-58.
[2] Siegmund G et al. (2009). Head and neck control varies with perturbation acceleration but not jerk: Implications for whiplash injuries. The Journal of Physiology 587(8); p.1829-42.

BIOMECHANICAL ASSESSMENT OF A TWO-FOOT VERTICAL JUMP FOLLOWING ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

Pratham Singh[1], Dveeta Lal[1], Timothy Burkhart[1]
[1]Faculty of Kinesiology and Physical Education, University of Toronto, Toronto, ON

Introduction: A two-foot vertical jump is commonly used as a return-to-sport (RTS) assessment following ACL reconstruction (ACLR)[1]. The conclusions drawn in a clinic (e.g. achieve 90% of range of motion or strength in the involved limb compared to the contralateral limb) may not reflect the underlying mechanisms to complete the jump by the athlete.

Aim: Compare kinematic and kinetic limb symmetry indexes between ACLR patients and healthy controls

Methods: Data were collected on 27 ACL patients (M:14; F:13; Age: 24.92 [5.14]) and 27 healthy controls (M:17; F:10; Age: 24.44 [3.27]). Isometric strength was measured bilaterally with a dynamometer with the knee positioned at 90˚ (Biodex System 4, Evome Medical Technologies, Shirley, NY). Marker data was collected using 17 Qualisys motion capture cameras (Qualisys, Göteborg, Sweden) and ground reaction force (GRF) data was collected synchronously using two force plates (BP600900; AMTI, Watertown, MA, USA). Wireless EMG electrodes (Delsys, Natick, MA) and (3M, Minnesota, USA) were positioned over the quadriceps, hamstrings, and calves. Data were collected while the participants performed a two-foot vertical jump and were analyzed at initial landing and 200ms post-landing. The Limb symmetry index (LSI) was also used to compare the involved limb and the uninvolved limb for ACL patients and the non-dominant limb and the dominant limb for the healthy participants. A two-tailed, independent samples t-test was performed on each of the LSI values. Significance was set at $\alpha < 0.05$.

Results: There were a number of statistically significant differences in the LSI values, between the ACLR patients and the healthy controls, with respect to knee joint kinematics and ground reaction forces. There were no statistical differences in the EMG LSIs between groups (Table 1).

Discussion and Conclusions: Despite statistically similar EMG LSI values, the ACLR patients are exhibiting kinematic, kinetic, and strength deficits compared to the healthy controls. This is despite being cleared by a clinician to RTS. Most RTS protocols, only consider the jump height in RTS assessment and not the underlying mechanisms of how this is achieved.

References: [1] Kotsifaki R. et al. (2023). Performance and symmetry measures during vertical jump testing at return to sport after ACL reconstruction. Br J Sports Med 57; p. 1304-1310.

Figure 1: Comparison of LSIs between the ACLR patients and the healthy controls (*p<0.05).

	Flex/ Ext	Abd/Add	Int/Ext	GRF Med/ Lat	GRF Ant/ Post	GRF Sup/ Inf	Ext. Moment	Flex. Moment
ACLR	0.8 [0.2]*	1.0 [0.3]	1.0 [0.5]*	0.8[0.3]*	0.8 [0.2]*	0.8 [0.3]*	0.7 [0.2]*	0.9 [0.2]
Healthy	1.0 [0.2]	1.1 [0.4]	1.3[0.5]	1.1[0.3]	1.2 [0.5]	1.1 [0.2]	1.0 [0.2]	1.0 [0.1]

DETERMINING EFFECTIVE DURATIONS IN LIFTING AND LOWERING TASKS

Gillian Slade[1], Michael Watterworth[1], Hayley Janes[1], Jim Potvin[2], Nicholas La Delfa[1]
[1]Faculty of Health Sciences (Kinesiology), Ontario Tech University, Oshawa, ON
[2]Work(s) Ergo Inc., Tecumseh, ON

Introduction: Despite shoulder injuries being the second most costly workplace musculoskeletal injury[1], there are relatively few ergonomics analysis tools available to assess upper extremity demands during manual materials handling tasks. More recent tools, such as the Arm Force Field, work in conjunction with the Maximum Acceptable Efforts curve or the ACGIH TLV for Upper Limb Localized Fatigue to assess upper extremity demands. These tools depend on task frequency and effort duration. While task frequency can be easily determined, effort duration is challenging to measure, and minimal data exist for lifting and lowering tasks. This study investigated the impact of vertical range and load on the effective duration of lifting and lowering tasks.

Methods: 21 participants (12F, 9M) aged 18-30 with no history of upper or lower extremity pain, injury or surgery in the last 12 months were recruited. A custom-built apparatus with an embedded uni-axial force transducer was constructed to measure hand force time histories during two-handed lifting and lowering tasks. A total of 72 trials (3 loads x 6 vertical ranges x 2 lift/lower directions x 2 trials) were completed during the two-hour data collection period, in a block-randomized order by vertical range. Participants were provided 15 seconds of rest between trials and one minute of rest between blocks. Effort “effective” duration was calculated by dividing the impulse of the force-time curve by the smoothed peak force.[2] A four-way ANOVA was used to analyze the effect of vertical range (6), hand load (3), trial number (2), and MMH action type (2) on effort duration. Tukey post hoc comparisons were used to examine differences between any significant interactions or main effects ($p<0.05$).

Results: Heavier loads led to longer effective durations across all conditions. Lowers were an average of 3% longer than lifts, with the effect amplified at higher vertical ranges. For example, in the Knu/Ovr condition, lowering the 23 lb box took an average of 22% longer than lowering the 8 lb box, whereas the difference for lifting the same boxes was only 10%.

Discussion & Conclusions: The location of the vertical range influenced the effective duration. Interestingly, lifting in the shoulder-to-overhead range (51cm) took slightly longer than the 102 cm floor-to-shoulder range, particularly with heavier box weights. Heavier loads were found to amplify the differences in effective duration, especially at the higher vertical ranges

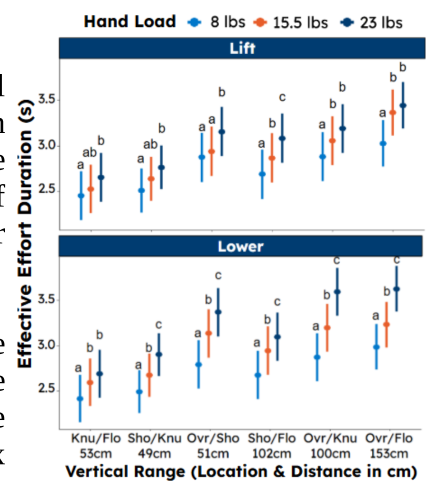

Figure 1: Effective durations at different vertical ranges

References:
[1] WSIB (2022). Safety Check: Health and Safety Statistics. WSIB, CSPAAT.
[2] Potvin, J. R. (2012). *Human Factors*, *54*(2), 175–188.

ASYMMETRICAL THORACIC AND LUMBAR PARASPINAL MUSCLE DEGENERATION AFFECT SPINAL CURVATURE IN AN UNEXPECTED WAY

Aliza R. Siebenaller, Stephen H. M. Brown
Human Health and Nutritional Sciences, University of Guelph, Guelph, ON

Introduction: Adult spine deformity is often associated with paraspinal muscle dysfunction, though the cause remains unclear [1]. It's been previously demonstrated that bilateral glycerol injections of the lumbar paraspinal muscles cause muscle degeneration and lead to hyper-kyphotic deformity [2]. Studies have shown that paraspinal muscle asymmetry is present in patients with adult degenerative scoliosis [3]. The purpose of this study was to evaluate the effect of asymmetrical glycerol-induced paraspinal muscle degeneration on spine deformity. It was hypothesized that an asymmetrical pattern of paraspinal muscle degeneration would create a muscle imbalance in the coronal plane and result in a scoliotic curvature.

Methods: 17 female C57BL/6 mice were divided into two groups (ipsilateral and contralateral). Glycerol (50% v/v) was injected in the multifidus and erector spinae (ES) muscles in the thoracic and lumbar regions (based on group) at 4 timepoints, each 2 weeks apart. For the ipsilateral group, glycerol was injected in the right lumbar and right thoracic regions of the multifidus and ES muscles, while the contralateral group received injections in the right lumbar and left thoracic regions. MicroCT imaging was conducted before the first injections (week 0), at the midpoint (week 4), and after the last injections before sacrifice (week 8). Spinal curvatures were evaluated in the coronal and sagittal planes by measuring the Cobb angles (superior endplate of T5 to the inferior endplate of L5). Statistical significance was determined using two-way repeated measures ANOVA (α=0.05), followed by Tukey's multiple comparisons test.

Results: Mean coronal plane Cobb angles were small (<6°) at all timepoints in both groups. There was a significant effect of group (injection pattern) in the coronal plane (p=0.0460), but there was no significant interaction or effect of time. In the sagittal plane, a significant effect of group (p=0.0061), time (p<0.0001), and interaction (p=0.0004) was found. Both groups demonstrated a significant decrease in sagittal plane Cobb angles over time, indicating a reduction in kyphosis.

Discussion and Conclusions: No clinically meaningful scoliotic curvatures were observed in the coronal plane, contrary to the hypothesis. However, glycerol-induced paraspinal muscle degeneration in the thoracic and lumbar regions did significantly alter the sagittal plane curvature, most significantly in the contralateral group. Surprisingly, this contralateral muscle degeneration resulted in lower sagittal plane Cobb angles (i.e. reduced kyphosis) compared to baseline.

References:
[1] Malakoutian M et al. (2022). Dysfunctional paraspinal muscles in adult spinal deformity patients lead to increased spinal loading. Eur. Spine J. 31 (9); p. 2383-98.
[2] Noonan AM et al. (2023). Glycerol induced paraspinal muscle degeneration leads to hyper-kyphotic spinal deformity in wild-type mice. Sci. Rep. 13 (1); p. 8170.
[3] Shafaq N et al. (2012). Asymmetric degeneration of paravertebral muscles in patients with degenerative lumbar scoliosis. Spine 37 (16); p. 1398-1406.

Podium Session 2

Thursday, May 22 (10:00am -11:00am)

Business and Information Technology Building (BIT) 2080

Co-chairs: Pratham Singh (University of Toronto) &
Kate Posluszny (University of Waterloo)

10:00am-10:10am	**Bryan Rivera Calagua** *Queen's University*	Musculoskeletal Adaptation During Gait of Highly Functional Unilateral Transtibial Amputees
10:10am-10:20am	**Stephen Boulanger** *York University*	A Comparison of Rotator Cuff Fatty Infiltration in Older Adults with And Without Shoulder Pain and Its Relationship to Function
10:20am-10:30am	**Jonathan Ying** *University of Waterloo*	Quantifying Areal Bone Mineral Density Bias of Fiberglass Cast in a Standardized Forearm Dual-Energy X-Ray Absorptiometry Protocol
10:30am-10:40am	**Tiffany Tiu** *University of Toronto*	Quadricep Activation Patterns Between Closed- And Open-Kinetic Chain Exercises
10:40am-10:50am	**Daimen Landori-Hoffmann** *Ontario Tech University*	Hero Glove Insight: Utilizing Computer Vision and Force Sensors for Object-Specific Control
10:50am-11:00am	**Jessa Davidson** *University of Waterloo*	Assessing Cumulative Changes in Lumbar Spine Stiffness Throughout A Week of Prolonged Seated Work

MUSCULOSKELETAL ADAPTATION DURING GAIT OF HIGHLY FUNCTIONAL UNILATERAL TRANSTIBIAL AMPUTEES

Bryan Rivera Calagua[1], Pouya Amiri[1]

[1] School of Kinesiology and Health Studies, Faculty of Arts and Science, Queen's University, Kingston, ON, Canada

Introduction: Unilateral transtibial amputees (UTAs) walk with asymmetric gait patterns [1], increased energy expenditure, and higher knee contact forces during gait [2]. While these characteristics are well documented, the underlying neuromuscular adaptation is still not well understood. The first step to developing a prosthesis and designing effective rehabilitation interventions to lower long-term issues is understanding the association between gait biomechanics and musculoskeletal neural control. Therefore, our objective is to quantify biomechanics and muscle activations of UTAs during gait.

Methods: Gait data from four highly functional male UTAs (Age: 34.5 $\pm$ 1.91 years; Weight: 83.73 $\pm$ 7.70 kg; Height: 180 $\pm$ 3.56 cm) wearing their prescribed prostheses were collected using 10 optical cameras (Vicon, Oxford, UK) and two force plates (Kistler, Winterthur, Switzerland). An open-source musculoskeletal model for UTAs [3] was scaled for each subject in OpenSim 4.4 [4]. Joint moments were obtained through inverse dynamics, and muscle activations were estimated via static optimization over one gait cycle for both the intact and amputated limbs by minimizing the sum of squared muscle activations.

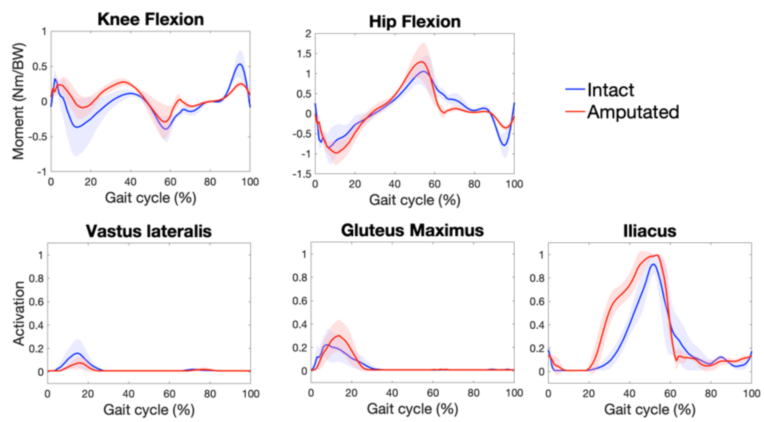

Figure 1: Joint moments and muscle activations (group average $\pm$ standard deviation) from the amputated and intact limbs.

Results: Figure 1 shows asymmetries in both joint moments and muscle activations between the limbs. The amputated limb exhibited a lower knee extension moment, but higher hip extension and flexion moment peaks during the stance phase. Regarding muscle activations, the amputated limb demonstrated increased activity in the iliacus and gluteus maximus and reduced activity in the vastus lateralis.

Discussion and Conclusions: The increased hip moments observed on the amputated limb were associated with greater gluteus maximus and iliacus activation during early and late stance, respectively, while the reduced knee extension moment corresponded to lower quadriceps activation. These findings highlight that UTAs rely more on hip muscles in the amputated limb, while the intact limb experiences greater knee loading. This has direct implications for prosthetic design and rehabilitation, emphasizing the need to reduce joint loading and improve energy efficiency to enhance long-term mobility and endurance in UTAs.

References:

[1] Y. Sagawa et al. (2011) *Gait Posture* 33(4); p. 511-26.
[2] Z. Ding et al. (2021) *J Orthop Res* 39(4); p. 850-860.
[3] A. M. Willson et al. (2023) *Comput Methods Biomech Biomed Engin* 26(4); p 412-423.
[4] S. L. Delp et al. (2007) *IEEE Trans Biomed Eng* 54(11): 1940-50, 2007.

A COMPARISON OF ROTATOR CUFF FATTY INFILTRATION IN OLDER ADULTS WITH AND WITHOUT SHOULDER PAIN AND ITS RELATIONSHIP TO FUNCTION

Stephen M. Boulanger[1], Anthony A. Gatti[2,3], Jaclyn N. Chopp-Hurley[1]

[1]School of Kinesiology and Health Science, York University, Toronto, ON
[2] Department of Radiology, Stanford University, Stanford, California, USA
[3] NeuralSeg Ltd., Hamilton, Ontario, CA

Introduction: Shoulder function and rotator cuff tissue health are critical to the performance of activities of daily living (ADLs), with impairments directly related to decreases in quality of life [1]. Importantly, there is a high incidence of rotator cuff pathology in the aging population (~ 65%) which negatively impacts shoulder function and consequently ADLs [2,3]. Further, greater rates of muscle FI have been shown to limit mobility and reduce muscle function in healthy older adults [4], however this relationship has yet to be studied in older adults experiencing shoulder pathologies. Thus, the purpose of this study was to assess whether FI differs between older adults with affected and unaffected shoulders and whether FI relates to objective and subjective shoulder function.

Methods: Twenty-six right hand dominant older adult participants (12 M, 14 F; 71.3 (8.33) years) have been recruited for this study thus far (anticipated sample size: n=40). Among these participants, 13 had unaffected shoulders and 13 had affected shoulders. Shoulder health was determined by a series of clinical tests used to identify the presence of shoulder pain [5]. MRI was performed on participants' right shoulder using a 3T Siemens MAGNETOM PrismaFit scanner (Two-Point T1 Dixon sequence). Manual segmentation of the supraspinatus (SS) and infraspinatus (IS) muscles were performed using 3DSlicer (https://www.slicer.org/). Ultrasound images of the SS and IS muscles were also captured to assess FI using echogenicity measurements [6]. Objective function was assessed by isolating the participant's right upper limb using a Biodex System 4 (Biodex Medical Systems, NewYork, USA). Maximum strength measurements were recorded for flexion/extension, abduction/adduction, and internal/external rotation. A series of questionnaires were administered to assess the participants' subjective function.

Results: From a preliminary analysis of 18 participants, significantly greater levels of FI have been identified for both SS and IS in older adults with affected compared to unaffected shoulders ($p < 0.01$ and $p = 0.03$). Thus far, Pearson correlation has revealed that SS and IS FI have moderate relationships with objective function ($r = -0.42$ and $r = -0.54$), and have a moderate-strong relationship with subjective function ($r = -0.69$; $r = -0.61$). Ultrasound analysis will be conducted once the full sample is collected.

Discussion and Conclusions: Rotator cuff FI was significantly greater in older adults with affected compared with unaffected shoulders [7]. Further, rotator cuff FI is a stronger predictor of subjective function but not objective function. This study is expected to provide insights into the importance of FI for maintaining adequate shoulder function among our aging population.

References:

[1] Lin et al. 2008. J Am Med Dir Assoc. 9(9); 626-632. [2] Lehman et al. 1995. Bull Hosp Joint Dis. 54(1); 30-31. [3] Sher et al. 1995. J Bone Joint Surg. 77(1); 10-15. [4] Visser et al. 2005. J Gero. 60(3); 324-333. [5] Michener et al. 2009. Arch Phys Med Rehab. 90(11); 1898-1903. [6] Mahna et al. 2024. J Clin Ultras. 52(4) ; 343-352. [7] Beeler et al. 2013. J Should Elb Surg. 22(11); 1537-1546.

QUANTIFYING AREAL BONE MINERAL DENSITY BIAS OF FIBERGLASS CAST IN A STANDARDIZED FOREARM DUAL-ENERGY X-RAY ABSORPTIOMETRY PROTOCOL

Jonathan Ying, Nikolas Knowles[1]

[1]Department of Kinesiology and Health Sciences, University of Waterloo, Waterloo, ON

Introduction: Fall on outstretched hand (FOOSH) injuries are a leading cause of distal radius fractures and can disrupt upper limb biomechanics, especially in those with low bone density. These injuries may result in joint instability, pain, and osteoarthritis [2]. Diagnosis typically involves radiographs, while surgical treatments are followed by reassessment. Fibreglass medical casts used during recovery can distort bone density readings in imaging [1, 2], particularly with DXA scans. Given the limitations of access to other advanced imaging techniques (CT), this study examines the potential biases introduced by casts in DXA measurements, aiming to better understand how cast material and thickness affect bone density readings. DXA data is compared to images collected using a spectral detector (Reveal Mobi Pro, KA Imaging, Waterloo, ON) to determine if equivalent bone parameters can be determined using the spectral system.

Methods: Using cadaveric forearms (n = 8), medical fibreglass casts (3M Scotchcast Plus Cast Tape) were used to investigate and test the bias under three casting conditions: no cast, two-roll casting, and four-roll casting. Each specimen was scanned for bone mineral content (BMC) and areal bone mineral density (aBMD), with a standardized bone area (BA) and a ± 5 % error margin in all sub-regions of interest for both the radius and ulna. The scans were performed on a DXA (Hologic Discovery W) by a certified medical radiologist technologist. A repeatability test was conducted using the same specimen scanned five times for intra-rater variability. Scans were repeated using the spectral detector at varying X-ray energies in the four-roll casting and baseline conditions. BMC and aBMD are currently being compared across devices.

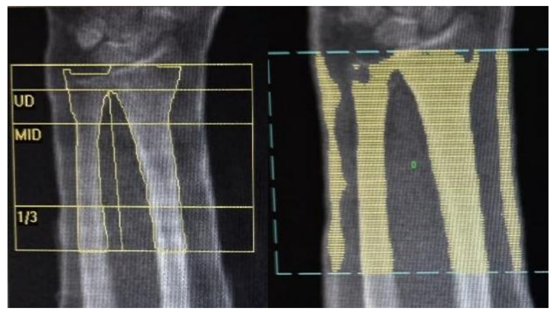

Figure 1: DXA global and sub-regions of interest (left) fibreglass bias on bone recognition software on DXA (right)

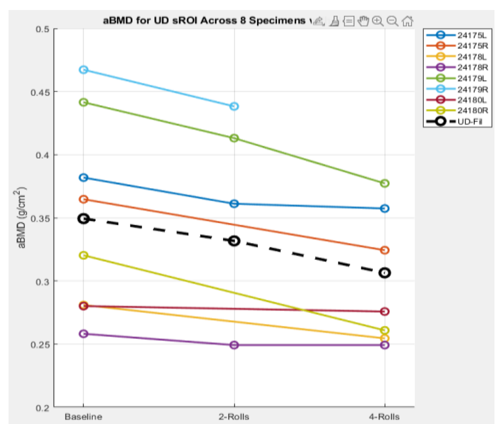

Figure 2: aBMD values in UD sROI in all specimens given the cast conditions. The mean is the black dashed-line

Results: Fibreglass medical casts significantly affect DXA bone density readings. aBMD values decreased notably in the midshaft region with both two- and four-layer casting, while BMC differences were most pronounced in the ultra-distal (UD) and midshaft (MID) areas.

Discussion: Casts increased variability during post-scan image processing, occasionally exceeding the accepted ± 5% error margin for bone morphology. Cast presence and thickness consistently biased bone measurements, highlighting the need for caution when interpreting DXA scans in casted limbs and its limitation in tracking bone healing.

References:

[1] Whittier et al., 2019 (DOI:10.1016/j.jocd.2018.11.005)
[2] Schwarzenberg et al., 2020 (DOI: 10.1007/s11914-020-00584-5)

QUADRICEP ACTIVATION PATTERNS BETWEEN CLOSED- AND OPEN-KINETIC CHAIN EXERCISES

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Introduction: Rehabilitation following anterior cruciate ligament reconstruction (ACLR) includes both open kinetic chain (OKC) and closed kinetic chain (CKC) exercises as regaining the strength of the quadriceps is an important rehabilitation goal. Existing strength and conditioning research suggests that OKC exercises recruit the rectus femoris (RF) more than CKC exercises [1,2], while CKC exercises activate the vastus medialis (VM) and vastus lateralis (VL) more than OKC exercises [2,3]. This suggests that both may be indicated during rehabilitation. However, a criticism of OKC exercises is that if they are implemented too early in the rehabilitation process, they may result in increased stress on the graft. During ACLR rehabilitation, it often takes 6-12 weeks to regain full knee range of motion. However, current research has not considered the interaction between muscle activation at various knee angles in OKC and CKC exercises.

Aim: to quantify and compare the quadricep muscle activation patterns between submaximal isokinetic OKC and CKC exercises and their different loading conditions to determine if there is a CKC exercise and load that stimulates the quadriceps in a similar way to OKC.

Methods: Forty healthy adults will perform a series of OKC (unilateral knee extension) and CKC exercises (bipedal squat and unilateral step-up) at body weight (BW), with 10% BW load, and with 25% BW load. Participants will perform three trials of each condition in a randomized order. Surface electromyography will be collected from RF, VM, and VL, and will be reported as a percentage of maximum voluntary isometric contraction of the quadriceps. Kinematics will be captured with an eight-camera markerless motion capture system and analyzed with Theia (Theia Markerless Inc., Kingston, ON, Canada) and Visual 3D (C-Motion Inc., Germantown, MD, USA).

Preliminary Results: To date, data from 20 participants have been collected. While no statistical analysis has been conducted, the trend of the preliminary data suggests that the step-up activates the VM and the VL more than knee extension and squat. It appears that the step-up activates RF as much as the knee extension. There is a clear trend that knee extension is able to activate the quadriceps to a similar extent in a more extended knee (<90 degrees), whereas the squat and the step up activate the quadriceps the most when the knee is >90 degrees.

References:

[1] Stien, N. (2021). Electromyographic comparison of five lower-limb muscles between single- and multi-joint exercises among trained men. Journal of Sports Science & Medicine, 20(1), 56.

[2] Ebben, W. P. (2008). Muscle activation during lower body resistance training. International Journal of Sports Medicine, 30, p. 1-8.

[3] Stensdotter, A. K. (2003). Quadriceps activation in closed and in open kinetic chain exercise. Medicine & Science in Sports & Exercise, 35 (12), 2043-7.

[4] Herrington, L. (2006). Does level of load affect relative activation levels of vastus medialis oblique and vastus lateralis? Journal of Electromyography and Kinesiology, 16 (4); p. 379-83.

HERO GLOVE INSIGHT: UTILIZING COMPUTER VISION AND FORCE SENSORS FOR OBJECT-SPECIFIC CONTROL

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[2]IEE Member

Introduction: Chronic stroke survivors that receive three or more hours of high intensity upper limb therapy per day show substantial, clinically meaningful gains in motor recovery. Soft exoskeleton robots provide forces on the human's limbs to assist motion and provide haptic feedback, enabling people with impaired motor function to practice more engaging therapeutic tasks and accelerate their motor recovery [1]. This research provides modifications to the original HERO Glove system and examines the HERO Glove system's ability to leverage a control system.

Methods: Using the improved HERO Glove system and the YOLO V3 computer-vision model [2], a series of grip tests were conducted first using a hand dynamometer, to verify the relationship between the force FSR sensor and the ground truth, and then to evaluate the system.

Results: The system could identify and grasp each of the objects. Key characteristics of the grasping trials are presented in Table 1.

Discussion and Conclusions: This improved system exhibited an increase in grip strength allowing it to complete 32% more activities of daily living.

The HERO Glove Insight demonstrates opportunities that sensing and computer vision can provide to increase the functionality of soft exoskeletons and identifies areas where future development and clinical trials are required to support safe and functional grasps for assistive and rehabilitation contexts.

References:

[1] J. Mehrholz, M. Pohl, T. Platz, J. Kugler, and B. Elsner, "Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke," Cochrane Database Syst. Rev., vol. 2018, no. 9, Sep. 2018. Accessed: Nov. 20, 2024.

[2] J. Redmon and A. Farhadi, "YOLOv3: An Incremental Improvement," Apr. 08, 2018, arXiv: arXiv:1804.02767. Accessed: Nov. 20, 2024.

Table 1: Key Characteristics of Gripping Tasks

Metric	Average Reading		
	Bottle	Phone	Pen
Rise Time (s)	5.06 (1.09)	4.66 (0.62)	24.04 (8.24)
Settling Time (s)	27.40 (6.46)	29.91(0.70)	42.80 (3.89)
Percent Overshoot (%)	15.00 (4.27)	13.22 (2.85)	4.28 (2.85)

ASSESSING CUMULATIVE CHANGES IN LUMBAR SPINE STIFFNESS THROUGHOUT A WEEK OF PROLONGED SEATED WORK

Jessa M. Davidson, Jordan Cannon, and Jack P. Callaghan
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Introduction: Low back pain in sitting is often linked to the adoption of prolonged lumbar spine flexion, and the associated viscoelastic response of spine tissue [1]. The objective of this study was to assess cumulative viscoelastic changes in the lumbar spine, specifically changes in range of motion and passive stiffness, over one week of primarily seated exposures during work hours, with unrestricted activity outside of work hours and on the weekend.

Methods: Over one week, twenty participants (10 male, 10 female) performed their seated office work at their own workstations and attended five laboratory sessions (Monday morning and evening, Tuesday morning, Friday evening, and Monday morning). Each morning and evening, participants provided low back pain ratings and performed maximum voluntary flexion. During waking hours, a tri-axial accelerometer on the thigh was used to classify sitting time. Two tri-axial accelerometers on the low back were used to measure seated lumbar spine flexion-extension angles. At the laboratory, lumbar spine stiffness in passive flexion was measured in a custom jig. Statistical tests compared between *pain status* groups (non-pain (<10 mm) and pain) and over *time*.

Results: Maximum voluntary flexion increased an average of 2.0° from morning to evening (p = 0.003). Small decreases in angular breakpoints occurred on Monday evening and Tuesday morning (4.6% and 6.8 %PassiveFlex), then angles progressively increased to within 1.7% to 2.3 %PassiveFlex of baseline values by the following Monday morning ($p \geq 0.056$). Significant effects of *pain status* did not emerge. The magnitude of change in the first angular breakpoint on Monday was correlated with sitting time at work ($R^2 = 0.21$ [95% CI: 0.00, 0.62]; $p = 0.04$ [95% CI: 0.00, 0.86]), wherein increases in sitting time led to larger decreases in the angular breakpoint.

Discussion and Conclusions: Daily increases in range of motion and stiffness at the start of the week were likely indicative of daily viscoelastic changes in spine tissue, such as creep of spinal ligaments [2] and altered fluid distribution in the intervertebral disc [3]. Nevertheless, the results indicated that the changes in spine mechanical properties did not accumulate throughout the week. While daily responses were identified in this young and healthy sample, these changes could accumulate with repetitive seated exposures or in aged or clinical populations.

References:

[1] Shin and Mirka (2007). An in vivo assessment of the low back response to prolonged flexion: Interplay between active and passive tissues. *Clinical Biomechanics.* 40 (11): p. 2457-2466.
[2] McGill et al. (1994). Passive stiffness of the lumbar torso in flexion, extension, lateral bending, and axial rotation: Effect of belt wearing and breath holding. *Spine.* 19(6): p. 696-704.
[3] Althoff, et al. (1992). An improved method of stature measurement for quantitative determination of spinal loading. Application to sitting postures and whole body vibration. *Spine*. 17(6): p. 682-693.

Podium Session 3

Thursday, May 22 (11:15am -12:15pm)

Business and Information Technology Building (BIT) 2080

Co-chairs: Aliza Siebenaller (University of Guelph) &
Ryan Foley (Ontario Tech University)

11:15am-11:25am	**Sarah Hallman** *University of Waterloo*	Comparing Minimal Detectable Changes Between Squat and Gait
11:25am-11:35am	**Jessica Wanyan** *Wilfrid Laurier University*	Understanding Balance Control in Response to Gait Perturbations In Adults with Attention Deficit Hyperactivity Disorder (Adhd)
11:35am-11:45am	**Daniel Sheffield** *York University*	Relationship Among Age, Lumbopelvic Control, Physical Activity Level, Muscle Morphology, And Extensor Muscle Endurance
11:45am-11:55am	**Sarah Hynes** *University of Waterloo*	A Data-Driven Approach to Optical Motion Capture Gap-Filling
11:55am-12:05pm	**Josh Briar** *University of Guelph*	Paraspinal Muscle Function Impairments Following Intervertebral Disc Puncture in Rat Model
12:05pm-12:15pm	**Ian Scagnetti** *University of Guelph*	Sex-Differences in Reported Discomfort During Exposure To Seated Whole-Body Vibration

COMPARING MINIMAL DETECTABLE CHANGES BETWEEN SQUAT AND GAIT

Sarah M. J. Hallman[1], Kimberly H. Peckett[1], Stacey M. Acker[1]

[1]Department of Kinesiology and Health Sciences, University of Waterloo, Waterloo, ON

Introduction: Minimal detectable change (MDC) quantifies the minimum difference required between trials to achieve a 95% probability of exceeding measurement error, mitigating the over-interpretation of small differences as meaningful [1-2]. While MDC has been reported for passive marker-based motion capture of gait [1-3], there is a significant knowledge gap for occupational postures. Gait studies have identified an MDC of ≤5° as acceptable for lower extremity joint angles in all planes [3]. The aim of this study was to quantify and compare MDC of peak frontal and sagittal knee angles and moments between squatting and gait. We hypothesized that knee angle and moment MDCs would be greater for squatting than for gait.

Methods: 13 female early childhood educators before and after their work shift performed 3 gait and 3 squat trials. Segment motion and ground reaction forces were recorded using 3 platform embedded force plates (AMTI, Watertown, MA, USA) synchronized with 8 markerless motion capture cameras (Qualisys, Göteborg, Sweden). 3D segment poses (Theia3D, Theia Markerless, Inc., Kingston, Canada), and knee angles and moments (Visual 3D, HAS-Motion, Kingston, Canada) were calculated. Peak knee adduction and flexion angles (KAA, KFA), and peak knee adduction and flexion moments (KAM, KFM) normalized to body mass (Nm/kg), were extracted (MATLAB, MathWorks, Natick, USA). MDC were computed [2] for the before-shift (baseline) session.

Table 1: MDC Thresholds for Peak Knee Outcomes

		Squat	Gait
MDC	KAA	4.0°	2.8°
	KFA	7.3°	4.5°
	KAM	0.1 Nm/kg	0.2 Nm/kg
	KFM	0.1 Nm/kg	0.3 Nm/kg

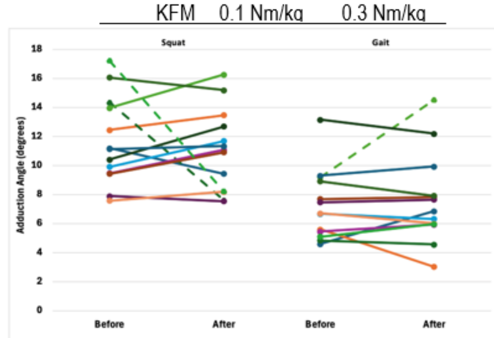

Figure 1: Squat and Gait Peak Knee Adduction Angles

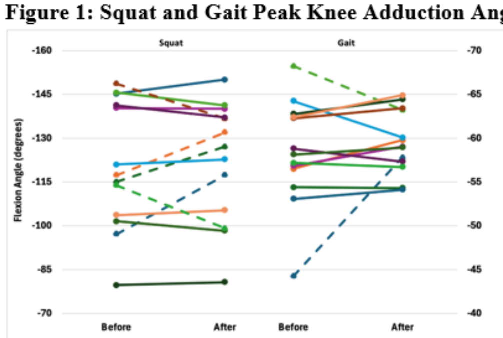

Figure 2: Squat and Gait Peak Knee Flexion Angles

**Dashed line – Participant exceeded MDC Threshold*

Results: All but the squat KFA MDC were ≤5° threshold (Table 1). Our hypothesis was partially supported, with greater knee angle MDCs for squatting but knee moment MDCs were unexpectedly larger for gait (Table 1). Some changes in outcomes from before to after shift exceeded the MDCs (Figure 2).

Discussion and Conclusion: This analysis quantified MDCs of peak knee outcomes for squat and gait. These results suggest that larger changes in KFAs are required to be interpreted as meaningful for squats. In contrast, larger changes in knee moments are required for gait. The complexity of phase transitions, variability in speed, stride length, heel strike patterns, and experimental uncertainty may account for this gait finding [3]. Future work on other postures is warranted to assess and develop task-specific MDCs, and resulting interpretations, for additional field professions.

References: [1] Hawkins & Milner (2021). *J Appl Biomech*, **37**: 477-480; [2] Fernandes et al., (2015). *Gait & Posture*, **42**: 491-497; [3] Kaufman et al., (2016). *Gait & Posture*, **49**: 375-381.

UNDERSTANDING BALANCE CONTROL IN RESPONSE TO GAIT PERTURBATIONS IN ADULTS WITH ATTENTION DEFICIT HYPERACTIVITY DISORDER (ADHD)

Jessica Wanyan[1], Stephen D. Perry[1]

[1]Department of Kinesiology and Physical Education, Wilfrid Laurier University, Waterloo, ON

Introduction: Previous balance studies have found that children with attention deficit hyperactivity disorder (ADHD) exhibit greater variability in baseline gait parameters [1]. Both adults and children with ADHD also exhibit greater postural instability, and deficits in balance responses to perturbations [2][3]. There are no studies investigating balance during gait in adults with ADHD, despite the greater instability involved in walking. The purpose of this study was to understand the effects of ADHD on balance control in adults to inform future research. The aim was to investigate differences in balance responses between ADHD and non-ADHD adults after unexpected perturbations during gait. It was hypothesized that adults with ADHD will be more unstable and have longer onset latencies and greater muscle activation in comparison to control/non-ADHD after perturbations.

Methods: 22 participants (12 ADHD, 10 non-ADHD), age 19-27, walked across an 8-meter walkway for 24 walking trials. 12 trials contained unexpected uneven walking surface perturbations in one of four directions (medial, lateral, anterior, posterior). The other 12 trials included no perturbations/random perturbations and were interspersed to ensure unpredictability. Stability was measured using the OptoTrak 3D Motion Capture System (Northern Digital Inc., Waterloo, Ont., CAN) to calculate the center of mass (COM) and determine the lateral base of support (BOS). Force plate data (AMTI, Waterdown, MA) was used for center of pressure (COP) and step timing. Surface electromyography (EMG) was recorded from four muscles of each leg using the Ultium EMG system (Noraxon, Inc, Scottsdale, AZ, USA). The Adult ADHD Self Report Scale (ASRSv1.1) was also used to record ADHD symptom severity to assess if ADHD symptoms had correlation with stability measures.

Results: The ADHD group had a significantly higher COM-COP separation maximum (max) in the anteroposterior direction (AP), a higher COM-BOS range, and a lower COM-BOS maximum and minimum (min) in comparison to controls. COM-BOS max and min was negatively correlated with ASRSv1.1 scores. No muscle response differences were observed.

Discussion and Conclusions: These results indicate adults with ADHD do exhibit balance deficits in comparison to non-ADHD adults, which supports the first hypothesis. The differences seen in the COM-COP separation interaction also indicate that ADHD participants likely used more conservative balance responses for perturbations that presented bigger threats to balance. Correlations shows that more severe ADHD symptoms may be related to greater instability. In conclusion, ADHD is associated with balance control deficits in adults and provides insight into specific differences in stability while experiencing perturbations during walking.

References:

[1] Simmons RW, Taggart TC, Thomas JD, Mattson SN, Riley EP (2020) Gait control in children with attention-deficit/hyperactivity disorder, Hum Mov Sci (70); 102584.

[2] Jansen I, Philipsen A, Dalin D, Wiesmeier IK, Maurer C. (2019) Postural instability in adult ADHD - A pilot study. Gait Posture (67); p. 284-289.

[3] Kooistra L, Ramage B, Crawford S, Wormsbecker S, Gibbard B, Kaplan BJ, et al. (2009). Can attention deficit hyperactivity disorder and fetal alcohol spectrum disorder be differentiated by motor and balance deficits? Hum Mov Sci. 28(4); p. 529-542.

RELATIONSHIP AMONG AGE, LUMBOPELVIC CONTROL, PHYSICAL ACTIVITY LEVEL, MUSCLE MORPHOLOGY, AND EXTENSOR MUSCLE ENDURANCE

Daniel W. Sheffield[1], Dan Desroches[1], Sam Vasilounis[1], Janessa D.M. Drake[1]
[1]School of Kinesiology and Health Science, York University, Toronto, ON

Introduction: Decreases in cross sectional area (CSA) have been associated with age-related declines in strength [1] but have a less clear relationship to muscle endurance, particularly in the lumbar spine region [2]. The Biering-Sørensen test (BS) is commonly used to assess low back muscle endurance [3] and as an indicator of risk for developing a low back disorder (LBD). However, it is not known how the BS relate to CSA, physical activity level (PA), and lumbopelvic control (LPC). Few studies have examined the relationship between lumbar muscle morphology and lumbar endurance [2], and questions remain regarding how muscle morphometric changes are impacting endurance and LPC, especially as we age. Likewise, this study examined the relationship between lumbar muscle CSA, LPC, PA, and muscular endurance in adults over 50y.

Methods: 18 participants (13 males, 5 females) between the ages of 50y and 85y (mean = 65.9y ± 11.4) underwent MRI scans at the L4-L5 level using IDEAL imaging on a Siemens 3T PrismaFit MRI scanner (Siemens Healthcare GmbH, Erlangen, Germany). Morphological measures of the erecter spinae (ES), and lumbar multifidus (LM) were extracted using ITK-SNAP open-source software. PA (HUNT 1 questionnaire), BS, and the active hip abduction test (AHAbd for LPC [4]) were collected. Multiple linear regression analyses were conducted to examine the relationship between BS time and Age, PA, LPC, and either ES or LM CSA normalized to BMI (ES/BMI; LM/BMI).

Results: For ES, the model was statistically significant, $F(4, 13) = 6.62$, $p = 0.004$, explaining 67% of the variance in the outcome ($R^2 = 0.67$). Age ($\beta = -2.14$, $p = 0.019$) and ES/BMI ($\beta = 1.53$, $p = 0.001$; Figure 1.) were significant predictors, whereas PA ($\beta = -0.79$, $p = 0.756$) and LPC ($\beta = 8.64$, $p = 0.408$) were not. The LM, model was not statistically significant, $F(4, 13) = 0.87$, $p = 0.507$, and explained only 21% of the variance in the outcome ($R^2 = 0.21$).

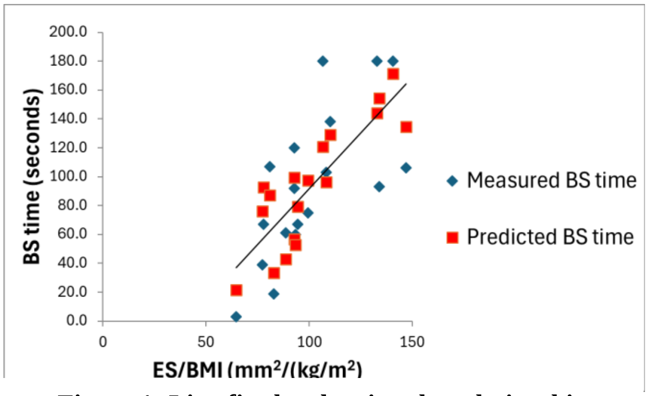

Figure 1: Line fit plot showing the relationship between measured and predicted BS times.

Discussion and Conclusions: These findings suggest that ES' CSA was more strongly associated with lumbar endurance in individuals over 50y, while PA level and LPC played a lesser role, was interesting. Perhaps for postural muscles CSA is associated with strength and endurance. Future research should explore additional trunk and pelvic muscles to see if the relationship exists beyond postural muscles, to further our understanding of the uses of BS and risk potential for LBD.

References: [1] Jubrias SA et al. (1997). *Pflügers Archiv*, 434(3); p.246-253. [2] Hultman G et al. (1993). *Clinical Spine Surgery*, 6(2); p.114. [3] Biering-Sørensen, F. (1984). *Spine*, 9(2); p.106. [4] Nelson-Wong E et al. (2009). *Orthopaedic & Sports Physical Therapy*, 39(9); p. 649–657.

A DATA-DRIVEN APPROACH TO OPTICAL MOTION CAPTURE GAP-FILLING

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Introduction: Marker-based optical motion capture (MOCAP) is widely used for movement analysis, but marker occlusion—when a marker is out of the camera's view—creates data gaps that need to be filled [1]. Traditionally, users manually fill these gaps by selecting interpolation methods, which are time-consuming and inconsistent, especially for longer gaps [2]. The goal of this study was to examine the use of a machine learning (ML) model for automated marker gap filling when paired and trained with IMU data for motion reference during marker dropout.

Methods: A MOCAP dataset containing 84 participants fitted with 7 markers on the right arm and upper torso performing 9 physiotherapy exercises was used in this study. Each exercise was captured with a 13-camera VICON MX20 passive optoelectronic motion capture system (VICON Motion Systems Ltd, Oxford, UK) while an IMU (Mobvoi TicE Smartwatch, Beijing, CN) was worn on the right wrist. The MOCAP data was traditionally gap-filled manually to develop ground truths. Gaps of varying lengths from 0.5-2s were then introduced randomly to each marker in the MOCAP dataset. The MOCAP data with gaps and the IMU reference data served as inputs for a long short-term memory recurrent neural network developed to predict appropriate values to fill the gaps. The model was trained by splitting the data with 70% allocated for training, 15% for verification, and 15% for testing.

Results: The model was found to converge after 54 epochs. The training loss was converged with a mean square error (MSE) of 0.0213 and testing loss of 0.0212. Figure 1 displays an example of the model's performance for gap filling of a marker trajectory compared to its true trajectory. The model performed better than basic interpolation for movements with non-linear trajectories, effectively reducing the mean square error produced by 50% in some cases.

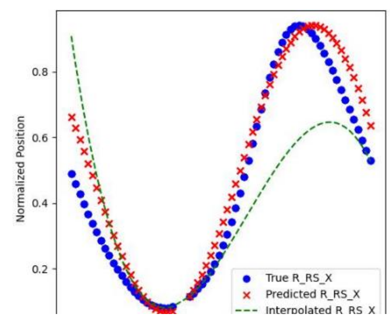

Figure SEQ Figure * ARABIC 1: True and predicted trajectory of a marker on the right radial styloid process.

Discussion and Conclusions: To automate the gap filling process, a ML approach was attempted to leverage the data collected when integrating an IMU with traditional MOCAP. The proposed model was successful in producing adequate values when predicting the trajectory of lost markers during smooth motion. This automated ML approach could serve as an alternative to the traditional methods that can be laborious and subjective. Future work includes parameter optimization to further improve the predicted trajectories along with investigation of real-time implementation.

References:

[1] Camargo, J. et al. (2020). Automated gap-filling for marker-based biomechanical motion capture data. CMBBE 23 (15); p. 1180-9.

[2] Skurowski, P. et al. (2021). Gap Reconstruction in Optical Motion Capture Sequences Using Neural Networks. Sensors 21 (18).

PARASPINAL MUSCLE FUNCTION IMPAIRMENTS FOLLOWING INTERVERTEBRAL DISC PUNCTURE IN RAT MODEL

K. Josh Briar[1], Alex Chan[2], Jana Michaud[1], Adam Bui[1], Courtney Phillips[1], Stephen H. M. Brown[1]
[1]Human Health and Nutritional Sciences, [2]Ontario Veterinary College, University of Guelph

Introduction: Paraspinal muscle dysfunction has been linked to chronic low back pain (LBP) [1], but the causative relationship between LBP and muscle dysfunction remains elusive. An experimentally induced intervertebral disc injury animal model has been used to study structural and biochemical degenerative changes associated with natural human lumbar spine aging, including their relation to pain and dysfunction [2]. However, to date, there has been a lack of investigation into the influence of this experimental model of intervertebral disc injury on the active contractile properties of the paraspinal muscles.

Methods: 32 male Sprague-Dawley rats were randomly divided into 4 groups: 15-week sham (n=8), 15-week puncture (n=9), 10-week puncture (n=7) and 5-week puncture (n=7). All rats underwent a retro-peritoneal incision and the L2-L3 and L4-L5 levels of the spine were identified. Animals in the puncture groups underwent an approximate 2 mm penetration into each disc of interest, while the sham group did not. Animals were sacrificed at different time points (5, 10 or 15 weeks) post-surgical intervention, and the contralateral multifidus and longissimus muscles were excised. Single muscle fibres (N=1240) were isolated and underwent active contractile testing. Specific force (SF), active modulus, and rate of force reproduction (KTR) were calculated.

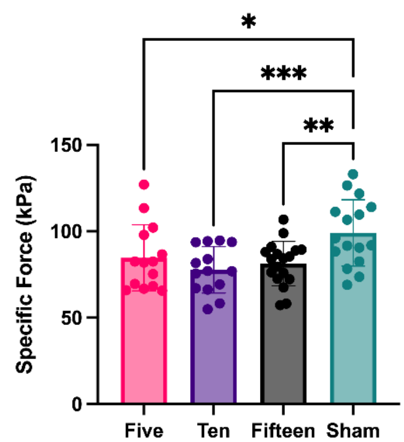

Figure 1: Mean specific force in each surgical group.

Results: A main effect of surgical group was observed for mean SF (F=5.284, df=3, p=0.003, Fig 1); highlighting that SF was significantly higher in the sham group than the week 5 (p=0.018), week 10 (p<0.001), and week 15 surgical groups (p=0.002). A main effect of surgical group was observed for mean KTR (p=0.044), indicating that mean KTR was significantly higher in the week 15 surgical group when compared to the sham group (p=0.014).

Discussion and Conclusions: The current work highlights that following an induced intervertebral disc injury there is a significant reduction in force generating capacity of the surrounding para-spinal single muscle fibres. Interestingly, the current work provides evidence for the possibility of compensatory changes developing within the paraspinal muscles as KTR was higher following surgical intervention in comparison to the sham group.

References:

[1] Noonan AM et al. (2021). Paraspinal muscle pathophysiology associated with low back pain and spine degenerative disorders. JOR SPINE
[2] Brown SHM et al, (2011). Adaptations to the Multifidus Muscle in Response to Experimentally Induced Intervertebral Disc Degeneration. Spine

SEX-DIFFERENCES IN REPORTED DISCOMFORT DURING EXPOSURE TO SEATED WHOLE-BODY VIBRATION

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Introduction: Exposure to whole-body vibration (WBV) increases back injury risk, particularly for females. Discomfort due to WBV is a predictor for low back injury. Previous work has shown significant sex-differences in x- (fore-aft), y- (lateral) and z- (vertical) axis vibrations experienced at the head and spine during exposure to WBV. It has not yet been determined if these sex-differences contribute to increased discomfort or injury risk. This study examines sex-differences in tri-axial vibrations at the pelvis and head, and the relationship between tri-axial vibration and self-reported discomfort during WBV exposure.

Methods: 24 participants (12 male /12 female) were exposed to WBV on a rigid seat with no backrest. Exposures included vertical root-mean-square (RMS) input accelerations of $0.25 m/s^2$ and $0.5 m/s^2$ at discrete frequencies of 1,3,5,7,9,11,13, and 15Hz. Participants were exposed to 3, 20 second trials of each combination of acceleration and frequency. Following vibration exposures, discomfort was verbally reported by participants using a 8-point scale and primary discomfort region was reported and binned according to Porter's Comfort Scale. Accelerations were recorded at the pelvis and head using tri-axial accelerometers and weighted for health according to ISO 2631-1. Accelerations and discomfort scores were analyzed with mixed-factorial analyses of variance ($p<0.05$) using within subject factors of input acceleration and frequency, and a between subject factor of sex. Post-hoc Bonferroni pairwise comparisons were performed when appropriate ($p<0.05$).

Results: Significant sex*frequency and sex*input acceleration interactions were found in discomfort scores and tri-axial accelerations at the head and pelvis. At 13 and 15 Hz, females experienced greater discomfort and fore-aft vibration at the pelvis compared to males. Females experienced greater lateral vibration at the head than males at $0.25 m/s^2$ RMS input vibration. At 13 and 15Hz, females reported low back as the primary discomfort location up to 3.5 times more often than males. Males experienced peak discomfort at 5Hz, where they reported greater discomfort than females and experienced greater vertical vibration at the head than females. Males reported discomfort diffusely throughout the trunk, neck and head, whereas females reported discomfort primarily in the low back and pelvis.

Discussion and Conclusions: This study is the first to investigate the relationship between discomfort and tri-axial vibration at the head and pelvis. The observed sex-differences in discomfort may be related to fore-aft and lateral accelerations experienced during WBV, which are associated with increased spinal shear forces. Some spinal tissues, such as vertebral discs and zygapophyseal joints, have a lower injury threshold for shear forces than compression, which may influence injury risk. The results of this work suggest that females may require vibration mitigation strategies that reduce accelerations in the fore-aft and lateral directions to better prevent discomfort and decrease injury risk.

Podium Session 4

Thursday, May 22 (2:50pm -3:50pm)

Business and Information Technology Building (BIT) 2080

Co-chairs: Josh Briar (University of Guelph) &

Claudia Town (University of Waterloo)

2:50pm-3:00pm	**Hailey Tabbert** *Ontario Tech University*	Understanding The Role of Vibration Exposure in Motor Skill Training and Performance
3:00pm-3:10pm	**Dominic Zapata** *York University*	A Biomechanical Analysis of Rehabilitative Exercises For Subacromial Impingement Syndrome and/or Rotator Cuff Tears
3:10pm-3:20pm	**Jared-Isaac Friedel** *University of Waterloo*	Accumulation And Recovery of Prolonged Low-Frequency Force Depression At Different Intensities of Repetitive Isometric Contractions
3:20pm-3:30pm	**Jarrod Smith** *University of Windsor*	Torque-Angle Regression Equations for Low-Back Exoskeletons
3:30pm-3:40pm	**Molly Malette** *McMaster University*	Stair Ascent and Descent in Older Adults with and Without Support
3:40pm-3:50pm	**Erinn McCreath Frangakis** *University of Waterloo*	Are Seated Spine Kinematics Associated with Between-Day Fluctuations In Low Back Pain Scores?

UNDERSTANDING THE ROLE OF VIBRATION EXPOSURE IN MOTOR SKILL TRAINING AND PERFORMANCE

Hailey Tabbert[1], Tanya Najib[1], Dr. Paul Yielder[1], Dr. Bernadette Murphy[1]

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Introduction: Workers across various industries, including healthcare, are routinely exposed to vibration from tools like surgical drills[1]. Prolonged exposure has been associated with musculoskeletal disorders and nerve damage[2]. Even brief exposure to neck muscles can significantly impair upper limb motor accuracy[3]. Given the critical role of motor precision in surgery, understanding the physiological impact of vibration exposure on motor skill training and performance is essential.

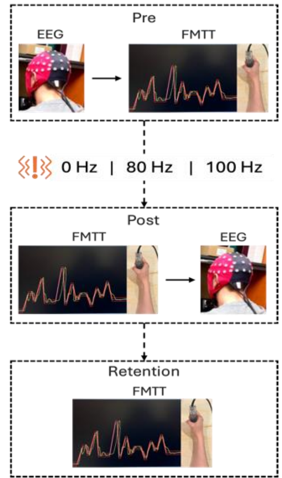

Figure 1. Experimental flowchart.

Methods: 27 Participants (20F, 21.56±3.4) were randomly assigned to: 0 Hz, 80 Hz or 100 Hz vibration, applied to the neck prior to acquisition of a force-matching tracking task (FMTT). Participants used a force transducer to trace a series of predefined templates with their dominant hand. Task performance was assessed pre/post-acquisition and 24-hour retention. Absolute error was calculated as the difference between the template and participant trace at all time points. Electroencephalography (EEG) was obtained pre/post task performance and SEP peaks were extracted to assess cortical responses to skill acquisition (Figure 1).

Results: All groups improved from pre- to post-acquisition ($p<0.001$), with no group differences ($p=0.62$). At retention, the 0 Hz group improved by 10% ($p=0.03$), with no change in 80 Hz ($p=0.35$) or 100 Hz ($p=0.21$). Increased cerebellar activity was seen in both vibration groups, and decreased activity in the 0 Hz group post-acquisition ($p<0.001$).

Discussion: The results suggest vibration exposure does not affect task acquisition, but does appear to impair skill retention. This is supported by changes in N24 peak amplitude, reflecting cerebellar activity. In healthy individuals, a decreased N24 amplitude is typically observed, indicating reduced cerebellar contributions as task proficiency improves[4]. The increased amplitude in the vibration groups suggests altered cerebellar inhibition responses to motor learning, which may underlie impaired retention of motor skills. These findings highlight the importance of understanding the neural mechanisms responsible for motor learning in the context of occupational vibration exposure.

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3. Tabbert, H., U. Ambalavanar, and B. Murphy, *Neck Muscle Vibration Alters Upper Limb Proprioception as Demonstrated by Changes in Accuracy and Precision during an Elbow Repositioning Task.* Brain Sciences, 2022. **12**(11): p. 1532.
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A BIOMECHANICAL ANALYSIS OF REHABILITATIVE EXERCISES FOR SUBACROMIAL IMPINGEMETN SYNDROME AND/OR ROTATOR CUFF TEARS

Dominic I. Zapata[1], Stephen M. Boulanger[1], Kara-Lyn Harrison[2], Trisha D. Scribbans[2], Jaclyn N. Chopp-Hurley[1]
[1]York University, Toronto, ON; [2]University of Manitoba, Winnipeg, MB

Introduction: The risk of subacromial impingement syndrome (SAIS), a prevalent musculoskeletal condition among older adults, is increased by disadvantageous shoulder mechanics. For example, hyperactivity of the upper trapezius (UT) can lead to scapular motion abnormalities that reduce the subacromial space, thereby elevating SAIS risk [1]. Exercise-based rehabilitation is prescribed for SAIS and rotator cuff tears (RCT), however a comprehensive biomechanical assessment of common rehabilitative exercises has not been explored. This research studied muscle activity and coactivation ratios among upper limb musculature for scapular strengthening exercises and body weight-bearing exercises.

Methods: Preliminary analysis of 14 young adults (F, n=7; M, n=7) with no self-reported shoulder pain or recent injury has been completed. Muscle activity was recorded bilaterally from UT, middle trapezius (MT), lower trapezius (LT), serratus anterior (SA), supraspinatus (SS), infraspinatus (IS), and middle deltoid (MD). Participants performed muscle-specific maximal voluntary contractions (MVC) [2] and two types of exercise trials (scapular strengthening exercises (n=13), body weight-bearing exercises (n=10)). Muscle activity and co-activity were evaluated in the context of exercise guidelines and injury-sparing mechanics [1,3].

Results: A significant effect of exercise type on muscle activity was elicited for each individual muscle, with the exception of left and right serratus anterior (Table 1). Co-activation ratios between UT and each of MT, LT, and SA varied with classifications of excellent, good, moderate [1], and disadvantageous across scapular stabilizing and body weight-bearing exercises. Generally, exercises yielded mechanically disadvantageous rotator cuff ratios between MD and both SS and IS which may elevate the risk of superior translation of the humeral head and consequent SAIS risk.

Discussion and Conclusions: Preliminary findings suggest that while scapular strengthening exercises generally produced higher levels of upper limb muscle activity, certain exercises within each exercise type had mechanically advantageous co-activation ratios while others yielded activation patterns that may pose risk for SAIS. This has important implications for the design of rehabilitation exercise programs for adults with SAIS and/or RCT.

Table 1. Mean (SD) muscle activity (%MVC) for body weight-bearing and scapular strengthening exercises

Exercise Type	RIS	RLT	RMD	RMT	RSA	RSS	RUT	LIS	LLT	LMD	LMT	LSA	LSS	LUT
Body weight-bearing	16.6 (17.8)	20.5 (29.1)	14.6 (12.1)	32.5 (75.7)	31.9 (41.2)	9.0 (13.0)	12.5 (30.7)	13.7 (10.7)	19.4 (18.6)	15.5 (12.2)	25.4 (44.4)	25.9 (30.6)	10.3 (13.7)	11.2 (17.5)
Scapular Strengthening	55.6 (147.8)	38.4 (32.0)	20.9 (28.2)	108.2 (209.2)	51.5 (151.5)	23.8 (23.7)	29.7 (32.9)	36.0 (78.2)	43.0 (34.8)	20.8 (21.0)	68.4 (71.7)	30.3 (38.7)	29.4 (27.1)	33.0 (35.9)
	p<0.01	p<0.01	p=0.01	p<0.01	p=0.14 (NS)	p<0.01	p<0.01	p<0.01	p<0.01	p<0.01	p<0.01	p=0.27 (NS)	p<0.01	p<0.01

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ACCUMULATION AND RECOVERY OF PROLONGED LOW-FREQUENCY FORCE DEPRESSION AT DIFFERENT INTENSITIES OF REPETITIVE ISOMETRIC CONTRACTIONS

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Introduction: Musculoskeletal disorders continue to debilitate workers despite ergonomists having tools to calculate risks and reduce peak exposures. Continued elevated injury rates suggest that a long-duration or sustained exposure effect of work may be a concern. Prolonged Low Frequency Force Depression (PLFFD) may provide an explanation for the accumulating effect of repeating the same works task over time.

Aim: Determine if force level during workload-matched protocols influences the accumulation and/or recovery of PLFFD. Determine whether PLFFD causes increased force variance and force instability in a force matching task.

Methods: A repeated measures design will require participants to visit the lab on two occasions to complete work protocols and on an additional two occasions for a follow-up visit on the mornings after the intervention days. The work task requires participants to use their right elbow flexors to suspend a weight from the ground cycling between an “on” and “off” phase at two different duty cycles for a total work time of four hours. During one lab visit participants will perform the work task with the low weight (15% maximum elbow flexion force, 30 seconds “on” per minute) and the other with the high weight (25% maximum elbow flexion force, 18 seconds “on” per minute). Once per hour during the work protocol, on the hour for three hours following the work protocol, and once per follow-up visit, a battery of measurements will be performed bilaterally on the participant. The measurement battery involves measuring the maximum voluntary elbow flexion force, the biceps brachii’s force response to transcutaneous electrical stimulation at a low and high frequency (Lo/Hi ratio) [1] and measuring the participant’s ability to maintain a target force (30% maximum elbow flexion force) for 15 seconds to interpret force variance and force instability [2].

Expected Results: The maximum elbow flexion force of the right arm will be expected to decrease post-work and return to resting by the follow-up visit. The Lo/Hi ratio is expected to decrease during work and slowly increase throughout same-day recovery and but not return to baseline by the follow-up visit. The Lo/Hi ratio is expected to have the same accumulation trend in response to work between protocols, however the high force protocol is expected to recover more quickly. Force variance and force instability measures are expected to increase with respect to work and stay elevated, even on the follow-up day.

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TORQUE-ANGLE REGRESSION EQUATIONS FOR LOW-BACK EXOSKELETONS

Jarrod Smith[1], Shahram Rasoulian[1], Joel Cort[1]

[1]Department of Kinesiology, University of Windsor, Windsor, ON

Introduction

Low-back injuries are a major concern in physically demanding industries [2], causing significant health and financial burdens Canada and the United States [1, 4]. Exoskeletons offer a potential solution by reducing physical demands during lifting and repetitive tasks. However, manufacturers often report only peak supportive torque values, limiting practical use. This study addresses this gap by developing torque-angle equations for two passive low-back exoskeletons to support ergonomic evaluations across a range of motion.

Methods

Two models of passive low-back exoskeletons (LBE) were tested using a Biodex System 4 Isokinetic dynamometer (Atlas Medic Inc, Quebec, Canada), SuitX backX (Ottobock, Netherlands) and Laevo V2.5 (Laevo, Netherlands). Each device was moved through its range of motion to measure the resistive torque during flexion and extension under different support settings (i.e., high and low). This methodology was designed based on previous work [3, 5]. Polynomial regression models were developed to predict the supportive torque at different angles.

Results

Both exoskeletons provided greater torque during trunk flexion. SuitX yielded higher peak and mean torque in the high-support setting, while Laevo performed better in the low condition.

Discussion and Conclusions

Findings confirm that supportive torque is higher during flexion, consistent with prior work. The resulting torque-angle equations offer a valuable tool for predicting exoskeleton performance, supporting task-specific ergonomic assessments and injury prevention efforts. These equations can be used independently or integrated into DHM software.

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STAIR ASCENT AND DESCENT IN OLDER ADULTS WITH AND WITHOUT SUPPORT

Molly Malette, Ryan Chhiba, Daanish M. Mulla, Nigel Majoni, Paul M. Tilley, Peter J. Keir*

Department of Kinesiology, McMaster University, Hamilton, ON

Introduction: Mobility challenges are a common barrier for older adults who wish to age at home, or “in place”, with one of the highest mobility issues being reported as stair safety [1]. Maintaining stair use has various health benefits, such as improving endurance, cardiovascular health, and dynamic balance [2]. However, aging is associated with factors that lead to decreased stability when ascending and descending stairs, which may elevate the risk of falls [3]. Traditional stair assists include handrails, stairlifts (chairs), and other emerging assistive devices. A new device, the AssiStep stair climbing aid (Assitech AS, Norway), acts like a walker attached to a railing and includes a locking mechanism for descent. This study aimed to compare stair ascent and descent with the AssiStep, railing, and without support.

Methods: Eighteen older adults (65–85 years old) completed stair ascent and descent trials using: (i) a standard railing, (ii) the AssiStep device, and (iii) no assistance. Segmental accelerations were collected using seven triaxial accelerometers placed on the head, chest, trunk, wrists, and ankles. Participants also completed questionnaires regarding their current stair use, use of stair aids and perceptions of the AssiStep. Resultant accelerations were time normalized, averaged, and analyzed using the Amplitude Probability Distribution Function (1st, 50th, and 99th percentiles).

Results: In general, all three conditions had similar accelerations, with the AssiStep device having small but significantly lower resultant accelerations for some segments than when using no support or rail support. Specifically, the peak acceleration (99th percentile) of the right and left wrists and ankles, as well as the head for both ascending and descending and at the waist for ascending the stairs. Additionally, the median (50th percentile) acceleration for the right wrist was significantly lower for the new device during both ascent and descent. In the stair-use part of the questionnaire, participants reported using varying levels of assistance on a regular basis but are not currently concerned with their safety.

Discussion: These results suggest that the assistive device presents similar or lower body segment accelerations during ascent and descent of the stairs compared to railings and no support. Importantly, lower accelerations combined with a locking mechanism suggest decreased risk of falls. Although participants were receptive to the device, they also noted that they would not use it frequently right now, but it may be an option in the future. Devices such as the one tested here may be a viable option in the home to help with mobility on the stairs for older adults.

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ARE SEATED SPINE KINEMATICS ASSOCIATED WITH BETWEEN-DAY FLUCTUATIONS IN LOW BACK PAIN SCORES?

Erinn McCreath Frangakis[1], Jessa M. Davidson[1], Jack P. Callaghan[1]

[1]Department of Kinesiology and Health Sciences, University of Waterloo, Waterloo, ON

Introduction: Sitting time accounts for 81-90% of an office worker's day [1]. While prolonged sitting has been identified as a risk factor in low back pain development [2], there is still considerable variation in reported pain scores [3]. As such, it is crucial to identify the within-subject biomechanical differences to understand and interpret these fluctuating pain reports. Therefore, the objective of this study was to assess between-day variation in seated activities and spinal kinematics in days with maximum and minimum reported pain scores.

Methods: Twenty participants completed this study. Data were collected over one workweek at participant's workstations. Low back pain ratings were collected at the start and end of each day via a 100 mm visual analogue scale. Individuals wore a tri-axial accelerometer on their dominant thigh during waking hours (GT9X Link, Actigraph, FL, USA) to classify activity data into sitting, standing, or stepping. Two additional tri-axial accelerometers were instrumented on the first lumbar (L1) and sacral (S1) vertebrae at the start of each workday to measure thorax, pelvis, and lumbar spine angles. Two-way repeated measures analyses of variance (ANOVA) were performed to assess the effect of *pain day* (Maximum and Minimum) and *time* (7 blocks, each ~1 hour) on seated spine kinematics and total sitting time.

Results: Nine participants (5 females) had days with maximum and minimum reported pain scores which varied >5 mm and were included in the ANOVAs. There was no significant difference between the two pain days for daily sitting or standing/stepping metrics ($p \geq 0.245$). Peak backwards thorax inclination was found to increase throughout the day (up to 11°) with a significant pairwise comparison found between the 1st and 5th and 1st and 6th blocks ($p_{adj} > 0.046$). The amplitude of spine movements were larger on the Maximum compared to the Minimum pain days (ranging from 1.5° to 10.9°) with significant differences at the 85th, and 91st to 97th percentiles ($p \leq 0.048$). Additionally, main effects of *pain day* were found for the time between spinal movements (approximately every 18-160 seconds) at the 91st, 92nd, 94th, and 95th percentile ($p \leq 0.046$).

Discussion and Conclusions: On days with higher pain scores, participants demonstrated larger, less frequent spinal movements. This suggests that micromovements of the lumbar spine are a possible response to low back pain while sitting.

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Podium Session 5

Friday, May 23 (8:30am-9:30am)

Business and Information Technology Building (BIT) 2080

Co-chairs: Stephen Boulanger (York University) &
Hannah Coyle-Asbil (University of Guelph)

8:30am-8:40am	**Jake Gimmy** *McMaster University*	Evaluating The Influence of Self-Selected Versus Ergonomic Recommendation On Spinal Curvature
8:40am-8:50am	**Charlotte Gregus** *University of Guelph*	Effect Of Cutaneous Input to the Foot Sole on the Rate Of Plantar Flexor Muscle Activation
8:50am-9:00am	**Steven Taras** *Brock University*	A Novel Method for Mapping Walking Terrains
9:00am-9:10am	**Sarah Quayyum** *University of Waterloo*	Dual Energy CT for More Accurate Diagnosis and Monitoring Of Early Osteoarthritis-Related Shoulder Injuries
9:10am-9:20am	**Sharath Nandan** *HAS-Motion*	Assessing Different Kinematic Methods of Structuring Gait
9:20am-9:30am	**Umar Yousufy** *Brock University*	Comparing Center of Mass Excursion in Individuals with Varying Levels Of Anterior Reach Asymmetry

EVALUATING THE INFLUENCE OF SELF-SELECTED VERSUS ERGONOMIC RECOMMENDATION ON SPINAL CURVATURE

Jake Gimmy[1], Heather O'Reilly [1]

[1]School of Interdisciplinary Science, McMaster University, Hamilton, ON

Introduction: Sedentary behaviour due to prolonged period of sitting has become increasingly prevalent in occupational settings. Numerous health risks have been associated with extended sedentary periods [1]. Standing desks have become popular for reducing sedentary behavior in workplaces and mitigating negative health impacts associated with prolonged sitting. However, improper desk heights could potentially contribute to postural strain and spinal adaptations.

Aim: This study explored the impact of self-selected standing desk height compared to recommended desk height (with ergonomic recommendations) on thoracic kyphosis (upper back curvature) and lumbar lordosis (lower back curvature) among working-age adults.

Methods: Thirty-four adult participants (n=34) from McMaster University (ages 18-46) were recruited for this study. Spinal curvature, including thoracic kyphosis (IK) and lumbar lordosis, (LL) were measured using a Flexicurve ruler [2] under two desk height conditions (self-selected and ergonomic recommendation), both before and after a 20-minute standing desk activity. A repeated measures ANOVA was conducted to analyze the effects between desk height and time on spinal curvature using SPSS (IBM SPSS Statistics for Macintosh, Version 30.0).

Results: A significant difference was found between desk conditions for IK $F(2, 29) = 4.80$, $p = .016$. There was a significant interaction between condition and sex on IK, $F(1, 30) = 6.96$, $p = .013$, where males self-selected a lower desk height than recommended, resulting in a higher index of thoracic kyphosis. Females self-selected a higher desk height, than recommended, reducing the IK, compared to recommended. For all participants, there was an increase in IK over the 20 min stand, when participants self-selected their standing desk height. There was no difference in IK over time, when recommended desk height was used $F(1, 30) = 4.51$, $p = .042$. No significant differences were observed for LL.

Discussion and Conclusions: Findings suggest that males tend to choose a desk height that is lower than ergonomically recommended, whereas females tend to select a higher desk height than ergonomically recommended. These self-selected desk heights influence thoracic posture. Moreover, the interaction between desk height and time, suggests that subtle changes in desk set-up may influence posture throughout a prolonged use of standing desk. Ergonomically recommended height appeared to help maintain spinal alignment more effectively over a 20 min. period, though prolonged standing studies will better explore this relationship. Overall, this study emphasizes the need for ergonomic adjustment, considering individual variability in height, including sex-related differences, when implementing standing desks in office settings.

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EFFECT OF CUTANEOUS INPUT TO THE FOOT SOLE ON THE RATE OF PLANTAR FLEXOR MUSCLE ACTIVATION

Charlotte Gregus[1], Tushar Sharma[1], Laura Marrelli[1], Ryan Weller[2], Jayne Kalmar[2], Leah Bent[1]
[1] Dept. of Human Health & Nutritional Sciences, University of Guelph, Guelph, ON
[2] Dept. of Kinesiology and Physical Education, Wilfrid Laurier University, Waterloo, ON

Introduction: Rapid muscle activation, particularly in lower-limb muscles, is essential for successful responses to postural perturbations [1]. Thus, improving rate of muscle activation is important to reduce fall risk in populations with deficits. Cutaneous stimulation has been shown to preferentially increase excitability of high-threshold MUs which may facilitate faster muscle activation [3]. Additionally, cutaneous stimulation of the foot sole has been shown to generate location-dependent reflex responses in the lower limb; heel stimulation excites the plantar flexors, while metatarsal stimulation inhibits the plantar flexors [4]. Together, this suggests heel cutaneous stimulation may increase the rate of muscle activation via the earlier recruitment of high threshold MUs. This study aimed to assess the potential location-dependent influence of foot sole cutaneous stimulation on the rate of plantar flexor muscle activation.

Methods: Ten young, healthy adults (6F, 4M) performed explosive isometric voluntary plantarflexions in a custom-made dynamometer under four conditions: heel control, heel vibration (HEEL), metatarsal control, and metatarsal vibration (MET). Cutaneous vibration stimulation was delivered using vibrational tactors, at 5×perceptual threshold. Electromyography (EMG) was recorded from the soleus, medial and lateral gastrocnemius muscles. Motor time (MT) was calculated as the time between EMG onset and the time when force surpassed 15% MVC. The rate of EMG rise (REMGR) was calculated as the slope of the processed EMG signal from onset to 30 ms. The difference in MT and REMGR between stimulation conditions and their respective control were compared.

Results: A decrease in MT signifies a shorter time from EMG onset to Force (faster contraction). Across the 10 participants; HEEL stimulation resulted in a decrease in MT in 6 and increase in 4. MET stimulation resulted in decreased MT in 3 and an increase in 7. An increase in REMGR signifies a faster EMG activation; HEEL stimulation resulted in decreased REMGR in 7 participants, but an increase in 3. MET stimulation resulted in an even split for REMGR, 5 increase, 5 decrease.

Discussion and Conclusions: Our results suggest that foot sole cutaneous stimulation may alter rate of muscle activation without a location dependence. This may be due to alterations to high threshold MU recruitment induced by cutaneous stimulation. Future considerations should include different responses between the sexes. Understanding the influence of cutaneous stimulation on muscle activation may serve as a tool in further clinical research aimed at improving motor outcomes in populations vulnerable to fall risk.

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A NOVEL METHOD FOR MAPPING WALKING TERRAINS

Steven B. Taras, Adam Swales, Zeyd Kharrubi, Ryan T. Schroeder
Department of Engineering, Brock University, St. Catharines, ON

Introduction: Human walking studies are often done in a controlled lab setting. Experiments of walking in real-world environments may benefit from precise measurements of terrain, including ground slope and land features. Specialized instrumentation such as global positioning systems (GPS) [1] or surveying drones [2] can be expensive, time-consuming, and/or lack the precision needed for relatively small-scale elevation changes suitable for human walking experiments. We developed a novel method for mapping real-world walking terrains using inertial measurement units (IMUs) commonly already used in many biomechanics labs.

Methods: Two Opal V2R IMUs (Clario Inc., Portland, USA) were secured to a frame and placed at regular 0.69 m intervals (about the length of a step) creating a 2-dimensional grid across a square land area of about 144 m^2. During each measurement, the frame and IMUs sat at rest for about 3 seconds and were then moved to each grid point in a known sequence. During the resting period, acceleration data (recorded at 60 Hz) were used to evaluate the local ground slope relative to vertical gravity, and elevation changes were subsequently calculated. Discrete obstacles such as rocks and trees were measured with a tape measure and the corresponding missing slope data were interpolated with a spline.

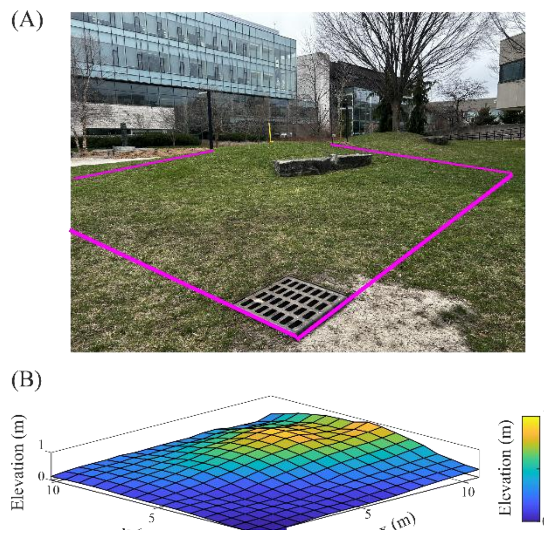

Figure 1: (A) Natural terrain measured. (B) Corresponding elevation map.

Results: The terrain measurements (N=269) took about 4 hours to complete (nearly a minute per 1 m^2). The maximum elevation change was measured at 0.96 m, equivalent to climbing about five stairs. Measurements of the terrain's slope ranged from -0.26 to 0.24 (or -14.6 to 13.5°, relative to horizontal), nearly three times steeper than a wheelchair ramp (typically about 0.08) but more modest than climbing a flight of stairs (about 0.70).

Discussion and Conclusion: The approach outlined here can be used to characterize terrains for walking experiments. The method is limited by it ability to accurately measure land composition (e.g., grass, dirt, pebbles) or discrete terrain changes such as a steps or large rocks. The measurements can be validated with alternative equipment such as survey drones in future work.

References:

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DUAL ENERGY CT FOR MORE ACCURATE DIAGNOSIS AND MONITORING OF EARLY OSTEOARTHRITIS-RELATED SHOULDER INJURIES

Sarah Quayyum[1], Monica Maly[1], Clark Dickerson[1], Nikolas K Knowles[1]

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Introduction: Early detection of shoulder OA-related changes is crucial for improving diagnosis and treatment [1]. DECT enhances tissue visualization and may serve as a biomarker for early OA. Before clinical application, imaging parameters must be optimized. This study evaluates the impact of reconstruction kernels and DECT energy pairs on volumetric bone mineral density (vBMD) in the proximal humerus of cadaveric models.

Methods: Cadaveric specimens (n = 7; 14 shoulders) were scanned bilaterally using DECT with a dipotassium phosphate (K_2HPO_4) calibration phantom. Images were reconstructed with bone (BONE) and standard (STD) kernels. Monochromatic images at 40, 90, and 140 keV were combined into energy pairs (40/90, 90/140, 40/140 keV). vBMD values were extracted from segmented regions using Python scripts [1] and 3D Slicer. Results were analyzed using a two-way RM-ANOVA.

Results: The highest vBMD values were in the diaphysis across all conditions, with BONE kernel values exceeding STD at higher energy pairs (e.g., 90/140 keV). The anatomical neck showed the lowest vBMD. No significant vBMD differences were found across energy pairs for the humeral head or anatomical neck, but the diaphysis showed significant variation ($p < 0.05$). Similar trends were observed in FEM stiffness values, with the diaphysis exhibiting the highest stiffness and the anatomical neck the lowest.

Location	40/90	90/140	40/140
Diaphysis: BONE	332 ± 103^{a,b}	407 ± 130^{a,c,f,g,h}	341 ± 106^{b,c}
Diaphysis: STD	340 ± 114^{d,f}	352 ± 121^{d,e,g}	341 ± 115^{e,h}
Anatomic Neck: BONE	107 ± 38	107 ± 38	107 ± 38
Anatomic Neck: STD	105 ± 37	105 ± 39	105 ± 39
Humeral Head: BONE	188 ± 51	188 ± 51	188 ± 51
Humeral Head: STD	184 ± 49	184 ± 49	184 ± 49

Table 1: vBMD [mgK_2HPO_4/cc] in three proximal humerus locations. Values sharing a common letter are significant

Location	40/90	90/140	40/140
Diaphysis: BONE	180 ± 47^{a,b}	223 ± 64^{a,c,d,e,f}	184 ± 49^{b,c}
Diaphysis: STD	179 ± 58^{d,g}	185 ± 63^{e,g}	179 ± 57^{f}
Anatomic Neck: BONE	121 ± 33	121 ± 33	120 ± 34
Anatomic Neck: STD	108 ± 38	108 ± 38	107 ± 38

Table 2: FEM stiffness [kN/mm] in two proximal humerus locations. Values sharing a common letter are significant.

Discussion and Conclusions: Higher vBMD in the diaphysis reflects cortical bone density, with the BONE kernel at 90/140 keV enhancing contrast and reducing noise. Lower vBMD in the trabecular-rich anatomical neck highlights measurement challenges. The humeral head's stability across energy pairs suggests minimal impact on vBMD. Significant diaphysis differences emphasize the need for optimized DECT protocols for cortical bone assessment, thus supporting early OA detection.

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ASSESSING DIFFERENT KINEMATIC METHODS OF STRUCTURING GAIT

Sharath Nandan[1], Amy Coyle[1], Richard Moulton[1]
[1]HAS-Motion Inc., Kingston, ON

Introduction: In gait analysis, waveform data is structured into cycles typically defined by heelstrike (HS) events detected using kinetic data. When such data is unavailable, kinematic-based methods must be used. It is vital that structuring methods are reliable as even a 10% offset in event timing can impact clinical metrics like Gait Deviation Index [1]. Here we evaluate different kinematic-based methods' ability to structure gait cycles.

Methods: Biomechanical waveforms were extracted during treadmill walking at varying speeds for 42 healthy participants in Visual3D™ (HAS-Motion Inc., ON, Canada) using a publicly available data set [2]. HS and TO [1,3,4,5], local maximums of the knee flexion/extension and the moment the hip joint surpasses the foot were identified using kinematic waveforms to structure left gait cycles. Gait cycles defined by each method were evaluated against gait cycles defined by kinetic HS using a Linear Mixed Model, with cycle times as the dependent variable, the method as the fixed effect, and the participant and trial as nested random effects.

Results: Our results show that the different kinematic methods' ability to structure gait cycles varied when the speed of walking changes (Figure 1). While most methods did not have a confidence interval (CI) that overlapped with zero, the Zeni et al method [3] that uses foot position and the method using max knee flexion/extension did.

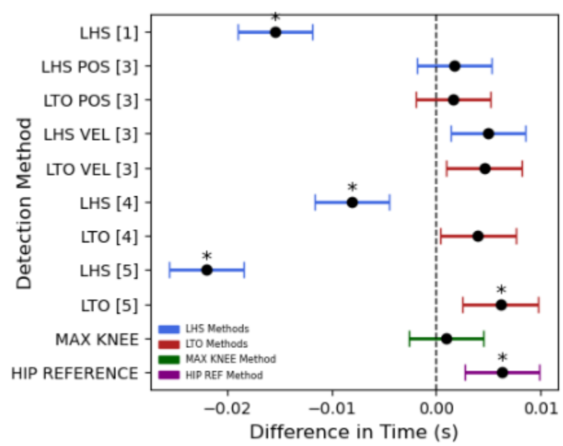

Figure 1: Mean cycle time differences (±95% CI) between kinematic and kinetic methods. Asterisks (*) indicate significance (Bonferroni-adjusted p < 0.0045).

Discussion and Conclusions: Certain kinematic-based methods can structure gait cycles comparably to kinetic-based methods, but caution should be taken to assess the methods' reliability.

References:

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COMPARING CENTER OF MASS EXCURSION IN INDIVIDUALS WITH VARYING LEVELS OF ANTERIOR REACH ASSYMMETRY

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[2]Department of Medical Science, University of Calgary, Calgary, AB

Introduction: Y-Balance Test (YBT) anterior reach (AR) asymmetry > 4cm is linked to injury [1] and while sway correlates with reach distance, asymmetry was not accounted for [2]. This study examined center of mass (COM) excursion in individuals across AR asymmetry levels.

Methods: This secondary analysis used YBT AR videos (Fs = 50Hz; Sony Handycam HDR CX) from 23 (12 males; 11 females) participants ages 18-35. Data were processed in FreeMoCap.org to compute anterior-posterior (AP)/medial-lateral (ML) COM data and joint coordinate data. Data were filtered (low-pass Butterworth, 2nd order, LP = 6Hz) and time normalized to calculate COM excursion (│max-min│) from 'start-to-reach' (SR) and 'reach-to-return' (RE) of the AR on both limbs in MATLAB® (MathWorks, 2024). Participants were grouped based on AR asymmetry (│right-left│): <1cm (G1), 2-3cm (G2), and >4cm (G3). A 2-way ANOVA examined differences in AP/ML COM excursion by limb side and AR asymmetry groups for SR/RE ($p < .05$), separately. Pairwise comparisons were conducted if significant interactions were present (IBM SPSS v.29).

Results: AP COM excursion was greater in G2 ($p = .02$) and G3 ($p = .02$) compared to G1 during the RE. A limb side by AR asymmetry interaction ($p = .01$) showed greater ML COM excursion in G1 ($p = .05$) and G3 ($p = .008$) compared to G2 for the left limb during the RE.

Discussion and Conclusions: Greater AR asymmetry relates to greater AP COM excursion, while limb differences in ML COM excursion may indicate limb dominance, influencing injury risk.

Acknowledgments: This research was funded by the internal awards to HL, SSHRC PEG award to NJC (892-2022-2024), and NSERC to SB (RGPIN-2020-05195).

References:; [1] Plisky et al (2006*). J Ortho Sport Phys Ther*; 36: 911-919; [2] Phyaklikhit et al. (2023). *Heliyon,* 15:e17318; 911-919

Table 1. Mean ± SD for AP/ML COM excursion in SR RE (R= right limb; L = left limb)

	SR: AP (cm)	SR: ML (cm)	RE: AP (cm)	RE: ML (cm)
G1 (*n* = 6)	R: 19.18 ± 13.32 L: 18.03 ± 7.36	R: 9.84 ± 5.16 L: 12.25 ± 8.42	R: 13.99 ± 5.16 L: 12.91 ± 7.10	R: 7.65 ± 3.91 L: 10.13 ± 8.07
G2 (*n* = 9)	R: 21.63 ± 8.08 L: 25.09 ± 9.98	R: 11.77 ± 4.78 L: 7.67 ± 4.82	R: 19.97 ± 10.28 L: 22.71 ± 11.16	R: 10.66 ± 5.18 L: 5.09 ± 3.67
G3 (*n* = 8)	R: 23.65 ± 10.58 L: 21.82 ± 10.17	R: 8.51 ± 4.29 L: 13.21 ± 7.26	R: 21.57 ± 6.71 L: 21.32 ± 7.68	R: 7.28 ± 2.87 L: 11.74 ± 4.99

Podium Session 6

Friday, May 23 (9:40am-10:40am)

Business and Information Technology Building (BIT) 2080

Co-chairs: Daniel Sheffield (York University) &
Jarrod Smith (University of Windsor)

9:40am-9:50am	**Joanna Misquitta** *McMaster University*	Height and Sex Effects on Two-Person Team Lifting
9:50am-10:00am	**Claire Thompson** *University of Waterloo*	Development Of an Integrated Virtual Twin Lumbar Intervertebral Disc Model for a Spinal Loading Simulator
10:00am-10:10am	**Olivia Szczepanek** *University of Waterloo*	Effect Of Cashier Workstation Design on Upper Extremity Muscular Activation and Perceived Exertion
10:10am-10:20am	**Ryan Foley** *Ontario Tech University*	Comprehensive Review of Upper Limb Strength Asymmetry: Implications For Rehabilitation, Biomechanics, and Ergonomics
10:20am-10:30am	**Mahziyar Darvishi** *University of Toronto*	Influence Of Depression Elevation on Tibial Plateau Biomechanics Following Tibial Plateau Fracture Fixation
10:30am-10:40am	**Justin Davidson** *University of Waterloo*	A Field-Ready Approach for Measuring Ground Reaction Forces and Center of Pressure During Occupational Tasks

HEIGHT AND SEX EFFECTS ON TWO-PERSON TEAM LIFTING

Joanna M. Misquitta, Ryan Chhiba, Peter J. Keir*
Department of Kinesiology, McMaster University, Hamilton, ON

Introduction: Team lifting allows two or more individuals to handle heavy loads that typically exceed an individual's lifting capacity [1]. Despite its frequent use in the workplace, current guidelines are lacking due to limited research. The purpose of this study was to examine the effects of height and sex on kinematics and loads borne by the body during various two-person team lifting tasks when team members are either matched or not matched for height.

Methods: This study was completed in two phases, a cohort of 23 female participants was followed by a cohort of 20 male participants (age 18-24 years). Each participant was paired with a height-matched (height difference ≤ 5 cm) or -unmatched (height difference ≥ 10 cm) partner and performed six manual materials handling (lifting, carrying, and transferring) tasks. Upper body motion was tracked using reflective marker-based motion capture (Motion Analysis Corporation, Santa Rosa, CA, USA). Hand forces were measured using four 6-DOF force transducers (MC3A, AMTI, Waterdown, MA, USA) affixed to each corner of a custom lifting apparatus. Joint angles and moments for the shoulder, elbow, and lower back (L4/L5) were determined (Visual3D, C-Motion, Inc., Rockville, MD, USA).

Results: For the knee-to-waist lifts, preliminary analyses show that taller participants have increased shoulder flexion for both the lift and lower phases of the task over both matched and unmatched pairings. Shorter participants tended to flex their elbows more over both conditions. Greater variability was observed for the left side in all participants. Low back angle was similar for both lifting partners over both matched and unmatched pairings, however, taller participants tended to flex more to pick up the apparatus. In the knee-to-chest lift, taller participants had greater shoulder flexion, particularly in the unmatched condition. Shorter participants were observed to have greater left and right elbow flexion in the knee-to chest lift, with lower variability compared to the knee-to-waist lift. Low back angle remained similar for both participants over both conditions. Hand forces were similar for both hands, indicating fairly even distribution of the load, with greater variability in fore-aft and lateral directions.

Discussion and conclusions: Depending on the type of lifting task, elbow and shoulder angles differ between each team member, particularly when their heights differ by more than 10 cm. Interestingly, the force applied by the left hand was much more variable than the right hand, for both lifting partners, regardless of height-matching. These observations suggest that shorter lifters adjust lifting using the elbow while taller lifters adjust lifting technique using the shoulder. The results of this study provide further evidence for the influence of height on injury risk in two-person lifting teams to formulate evidence-based guidelines for the use of team lifting in the workplace.

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DEVELOPMENT OF AN INTEGRATED VIRTUAL TWIN LUMBAR INTERVERTEBRAL DISC MODEL FOR A SPINAL LOADING SIMULATOR

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[1]Mechanical and Mechatronics Engineering, University of Waterloo, Waterloo, ON
[2]Mechanical and Materials Engineering, Western University, London, ON

Introduction: Pre-clinical testing of spinal devices is often evaluated using joint simulators to apply loading to either synthetic materials/models or cadaveric/animal tissues to measure and compare the response [1]. Yet, these engineered and organic materials have limitations, variability, and biases that can affect the efficacy for clinical translation to spine surgery. One recognized issue is the lack of the intervertebral disc (IVD) response in many implant testing methods that use synthetic materials [2]. To address this problem, there is a need to develop a method to integrate the mechanical response of the IVD in experimental testing. This capability could be achieved with the AMTI VIVO joint motion simulator (AMTI, USA), which can be optimized to replicate the effect of soft tissues using virtual constraints in the control system [3].

Aim: To develop an integrated virtual twin of the lumbar IVD using virtual constraints to replicate experimental spinal loading.

Methods: Fourteen fresh-frozen human cadaveric lumbar spinal motion segments will be prepared through removal of all posterior elements and soft tissue except IVD. Each motion segment will be mounted on the AMTI VIVO and actuated through pure moment loading protocol to measure intact displacements. The IVD will be serially sectioned and the same displacements will be applied to the deficient specimen to measure the IVD force contributions through superposition. This process will be repeated until all sections of the IVD have been removed. A custom optimization script will then be used to find ideal parameters for the virtual constraints in order to match the intact and deficient IVD force response (MathWorks, MA, USA). Model validation will compare the resulting kinematics under pure moment loading between the intact and virtual IVD.

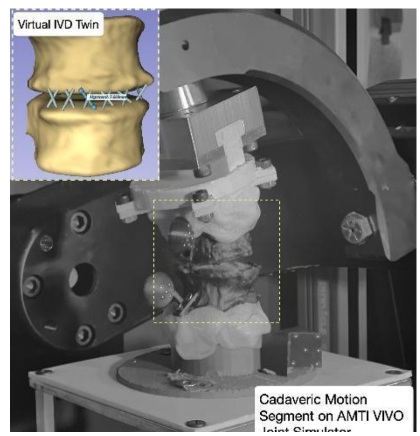

Figure 1: Experimental testing set-up with corresponding Virtual IVD Twin

Expected Results: Based on preliminary testing with pilot data, the virtual constraints have demonstrated the ability to recreate the desired mechanical response under simulated spinal loading. Ongoing work to optimize virtual constraint parameters to produce a robust virtual twin of the IVD will represent a crucial step towards soft tissue integration in spinal implant testing.

References:

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EFFECT OF CASHIER WORKSTATION DESIGN ON UPPER EXTREMITY MUSCULAR ACTIVATION AND PERCEIVED EXERTION

Olivia Szczepanek, Aidan Armitage, Alexandra Blandford, Alireza Karimi, Alan Cudlip, Clark Dickerson

Department of Kinesiology and Health Science, University of Waterloo, Waterloo, ON

Introduction: Occupational disease is common in environments that feature repetitive work. Grocery cashiers are susceptible as they often experience repetitive strain injuries due to the awkward postures and poor workstation design encountered in their work.[2] These overuse injuries are often affect the upper extremities, where up to 51% are shoulder disorders.[3] While previous research indicated high workstation height, bagging plastic or reusable bags and high workstation intensity contribute to shoulder disorders,[1] little research has been conducted on upper extremity loading related to input device use in cashiers. The purpose of this study was to 1) identify differences in postures, muscle activation strategies and perceived effort and discomfort across emulative workstation setups and 2) quantify kinematic and activation changes between planar and oblique keyboard orientations.

Methods: 40 healthy, right handed university-aged individuals (20M, 20F) completed scanning and keypad entry tasks at varying combinations of grocery workstation orientations, keypad heights and keypad angles. These included two workstation orientations (keypad in front of the participant, keypad to the right of the participant), two keypad heights (low, high) and four keypad angles (5/15/75/85° from horizontal). Activity of 16 upper extremity muscles was collected through surface electromyography (sEMG) electrodes, sampled at 1500 Hz. Upper limb kinematic data was collected using Qualisys motion capture (Qualisys AB Gothenburg, Sweden) with reflective passive markers placed on the back, chest, shoulder, arm and hand. The kinematic data was low pass filtered with a cut-off frequency of 4 Hz and used to calculate wrist flexion/extension, radial/ulnar deviation, and shoulder elevation angles. Perceived exertion was also recorded for each task condition. An analysis of variance (ANOVA) evaluated the influence of task conditions on muscle activation, upper extremity posture and perceived discomfort and exertion scores, including Bonferroni corrections.

Results: Currently available results indicate that high keypad locations led to the highest relative integrated muscle activation in all muscles (up to 250%) except FCU when the keypad position is at the side of the shoulder, while specific muscle demands shifted depending on the workstation orientation. Higher discomfort was generally reported (2-3x) for the shoulder than other body regions, and for right keypad orientations (1.5-2x).

Discussion and Conclusion: Complete findings will help delimit workstation design influences on upper extremity loading and highlight scenarios that may cause awkward postures, leading to recommendations on workstation arrangement for cashiers.

References: [1] Maciukiewicz et al. (2017). *International Journal of Industrial Ergonomics*, 59:80-91. [2] Niedhammer et al. (1998). *International Journal of Occupational and Environmental Health, 4*(3), 168–178. [3] Silva et al (2024). *Safety*, *10*(1), 21.

COMPREHENSIVE REVIEW OF UPPER LIMB STRENGTH ASYMMETRY: IMPLICATIONS FOR REHABILITATION, BIOMECHANICS, AND ERGONOMICS

Ryan C. A. Foley[1], Danny H. Callaghan[1], Garrick N. Forman[2], Jeffrey D. Graham[1], Michael W.R. Holmes[2], Nicholas J. La Delfa[1]

[1]Faculty of Health Sciences (Kinesiology), Ontario Tech University, Oshawa, ON
[2]Department of Kinesiology, Brock University, St. Catharines, ON

Introduction: The “10% rule” of handedness asserts the dominant hand is 10% stronger than the non-dominant hand [1]. Primarily derived from handgrip data [2], it is unclear if a generalised asymmetry persists across the upper limb. Understanding how strength asymmetry is affected by handedness, sex, and exertion type has important implications for ergonomics design, sports performance, and clinical rehabilitation. The purpose of this study was to systematically synthesize available evidence examining upper limb strength asymmetry.

Methods: A scoping review was used to compile literature in accordance with PRISMA-ScR best practice guidelines. Data were included for neurotypical, working-age participants (18-65 years), free of any injuries or disease, and with no lateralisation specialties. Asymmetry ratios were calculated to examine the effects of handedness, exertion side, arm region, and sex.

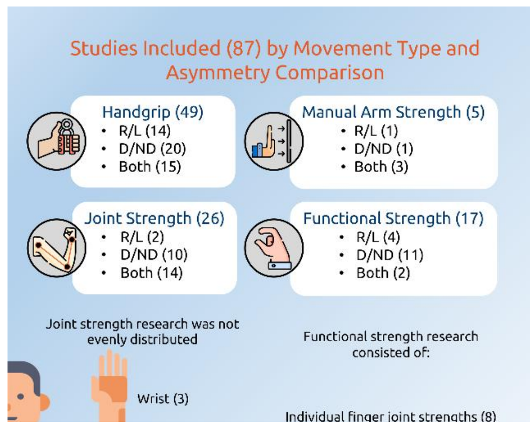

Figure 1: Counts of studies retrieved for data extraction synthesized by movement type and hand dominance classification.

Results: 10,061 results were retrieved, and 174 studies remained after title/abstract screening. 87 studies were synthesized. Results were compiled by exertion type and manner of asymmetry comparison (i.e. right/left, dominant/non-dominant). Strength differences were most frequently reported for grip exertions (n = 49). 25 studies reported other joint strength asymmetries. Overall, the right limb was 6.7% stronger than the left limb (n = 9342) and the dominant limb was 11.6% stronger than the non-dominant limb (n = 9327), though strength asymmetry varied across joints and movements (2.1% to 19.5%).

Discussion and Conclusions: This research demonstrates that the 10% rule is a good approximation for upper limb strength asymmetry, especially for hand dominance. However, several factors, including joint, movement type, and sex, can affect this relationship.

References:
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INFLUENCE OF DEPRESSION ELEVATION ON TIBIAL PLATEAU BIOMECHANICS FOLLOWING TIBIAL PLATEAU FRACTURE FIXATION

Mahziyar Darvishi[1], James Campbell[2], David Wasserstein[2], Timothy Burkhart[1]
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[2]Sunnybrook Health Sciences Centre, Toronto, ON

Introduction: Schatzker type II (split-depression fractures) tibial plateau fractures (TPF) are the account for 35% of all TPFs [1]. These involve a split and depression of the lateral tibial plateau and typically require bone defect filling and plate fixation [2]. Increased step-off height in these fractures raises articular contact pressure [3]. While, surgical correction can alter the pressure distribution, the effects of varying correction heights are not well understood.

Aim: Quantify the effects of under- and over-correction of TPF defects using a finite element model

Methods: A CT scan of a patient with a Schatzker type II TPF was imported into 3D Slicer (v5.6.1) to extract the geometry of the tibia and femur. Simulated fracture fixations were performed by including filler bone cement and tibial plateau correction heights of: i) normally corrected; ii) 2.5 mm over-correction; and iii) 2.5 mm under-correction. The models were meshed with tetrahedral elements (ABAQUS CAE; Dassault Systèmes) and homogeneous, isotropic, and linear elastic materials were assigned. A 2 mm displacement was applied to the proximal femur, while fixing the distal tibia, and the stress and strain distributions were quantified.

Results: Over-correction increased the lateral stress and displacement in the tibial cartilage) and subchondral bone (Figure 1). Under-correction shifted the stress and displacement to the medial and antero-medial regions, with the highest subchondral displacement among all models. Though closer to natural loading, it may cause medial strain and instability.

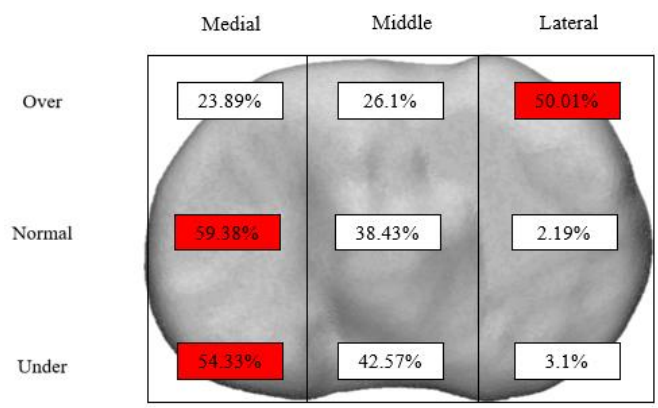

Figure SEQ Figure * ARABIC 1: Regional stress distributions across the different models. The red boxes highlight the highest percent of the total stress each model is experiencing across

Discussion and Conclusion Under- and over-correction resulted in elevated stress and displacement in different regions. This underscores the need for precise correction. Altered load mechanics and potential gait issues. may indicated a risk of joint overload, resulting in long-term complications following TPF fixation.

References:

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A FIELD-READY APPROACH FOR MEASURING GROUND REACTION FORCES AND CENTER OF PRESSURE DURING OCCUPATIONAL TASKS

Justin Davidson[1], Dennis Larson[1], Julia Li[1], Steven Fischer[1]

[1]Department of Kinesiology and Health Sciences, University of Waterloo, Waterloo, ON

Introduction: Lab-based equipment such as force plates used in "bottom-up" inverse dynamics provide a research-grade standard for measuring ground reaction forces (GRFs) and center of pressure (CoP) but are often not feasible for field use due to the dynamic nature of occupational environments. Instead, ergonomists often resort to single-task assessments that ignore worker dynamics and the accumulation of loads throughout a worker's shift [1]. Emerging technologies, such as force estimating insoles, offer a promising alternative and ambulatory method for measuring these critical kinetic variables in real-world settings. However, their validity in accurately measuring the kinetics of occupationally relevant tasks remains untested. Furthermore, to integrate these systems into inverse dynamics calculations, a novel method for estimating CoP is essential. Therefore, the purpose of this study was to establish the validity of using force estimating insoles to measure vertical GRFs and CoP during simulated occupational tasks.

Methods: Thirty-nine participants (F=19, M=20) completed four occupational tasks including floor-to-shoulder crate lifting (5.7kg), packaging (0.11kg), crate palletizing (5.7kg), and above shoulder work while wearing three compartment force estimating insoles and standing on two in-ground mounted force plates. Kinematics were captured with a Qualisys system and Theia3D post-processing. The insoles measured GRFs at three regions along the foot (medial and lateral forefoot, and heel). We developed a novel weighted algorithm that shifted the CoP relative to the foot based on the forces in each of the insole regions. Local CoP estimates were transformed to the global space and compared to force plate-derived CoPs. Vertical GRFs and CoPs from insoles and force plates were compared using correlations and RMSEs.

Results: Force insoles estimated vertical GRFs effectively with high correlations (0.77-0.99) and average RMSEs of 26.8N when compared to force plates. The weighted CoP algorithm resulted in moderate to high correlations and RMSEs ranging from 1.7-3.4cm, magnitudes below what is typically found between pressure insoles and force plate CoPs [2].

Discussion and Conclusions: The force estimating insole vertical GRFs and now CoP estimates from our novel weighted algorithm appear to reasonably predict kinetics during occupational tasks when compared to the research-standard force plates. This suggests that such insoles may be a useful method of collecting worker kinetics in the field to compute bottom-up inverse dynamics, especially when force plates are not feasible to use.

References:

[1] Veerasammy, S., Davidson, J., & Fischer, S. (2022). Multi-task exposure assessment to infer musculoskeletal disorder risk: a scoping review of injury causation theories and tools available to assess exposures. Appl. Ergon. 102; p.103766

[2] Debbi et al. (2012). In-shoe center of pressure: Indirect force plate vs. direct insole measurement. Foot. 22 (4); p.269-275

Podium Session 7

Friday, May 23 (10:50am-11:50am)

Business and Information Technology Building (BIT) 2080

Co-chairs: Olena Klahsen (University of Ottawa) &

Ryan Chhiba (McMaster University)

10:50am-11:00am	**Shaunacy Barron** *University of Guelph*	Exploring The Location Dependence of Cutaneous Reflexes in The Abductor Hallucis in Standing, With and Without Load
11:00am-11:10am	**Chloe Stiles** *University of Waterloo*	Validating Internal Density Calibration in The Proximal Humerus To Estimate Bone Stiffness for Stemless Shoulder Arthroplasty
11:10am-11:20am	**Eliza Cazzola** *University of Guelph*	Sex-Differences in Three-Dimensional Spine Angles During Seated Whole-Body Vibration Exposure
11:20am-11:30am	**Grace Collins** *University of Ottawa*	The Impact of Intravaginal Devices on Pelvic Floor Strain Among Females Who Experience Running-Induced Urinary Incontinence
11:30am-11:40am	**Emily Guzzo** *Western University*	Feasibility Of an MRI-Compatible Arthrometer for Quantifying Acl Elongation and Meniscal Deformation
11:40am-11:50am	**Taylor Tiessen** *Brock University*	Dynamic Strength Index and Countermovement Jump in Female and Male Collegiate Basketball Athletes Across a Season

EXPLORING THE LOCATION DEPENDENCE OF CUTANEOUS REFLEXES IN THE ABDUCTOR HALLUCIS IN STANDING, WITH AND WITHOUT LOAD

Shaunacy L. Barron, Hunter M.M. Gale, Tushar Sharma, Laura C. Marrelli, Ashley V. Vanderhaeghe, Leah R. Bent

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Introduction: Sensory feedback from foot sole mechanoreceptors is essential for balance, largely through cutaneous reflex modulation of muscle activity [1]. While prior research has identified location-dependent cutaneous reflex modulation in lower limb postural muscles [2], our recent work suggests cutaneous reflexes of the abductor hallucis (AH), a postural muscle important for arch support and the abduction and flexion of the big toe, may not exhibit location-dependence in a seated, unloaded position [3]. This study investigated whether weight-bearing influences AH reflex responses, hypothesizing that middle latency reflexes (MLRs) would exhibit location-dependent variations in amplitude and polarity during standing tasks with varying loads.

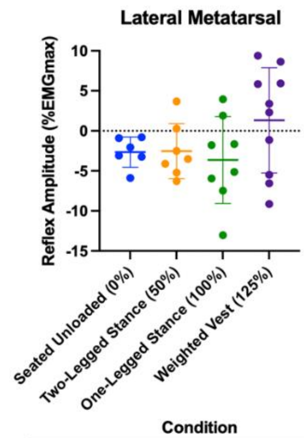

Figure 1: Reflex amplitude across the four weight conditions at the lateral metatarsal site. Each dot represents a significant response evoked at this site for each condition.

Methods: Reflex responses were recorded following non-noxious cutaneous electrical stimulation to the heel, lateral metatarsal, and big toe of the right foot sole. To activate AH, participants (10F, 2M) performed a low-level isometric big toe abduction in seated (unloaded), two-legged (50% load), one-legged standing (100% load) and one-legged standing with a weighted vest (125% load) condition. Reflexes (amplitude and polarity) were analyzed in the middle (70-120 ms) and long-latency (120-150 ms) windows. Responses were considered significant if they exceeded the mean $\pm 3\,SD$ of pre-stimulation background activity for a duration ≥8 ms.

Results: As load increased, more significant reflexes were observed. The seated unloaded condition yielded 16 significant reflexes (3/12 big toe, 6/12 lateral metatarsal, 5/8 heel), with only 1 excitatory response following heel stimulation. In contrast, the weighted vest condition elicited 23 significant reflexes (9/10 big toe, 10/12 lateral metatarsal, 4/7 heel), including 11 excitatory responses, 6 of which were evoked by lateral metatarsal stimulation.

Discussion and Conclusions: Our results suggest that an increase in load and postural demand has a significant effect on cutaneous reflex responses in the AH, with an increase in excitatory responses seen under greater loads. However, no clear location dependence was observed across stimulation sites. These findings suggest a potential polarity shift under higher postural demands, particularly following lateral metatarsal stimulation. Understanding how intrinsic foot muscles respond to varying loads may have implications for balance training and rehabilitation strategies.

References:[1] Felicetti, G. et al. (2021). J Peripher Nerv Syst. 26(1); p. 17-34. [2] Nakajima, T. et al. (2006) Exp Brain Res. 175(3); p. 514-25 [3] Sharma, T. et al. (2024). Neuroscience Meeting Planner 2024; PSTR402.21:34-6.

VALIDATING INTERNAL DENSITY CALIBRATION IN THE PROXIMAL HUMERUS TO ESTIMATE BONE STIFFNESS FOR STEMLESS SHOULDER ARTHROPLASTY

Chloe Stiles[1], Bryn Matheson[2], Steven Boyd[2], George Athwal[3], Nikolas Knowles[1]

[1]Kinesiology and Health Sciences, University of Waterloo, Waterloo, ON; [2]McCaig Institute for Bone and Joint Health, University of Calgary, AB, Canada; [3]Roth |McFarlane Hand and Upper Limb Centre, London, ON

Introduction: Stemless humeral head components are common in shoulder arthroplasty for end-stage osteoarthritis (OA) since they preserve non-diseased bone for future surgical revisions [1]. Current pre-operative clinical measures are limited in assessing bone quality in the proximal humerus region supporting the component [2]. OA can alter bone mineral density [1] in the proximal humerus compromising implant fixation. While phantom calibration is the gold standard for determining volumetric bone mineral density (vBMD) from a CT, most clinical CT images are taken without a phantom [3], requiring alternate methods for accurate vBMD across individuals [4]. Recently, an internal density calibration method has been developed that uses internal tissues as density references [3]. While this method has been validated in the spine and hip, it has yet to be validated in the proximal humerus.

Aim: To determine the correlation between vBMD from phantom and internal density calibration, using three different reference tissue combinations in the proximal humerus.

Methods: Non-pathologic cadaveric CT images (n = 42) containing a K_2HPO_4 phantom were used. The proximal humerus was segmented using a semi-automated method [5,6], and comparisons were made in a 10 mm region directly below the anatomic neck. Phantom calibration was performed by manually identifying the phantom rods in each specimen. For internal calibration [3], air (A), adipose (A), skeletal muscle (M) and cortical bone (C) were segmented. Three tissue combinations (AACM, ACM, AAC) were used to determine the combination with the lowest error bounds. Results were compared for each tissue combination using linear regression and Bland-Altman analysis.

Results: Linear regression, for each tissue combination (AACM: y= 39.96 + 0.86x; ACM: y= 28.20 + 0.91x; AAC: y= 48.62 + 0.81x) showed a strong correlation between vBMD values from phantom and internal density calibration (AACM $R^2 = 0.9$; ACM $R^2 = 0.9$; AAC $R^2 = 0.84$) and a slope not significantly different from 1 ($p < 0.001$). Bland-Altman analysis revealed the ACM tissue combination had the lowest error bounds, with a mean bias of 14.63 mgK_2HPO_4/cc and 95% limits of agreement ranging from -11.88 to 41.15 mgK_2HPO_4/cc. On average, internal density calibration overestimated phantom-based vBMD. The results of this study support the use of internal density calibration as a valid method for determining vBMD in the proximal humerus with the ACM tissue combination providing the lowest error.

References:

[1] Athwal, J Bone and Joint Surgery, 98:28, 2016
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[3] Michalski et al, Med Eng & Physics, 78:55-63, 2020.
[4] Matheson et al, Med Eng & Physics, 124:104-109, 2024.
[5] Besler et al, Med Image Anal, 67:101887, 2021.
[6] Boykov et al, Int J Comput Vision, 70:109-131, 2006.

SEX-DIFFERENCES IN THREE-DIMENSIONAL SPINE ANGLES DURING SEATED WHOLE-BODY VIBRATION EXPOSURE

Eliza Cazzola[1], Megan E. Govers[1], Ian Scagnetti[2], Michele Oliver[1,2]
[1]School of Engineering, University of Guelph, Guelph, ON
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Introduction: Individuals who operate heavy mobile machinery are exposed to whole-body vibration (WBV) which is associated with back injury with females reporting a greater incidence. Accelerometry at the input (seat) and the body is the gold standard for WBV exposure quantification as defined in ISO 2631-1. ISO 2631-1 indicates that all acceleration measurements should only deviate a maximum of 15° from the basicentric coordinate system.
To our knowledge, previous literature has not investigated if spine curvature during vertical WBV exposure results in accelerometers deviating more than 15° from the basicentric coordinate system. Given the known differences in static seated posture between males and females, we hypothesized that there would be differences in spine angles between the sexes during WBV exposure.

Methods: 51 participants (28 female, 23 male) were exposed to vertical sinusoidal vibration while sitting on a rigid seat with no backrest on a hexapod robot. Vibration conditions consisted of root-mean-square (RMS) input vertical accelerations of $0.25 m/s^2$ and $0.50 m/s^2$ at discrete frequencies of 1, 3, 5, 7, 9, 11, 13, and 15Hz. Each participant completed 3, 20-second exposures of each vibration frequency and RMS acceleration combination. Participants were asked to self-select and maintain a comfortable, upright posture while wearing a head-mounted laser to maintain a similar posture throughout the vibration exposures. Four retro-reflective motion capture markers were attached to the sacrum (S1), 3rd lumbar vertebra (L3), 6th thoracic vertebra (T6) and head (markers attached to a bite-bar). Motion capture data were sampled at 100Hz using a 10-camera (MX T160) system (Vicon Motion Systems Ltd., Oxford, UK). 3D spine angles (roll, pitch, and yaw) were calculated at each location using a cardan rotation sequence.

Results: 78% of participants exceeded the 15° ISO recommendation of pitch (anterior/posterior) rotation in at least one location. At the sacrum, 35% of participants exceeded 15° of pitch rotation (of the 35%, 66% female). A similar trend was noted at the head where 31% of all participants exceeded 15° of pitch (of the 31%, 69% female) while an opposite trend was noted at the thorax with 37% of all participants exceeding 15° pitch (of the 37%, 68% male).

Discussion and Conclusions: To our knowledge, this was the first investigation to quantify 3D spine angles during WBV exposure to determine if they exceeded 15° deviation from the ISO 2631-1 basicentric axes. This is significant because accelerations measured in the basicentric axes are used to determine health risks with the fore-aft and side-to-side axes being weighted higher according to ISO 2631-1. If accelerometer axes deviate from the basicentric axes, they may not quantify acceleration accurately. Results from this study indicate that many participants exceeded the 15° threshold consequently vibration exposure may have been quantified incorrectly. Future work should incorporate accelerometer rotation to quantify the extent to
which vibration exposure is mischaracterized to better understand injury risk for both sexes.

THE IMPACT OF INTRAVAGINAL DEVICES ON PELVIC FLOOR STRAIN AMONG FEMALES WHO EXPERIENCE RUNNING-INDUCED URINARY INCONTINENCE

Grace Collins[1], Marina Petter Rodrigues[1], Sabine Vesting[1], Linda McLean[1]
[1]School of Rehabilitation Sciences, University of Ottawa, Ottawa, ON

Introduction: Approximately 30% of females report urine leakage during exercise [1]. We hypothesized that, among female runners with running-induced urinary incontinence (RI-UI), both a pessary and a tampon used during running would reduce urine leakage symptoms and pelvic floor strain [2].

Methods: All participants provided written informed consent. Adult female runners with RI-UI attended three laboratory-based sessions over 10 days, each involving a 38-minute treadmill run with no device, then either a pessary or tampon placed intravaginally, in random order. Outcomes included levator plate length (LPL), bladder neck height (BNH), and levator hiatus area (LHA) measured through ultrasound imaging before and after each run, urine leakage severity reported throughout each run [scale 0-2 based on frequency and perceived volume] and satisfaction and perceived improvement (0-100%) reported after each run. Evaluators remained blinded to the intervention. Friedman's ANOVAs and GLMs (α=0.05) compared leakage severity and changes in LPL, BNH and LPA across sessions, respectively. Wilcoxon tests were used to compare Improvement and Satisfaction between the pessary and tampon interventions.

Results: Sixteen runners participated (age 45±11.5 years, n=12 parous, n=5 postmenopausal). Table 1 summarizes the findings. Leakage severity was lower when running with the pessary than it was the tampon and with no intervention. The pessary led to greater perceived improvement and satisfaction than the tampon. Across all sessions, after running, the LHA and LPL were larger relative to before the run while the BNH remained unchanged. Neither intervention impacted the extent of change in LHA, LPL, nor BNH observed after the run.

Table 1. Summary of findings

	Baseline	Tampon	Pessary	p	Effect sizes
Leakage Severity	0.97±0.53[a]	0.77±0.69[a]	0.25±0.28[b]	<0.01	0.70 (r)
Improvement (%)	-	38 (0-100)	85 (0-100)	0.01	0.68 (r)
Satisfaction (%)	-	50 (0-100)	88 (10-100)	0.01	0.67 (r)
LHA (diff) (cm^2)	1.71±1.36	2.03±1.57	2.57±2.12	0.15	0.13 (η^2)
LPL (diff) (mm)	3.31±3.22	3.68±4.19	4.01±3.28	0.76	0.02 (η^2)
BNH (diff) (mm)	-1.40±3.75	-1.06±3.10	-1.44±3.15	0.91	0.01 (η^2)

LHA: levator hiatal area; LPL: levator plate length; BNH: bladder neck height; diff: difference between the start and the end of the run. r: Kendall's r; η^2: partial eta squared. Values are presented as mean±SD or median (range).

Discussion and Conclusions: The pessary appears to be associated with greater improvements in urine leakage severity, higher satisfaction and greater perceived improvement in leakage than the tampon but does not appear to mitigate strain of the pelvic floor.

References:

[1] Brennand E et al. (2018). Int Urogynecol J 29; p. 497-503.
[2] Petter Rodrigues M et al. (2024). BJU Int. 134(6); p. 906-17.

FEASIBILITY OF AN MRI-COMPATIBLE ARTHROMETER FOR QUANTIFYING ACL ELONGATION AND MENISCAL DEFORMATION

Emily Guzzo[1], Emma Donnelly[1], Alan Getgood[5], Ryan Willing[1,2,3,4]

[1]School of Biomedical Engineering, Western University, London, ON [2]Western Bone and Joint Institute, London, ON [3]Lawson Health Research Institute, London, ON [4]Department of Mechanical and Materials Engineering, Western University, London, ON [5]Aspetar Orthopedic and Sports Medicine Hospital, Qatar

Introduction: Anterior cruciate ligament (ACL) injuries, often accompanied by meniscal ramp lesions, represent a significant portion of knee injuries and create joint instability. Arthrometry, the measurement of joint displacements resulting from applied loads, is challenging because bone motions cannot be directly measured. Magnetic resonance imaging (MRI) offers a means to visualize bone and soft tissue anatomy behaviours within the joint without exposure to ionizing radiation; however, the static positioning employed in MRI limits its utility for studying injuries under more provocative loading scenarios. Combining arthrometry with MRI, it is possible to apply known loads across the knee and measure the resulting displacements and tissue deformations. Using an experimental MRI-compatible arthrometer, we can apply controlled loads across the knee joints of study participants to investigate the feasibility of the device and measure the resulting bone and soft tissue displacements using an MRI.

Methods: Twenty ACL-deficient patients, including those with suspected meniscal ramp lesions, undergo passive and loaded knee MRI, with knee loads applied using an MRI-compatible pneumatic arthrometer (Figure 1). The loads applied (8 ± 1 N/m external rotation torque and 95 ± 10 N anterior tibial force) are comparable to those applied during a typical clinical examination. Both contralateral (healthy) and injured knees are imaged, and 3D reconstructions of the femur, tibia, ACL, and meniscus are generated. Boney kinematics are used to measure tibiofemoral kinematics. ACL elongation is quantified by tracking changes in ligament length relative to its slack length. Meniscal deformation is analyzed by tracking changes between the loaded and unloaded states of the centroid and dimensions of an ellipse fit to a digitization of the periphery of each meniscus, alongside width, length, and height measurements at the anterior horn, body, and posterior horn. Clinical Lachman scores are recorded and compared to the tibiofemoral kinematic results derived from the arthrometer data. All data analysis will be performed using the commercial statistics software package, SPSS (IBM, Inc.).

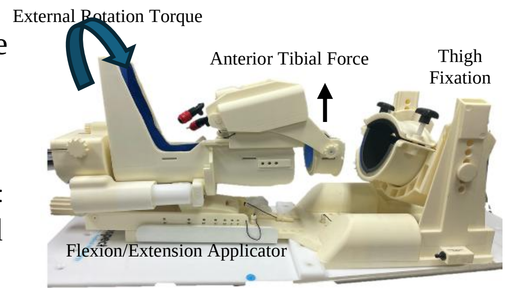

Figure 1: The Pedal Orthospect Knee Arthrometer showing the loads applied to a right knee.

Results: To date, three participants have completed testing. Preliminary findings include greater ACL elongations and meniscal deformations in ACL-deficient knees compared to healthy contralateral knees. These early findings align with expectations; however, further data collection is required for statistical analysis.

Conclusions: By provocatively displacing the joint under controlled loads, MRI arthrometry has the potential to improve the detection and grading accuracy of ACL injuries and meniscal ramp lesions.

DYNAMIC STRENGTH INDEX AND COUNTERMOVEMENT JUMP IN FEMALE AND MALE COLLEGIATE BASKETBALL ATHLETES ACROSS A SEASON

Taylor Tiessen[1], Kelly Lockwood[1], Michael Holmes[1], Nicole Chimera[1]

[1]Department of Kinesiology, Brock University, St. Catharines, Canada

Introduction: Force plates are used to assess jump performance and inform training with metrics such as dynamic strength index (DSI). DSI, calculated as Countermovement Jump (CMJ) to Isometric Mid-Thigh Pull (IMTP) peak force, indicates training emphasis: power (<0.60) or strength (>0.80)[1]. While DSI varies between sexes, limited data exist on basketball athletes. This study compared DSI, CMJ jump height (JH), and lower extremity kinematics at four timepoints across a collegiate basketball season in female and male athletes.

Methods: Collegiate basketball athletes (n=18; 12 females, 6 males) were assessed in the pre-season (TP1), early-season (TP2), late-season (TP3), and off-season (TP4). CMJ and IMTP trials were performed on bilateral force plates (1000Hz, Hawkin Dynamics). Kinematics were captured via OpenCap (Stanford University, CAL, USA) using two iPads (120Hz; Apple Inc., 7th generation). DSI, CMJ JH, and peak ankle dorsiflexion (DF), knee flexion (KF), and hip flexion (HF) angles were analyzed using repeated-measures ANOVA (p<.05, IBM SPSS v.29).

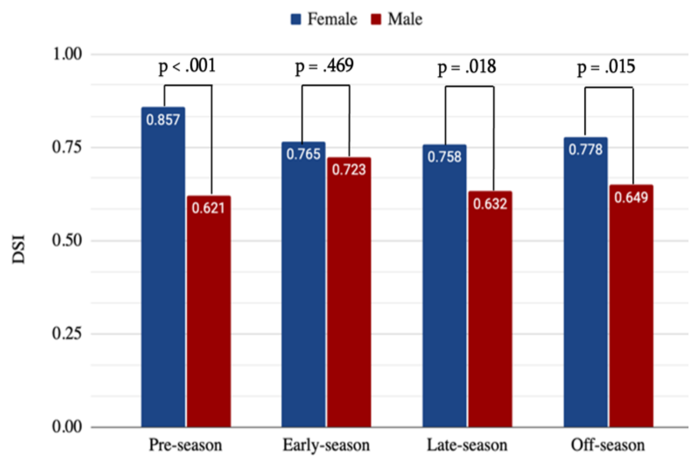

Figure 1: Mean DSI across a season for females and males.

Results: A significant time x sex interaction occurred for DSI (p=.011), with females having higher DSI in TP1 vs. TP2 (p=.002) and TP3 (p=.009), while males had higher DSI in TP2 vs. TP1 (p=.010) and TP3 (p=.040) (Figure 1). Males had significantly higher CMJ JH than females at all timepoints (p<.001). However, HF strategies differed between sexes over time, with females using greater right HF at TP3 (81.9±14.1°; p=.004) and TP4 (82.5±12.6°; p=.004) vs. TP1 (76.0±11.4°) and greater left HF at TP2 (78.3±12.7°) vs. TP1 (75.5±11.8°; p=.006). Males exhibited greater right HF at TP1 (77.3±13.1°) vs. TP2 (74.8±14.8°; p=.033) and TP3 (73.4±12.5°; p=.031). There were no significant effects for sex or time in peak DF or KF kinematics (p<.05).

Discussion and Conclusions: Male basketball players exhibited lower DSI and higher CMJ JH than females, with males using lower HF across timepoints and females using significantly greater HF at later timepoints. These results suggest females may benefit from strength, while males may benefit from explosive training across a season.

References:

[1] Sheppard J et al. (2011). An evaluation of a strength qualities assessment method for the lower body. *JASC* (19); p. 4-10.

Poster Session A

Wednesday, May 21 (7:45pm-8:45pm)

Science Building UA Atrium

HOW DO HEAD IMPACTS IN YOUTH HOCKEY VARY BASED ON PLAYER POSITION, ON-ICE LOCATION, SCORE DIFFERENTIAL, AND PENALTY KILLS?

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Introduction: Concussion incidence rates in hockey are nearly double those experienced in other contact sports [1]. Concussions in youth athletes tend to be more severe and more detrimental compared to adults, so documenting head impacts in youth sport is of critical importance. Previous research has highlighted the valuable contribution of multi-camera video systems for identifying head impacts in youth sport [2,3]. For youth hockey specifically, the frequency, mechanism of head impact, and the location of impacts on the head during game play has been quantified for an entire season [3]. However, the role that player position, on-ice location, score differential, and penalty kill status on head impact frequency and mechanism, have not been analyzed to date.

Methods: Seven GoPro Hero9 cameras placed around a bowl-shaped rink captured play for three U15 and U16 boys ice hockey teams over 21 games for the 2023-2024 season. The cameras were placed on removeable mounts with rechargeable battery packs and a fan to keep the cameras cool. Head impact occurrence and mechanism of impact determined from the video records were categorized as a function of player position (defense, forward), on-ice location (near boards, behind net, open ice), score differential, and penalty kill (PK) status.

Results: Of the 674 head impacts analyzed, 61.4% (n=414) were experienced by forwards and 38.6% (n=260) by defensemen. In terms of ice location, 62.0% (n=418) of impacts were board contacts and 37.9% (n=256) were open-ice contacts. The majority of impacts occurred in the offensive zone (45.7%; n=308), followed by the defensive zone (35.8%; n=241), and then neutral zone (18.5%; n=125). More than 77% and 87% of the impacts occurred when the score differential was ≤ 2 points, and during even strength play, respectively. In terms of the mechanism of impacts, 70% (n=471) occurred between the head and body (n=260) and head and boards (n=211).

Discussion and Conclusions: This analysis confirmed that the number and mechanism of head impacts varied based on player position, ice location, score differential, and PK status. More head impacts to forwards is consistent with the greater number of impacts seen in the offensive zones. Closer scoring games resulted in more head impacts, which may reflect more aggressive player interactions since the chance of winning is greater than when the score differential is higher. The dramatic decrease in head impacts during PK may be due to a change in focus to more conservative play by the penalty killing team. Given the considerable number of head impacts observed overall, further study is needed to quantify head impact severity and injury risk potential in youth players.

References:

[1] Canadian Institute for Health Information. (2018). Head's up on sport related brain injuries.
[2] Gyemi et al. (2022). A descriptive video analysis of helmet impact cases in North American youth football players. IJKSS, 10(3): 57-63.
[3] Roberts, E (2024). Multi-camera video analysis of head impacts in youth hockey. Masters Thesis, University of Windsor.

QUANTIFIABLE MEASURES OF EYE-TRACKING AND THEIR CORRELATION WITH THE VOMS SCORE IN CONCUSSED SUBJECTS

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[2]Department of Systems and Computer Engineering, Carleton University, Ottawa, ON

Introduction: Concussion prevalence has become a concerning issue, compounded by limitations in current assessment tools that rely on subjective, qualitative data with only moderate test-retest reliability [1,2]. The need for a quantitative tool is apparent.

Aim: The objective of this study was to determine the extent of correlation between quantifiable measures of eye-tracking and the VOMS test score in concussed subjects.

Methods: Participants completed the VOMS test before a series of saccadic visual tasks, the eye-tracking was then processed in the open-source Tracker software and run through a code that detected the eye transitions (Figure 1).

Expected Results: It is predicted that there will be a positive correlation between the eye-tracking metrics and the VOMS test score. As well, that increased measures of (ms) and error (%) will be seen shortly after sustaining a concussion and will improve throughout the recovery period (Figure 2).

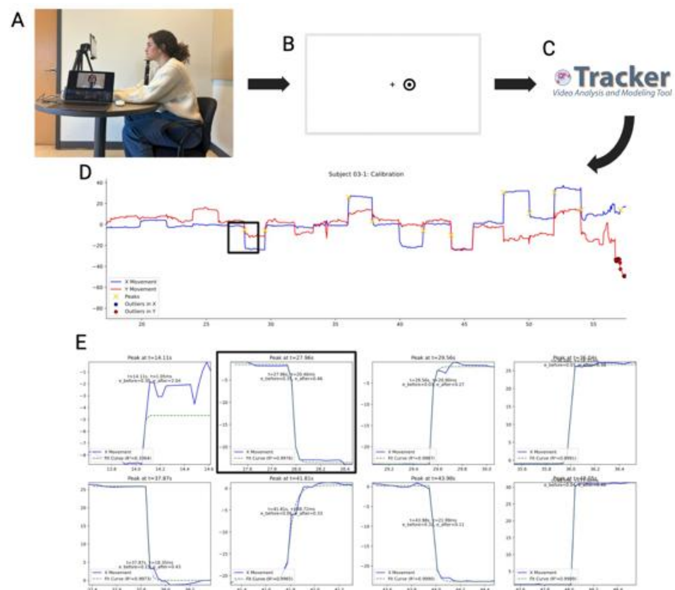

Figure 1: Overview of experimental protocol. (A) Subject setup. (B) Stimuli screen. (C) Open-source Tracker modeling tool. (D) Python code produced the x and y displacement of the eye. (E) The R^2 value, tau, start and end error were calculated for each transition.

tau

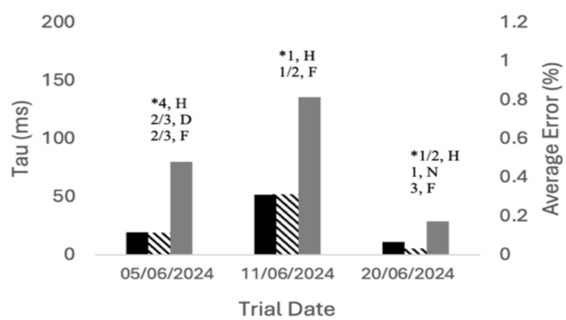

Figure 2: The average tau (ms) and error (%) values for a concussed subject during a saccadic exercise. Subject sustained a concussion on 17-02-2024, followed by 3 trial dates. The asterisk (*) represents the VOMS score, where headache (H), dizziness (D), nausea (N), and fogginess (F) are indicated on a scale from 0-10.

References:

[1] **Knell, G. et al.** (2021). Evaluation of the VOMS as a prognostic tool for protracted recovery following pediatric sports-related concussion. *BMJ Open Sport Exerc Med* **7**, e000970.

[2] **Kontos, A. P. et al.** (2021). Test-retest reliability of the VOMS tool and mBESS in US military personnel. *J Sci Med Sport* **24**, 264-268.

THE EFFECT OF KNEE BRACING ON THE BIOMECHANICS OF VOLLEYBALL-RELATED MOVEMENTS

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[2]Department of Kinesiology, McMaster University, Hamilton, ON

Introduction: Approximately 41% of all sports-related injuries are related to the knee joint, with one-fifth of these knee injuries involving the anterior cruciate ligament [1]. To minimize this risk of injury, volleyball athletes often wear knee braces as a preventative measure to reduce impact forces on the knee and enhance stability. However, there are conflicting findings regarding the effects of knee bracing on injury mitigation. Some have reported wearing a knee brace reduces injury risk by decreasing knee forces and joint motion [2] while others have found no differences in ground reaction forces when jumping and landing with or without a knee brace [3]. These discrepancies in findings may be due to differences in the tasks evaluated, the athlete population tested, and anatomical differences between men and women.

Aim: This study aims to evaluate how knee brace application impacts the biomechanics of volleyball-specific movements such as jumping, cutting, and landing in male and female volleyball players.

Methods: Twenty male and 20 female volleyball athletes will perform three commonly performed volleyball movements with and without wearing a knee brace (Genumedi E+motion Knee Sleeve, Germany) on both legs. The three movements will consist of a counter movement jump, a 45 cm drop jump and a side-cut. Each movement will be performed three times for each bracing condition, and the order of the bracing conditions will be randomized between participants. After every trial, participants will rate their perceived knee stability on a 5-point scale. Kinematic data will be collected using a 3D motion capture system to calculate the knee valgus and knee flexion angles, as well as the knee-to-ankle ratio. Ground reaction forces will be collected from two force plates to determine the peak vertical forces during the push-off and landing phases of each task.

Expected Results: It is hypothesized that wearing knee braces will reduce peak ground reaction forces and improve knee valgus angles during the jumping, landing and cutting tasks. Given the greater underlying risk of injury, it is expected that compared to male athletes, female athletes will experience larger improvements in knee joint mechanics and report greater changes in perceived knee stability when wearing braces. These findings will help determine whether bracing can reduce knee joint impact, improve movement mechanics and lower the risk of injury in volleyball athletes.

References:
[1] Sancheti et al. (2010). Br J Sport Med, 44(Suppl 1), i1-i1.
[2] Yu et al. (2004). The American Journal of Sports Medicine, 32, 1136-1143.
[3] Tuang et al. (2023). Clin J Sport Med. 33:78-89.

COMPARING FRONTAL PLANE HIP AND KNEE MECHANICS BETWEEN DROP LATERAL JUMPS AND DROP VERTICAL JUMPS

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Introduction: Aberrant frontal plane knee mechanics during drop vertical jumps (DVJ) have been linked to increased risk of non-contact anterior cruciate ligament (ACL) injury in female athletes [1,2]. Specifically, increased knee abduction angles and (internal) knee adductor net joint moments (NJMs) during landing elevate ACL forces and strain [3,4]. During landing, these aberrant frontal plane knee mechanics are thought to be driven by proximal factors in the kinetic chain, specifically increased hip adduction due to low hip abductor NJMs [1,2]. Drop lateral jumps (DLJ) are similar to DVJ with the primary difference being the direction of propulsion forces required for jumping that are expected to increase lower extremity frontal plane demands. Therefore, DLJ could elicit greater ipsilateral (to jump direction) hip abductor NJMs consequently reducing knee abduction angles and NJMs, or could be so demanding that aberrant knee mechanics are exacerbated.

Aim: To compare frontal plane hip and knee angles and moments between DVJ and DLJ tasks.

Methods: Eighteen female athletes (20.6 ± 1.2 years, 65.2 ± 11.0 kg, 1.64 ± 0.05m) performed three drop jump tasks from a 30cm box landing with each foot on a force plate before maximally jumping vertically (DVJ), laterally to the right (DLJ_R), and laterally to the left (DLJ_L). Full body-kinematics and ground reaction forces were collected. Linked segment models and inverse dynamics were used to calculate lower extremity joint angles and NJMs.

Expected Results: Preliminary results show that the ipsilateral hip abductor NJM is not greater during DLJ than DVJ (Figure 1). Knee abduction angles and knee adductor NJMs appear to be greater in both limbs during DLJ than DVJ, with ipsilateral angles but contralateral peak NJMs greatest. These results suggest that DLJ can introduce frontal plane demands that exacerbate aberrant knee mechanics associated with ACL injury risk differently between limbs. Next steps will include statistically analyzing results and investigating trunk-lower extremity mechanics to understand why ipsilateral hip abductor NJMs were not greater during DLJ as expected.

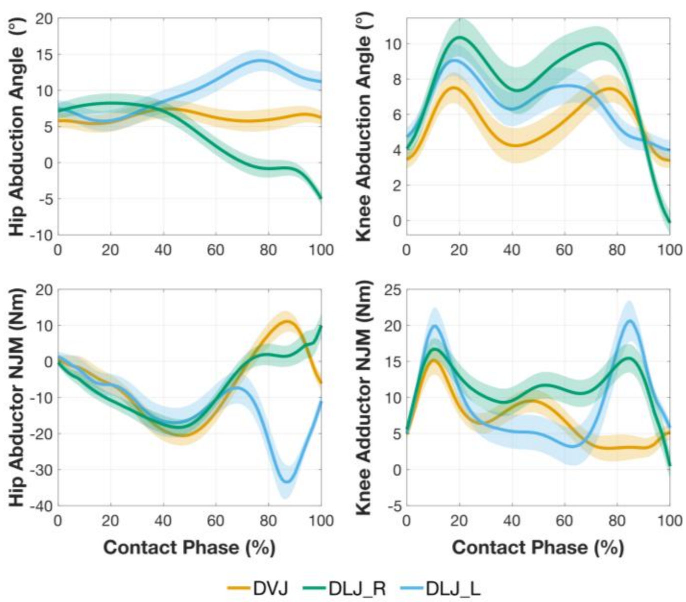

Figure 1: Mean frontal plane right hip and knee angles and moments for each task (shaded = standard error).

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ASSESSING DIFFERENCES IN HELMET FIT BETWEEN FEMALE AND MALE YOUTH HOCKEY PLAYERS

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Introduction: Concussions in youth athletes, particularly in contact sports like hockey, pose significant long-term health risks [2]. Studies have indicated a higher rate of concussions among female athletes compared to their male counterparts, although the mechanisms remain understudied [1]. Previous research on helmet fit found that, while feedback improved fit for male varsity athletes, it had less effect on females [3], suggesting that differences between male and female players may influence helmet fit. Data on psychosocial influences in hockey are lacking, but cycling studies show women, particularly those who have long hair, report more discomfort wearing helmets than men [4]. As helmet fit is important for reducing concussion severity [2], more research is needed, particularly in understudied sports such as youth hockey.

Aim: This study will examine differences in helmet fit, knowledge, and attitudes toward helmet use between male and female youth hockey players. It will also serve as a means of transferring knowledge regarding proper helmet fit to youth hockey players in the Windsor/Essex region.

Methods: Youth hockey players from six teams (3 male, 3 female) will be recruited from three communities in the Windsor/Essex region. Data collection will occur twice during the season (early and late assessments). A multidimensional helmet fit checklist [3] will be used to assess the physical fit of helmets. Participants will also complete a helmet fit knowledge survey [3] and a helmet fit behaviour survey to evaluate factors influencing helmet use, including comfort, risk perception, and social influences. Feedback on helmet fit will be provided after the early assessment, and changes in helmet fit behaviours will be assessed following the late assessment.

Expected Results: It is hypothesized that female players will demonstrate less improvement in helmet fit compared to male players, potentially due to factors such as comfort. This study is expected to identify a positive correlation between helmet fit and the level of comfort, with a higher rate of reported discomfort in female players.

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INVESTIGATING SEX DIFFERENCES IN FOREARM MOTOR UNIT PROPERTIES ACROSS CONTRACTION TYPE

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Introduction: A motor unit (MU) is one of the key functional elements linking the nervous and musculoskeletal systems, with muscle force controlled by the number of active MUs, their firing rates, and coordination. While MU analysis provides valuable insights into neuromuscular control, research on sex differences in MU properties remains limited due to the under-representation of female participants in research studies. Understanding these differences is crucial, as females tend to experience poorer motor recovery outcomes post-stroke and may require different training intensities for optimal adaptation [1]. Sex differences in MU discharge rates at submaximal contractions have been reported, however, sex differences in conduction velocity and peak-to-peak amplitude remain unclear [2]. Additionally, MU properties in forearm muscles may vary across different contraction types, specifically wrist flexion, handgrip, and a dual task involving both contractions [3]. Limited studies suggest that contraction type can influence MU recruitment and firing patterns, but the extent to which these changes occur in the forearm remains unexplored. The flexor carpi radialis (FCR) plays a key role in wrist flexion and grip force generation and may show differential activation in hybrid conditions.

Aim: To explore the influence of sex and fatigue on MU properties during submaximal wrist flexion and handgrip contractions.

Methods: Forty participants (20 males, 20 females, 18-30 years) will perform maximal voluntary contractions (MVCs) for wrist flexion, handgrip, and a hybrid contraction. Wrist flexion will occur in a neutral forearm posture against a load cell (Mark-10 Corporation, New York, USA). Grip force will be measured using a handgrip dynamometer (MIE Medical Research Ltd, Leeds, UK). The hybrid contraction will include a dual task of wrist flexion with handgrip. A 96 channel (8mm ied, 16x6 array) high density electrode grid will be placed over the flexor carpi radialis muscle. MU properties will be assessed using HD-sEMG (Novecento+, OT Bioelettronica, Torino, Italy) decomposition. Each contraction type will be randomly selected and three repetitions per condition will be completed using a sombrero contraction template to 30% and 70% MVC. Following rest, fatigue will be assessed with a submaximal isometric wrist flexion contraction (70% MVC) until failure. MU decomposition will assess conduction velocity, peak-to-peak amplitude, recruitment threshold and discharge rate during both contraction type conditions and fatigue protocol. Sex differences in MU properties will be analyzed across conditions to investigate any potential sex-related neuromuscular adaptations.

Expected Results: MU properties are expected to vary by contraction type, with wrist flexion exhibiting the highest peak-to-peak amplitude and discharge rates, followed by the hybrid condition, and handgrip. Sex differences are anticipated, with females exhibiting higher discharge rates and greater fatigue resistance, while males are expected to have higher conduction velocities and peak-to-peak amplitudes.

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THE EFFECT OF DISTRIBUTED PRACTICE ON LEARNING TO WALK WITH ROBOTIC ANKLE EXOSKELETONS

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Introduction: Robotic ankle exoskeletons can reduce metabolic energy expenditure by decreasing the biological work required of the plantar flexor muscles. To achieve these metabolic savings, the user must adapt their motor patterns to the assistance provided by the exoskeleton, for example, by reducing muscle activity [1]. To facilitate this adaptation, exoskeleton protocols often require long periods of walking (i.e., over 90 minutes), which can be taxing for the user [2]. Some evidence suggests that user adaptation is enhanced by multi-day sessions separated by extended rest periods (distributed practice) compared to a single, lengthy session with minimal rest (massed practice) [3, 4]. This suggests that distributed practice may enhance user adaptation to exoskeletons, but it remains unclear whether these improvements are due to rest or simply additional practice time.

Aim: My aim is to test if distributed practice better facilitates motor adaptation during ankle exoskeleton walking compared to massed practice, when practice time is kept constant.

Methods: Participants will be instrumented with indirect calorimetry to measure metabolic energy expenditure (Cosmed, Italy) and electromyography (EMG) sensors (Avanti, Delsys, USA) on the tibialis anterior, medial gastrocnemius, and soleus muscles to measure muscle activity. They will also wear robotic ankle exoskeletons (Humotech, USA) that apply assistive plantarflexion torques during the stance phase of the gait cycle. Participants (n=34) will be randomized into two practice designs: Massed and Distributed. The Massed group will complete two 15-minute powered walking sessions (Exo On) in one day (separated by 10 minutes), while the Distributed group will do so over two consecutive days (separated by 24 hours) (Fig. 1A). I will use a mixed ANOVA to test if differences in the magnitude and rate of adaptation are attributable to *practice design* (massed and distributed) and/or *practice time* (15 and 30 minutes).

Expected Results: I hypothesize that the Distributed group will display a greater magnitude and faster rate of adaptation for peak muscle activity and steady-state metabolic savings, compared to the Massed group. My preliminary data (n=3) may support this hypothesis (Fig. 1B,C). This proposed work could improve our understanding of how practice designs can be best structured to enhance and expediate adaptation to lower limb exoskeletons. Prioritizing rest intervals between practice sessions could reduce session duration and lead to more effective and user-friendly practice designs.

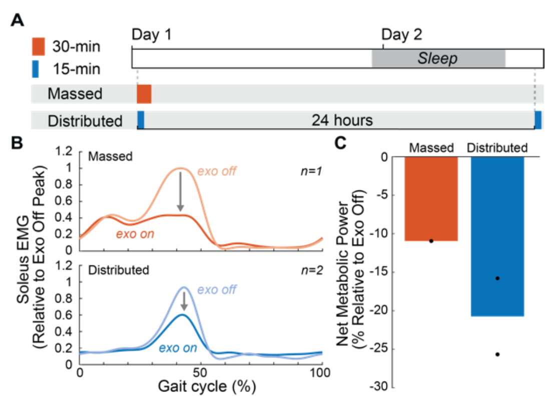

Figure 1. Practice design (A). Preliminary EMG (B) and metabolic energy expenditure (C) results after 30 mins of Exo On.

References:

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PREDICTING ENERGY EXPENDITURE IN PRESCHOOL CHILDREN USING ACCELEROMETER AND GYROSCOPE DATA

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Introduction: Accelerometers have been widely used to monitor the free-living physical activity of young children [1]. To reflect energy expenditure (EE), calibration studies are performed whereby the acceleration is tethered to a physiological metric [2]. However, it is important consider that a representative model of human movement requires that a measurement system be responsive in all three planes of motion. Human movement in free living situations is composed of both linear and angular motion; the latter is often recorded via gyroscopes. Prior research in adults suggests that coupling data from gyroscopes and accelerometers improved EE predictions [3]. This study sought to develop and compare EE prediction models in young children for prescribed motor activities and built using (1) accelerometer, (2) gyroscope, (3) and dual sensors.

Methods: Thirty-nine children (3 to <6 years) were equipped with OPAL, GT9X and GENEActiv monitors on the right hip, right wrist and left wrist. A portable metabolic unit was used to record EE. The children were asked to participate in a semi-structured activity protocol. Fifty-four machine learning models were built to predict EE (2 EE measures (METs, kJ/min) x 3 wear locations x 3 model types (random forest, linear regression, fully connected neural network) x 3 sensor configurations). Root mean squared error was used to evaluate performance.

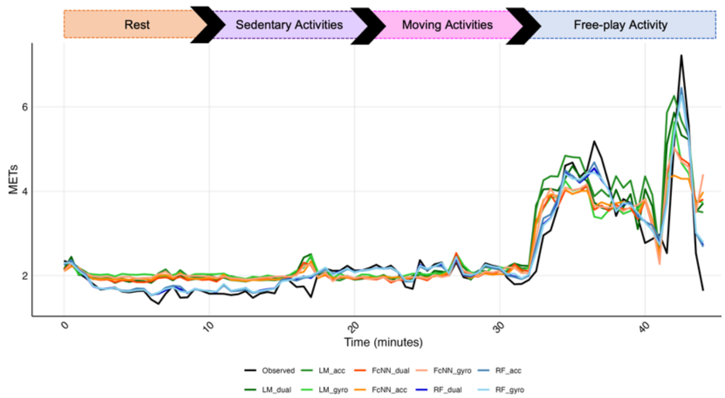

Figure 1: Representative graph of one child participating in the activity protocol.

Results: The results from the study revealed that compared to the linear regression and the fully connected neural network model, the random forest models utilizing dual sensor data consistently resulted in reduced root mean square error values, however, these improvements were minimal (e.g., Figure 1).

Discussion and Conclusions: Although we did see improvements when machine learning models were created using both accelerometer and gyroscope data, reductions were minimal. Given these observations, our recommendation is to implement accelerometer-based models in future studies.

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EFFECT OF REAR FOOT POSITION ON KICK START PERFORMANCE METRICS IN COMPETITIVE SWIMMERS

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Introduction: Swim starts play a crucial role in determining overall race performance, contributing up to 26% of total race time in certain events. The use of an adjustable kick plate on the starting block was approved for competition in 2009[1]. The kick plate permits variation in rear foot position to assist in generating greater takeoff velocity while reducing time spent on the block[2,4]. Key performance indicators used to evaluate the effectiveness of the start include entry distance (m), time on the block (s), vertical and horizontal takeoff velocities (m/s), takeoff and entry angles (deg), entry velocity (m/s) and peak force production (N); collectively providing a comprehensive assessment of start performance[3].

Aim: The objective of the study is to determine the optimal rear foot positioning of a kick start.

Methods: A quasi-experimental, repeated-measures study design using a multi-instrumental approach to simultaneously collect kinematic and kinetic data is proposed. Sixteen male competitive varsity-caliber swimmers (age 18-24 yrs), currently competing in USPORTS and self-reported as injury free will be recruited to participate. The research will be conducted using an Omega OSBl1 starting block. Participants will perform five dives using each of the three experiment foot positions, for a total of fifteen dives. Kinematic data will be collected using Theia3D (Theia Markerless Inc., Kingston, ON, Canada) with eight Sony DSCRX0M2 cameras arranged in a lateral and posterior L-pattern around the starting blocks at a sampling rate of 120 Hz. Lower-body kinematics will include torso, hip, knee and ankle joint angles (deg) and velocities (deg/s). Kinetic data will be collected using XSENSOR (Intelligent Insoles, XSENSOR® Technology Corporation, AB, Canada) pressure insoles secured to the starting block at a sampling rate of 120 Hz. Kinetic data will include total surface pressure (PSI), total force production (N), total contact area (cm^2), and center of pressure (mm). Kinematic and kinetic data will be synchronized to align time-series data for the purpose of analysis. Statistical Package for the Social Sciences statistical software (SPSS for Windows, Version 27, 20XX. Chicago, Illinois) will be used for all statistical analysis. Descriptive statistics, including means (M) and standard deviations (SD) will be calculated for all variables. Repeated measures analysis of variance will be completed to identify significant differences in kinematic and kinetic variables across foot positions. Pearson product moment correlations will be used to identify significant relationships between foot positions and key performance indicators. An alpha level of $p < 0.05$ will be used for all analyses.

Practical Implications: The findings of the study will have the potential to provide coaches and athletes with a better understanding of the contribution that rear foot positioning has on start effectiveness and overall race performance in competitive swimmers.

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EFFECT OF SPINE EXTENSION ON THE ANNULUS FIBROSUS: INVESTIGATING DANCERS' RANGE OF MOTION AND ITS IMPACT ON ANNULUS INTEGRITY

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Introduction: Low back pain (LBP) is the most common musculoskeletal issue worldwide and a leading cause of disability [1] with mechanical factors contributing to a significant proportion of cases [2]. While spine flexion has been extensively studied, extension is less understood. Dancers often perform extension-based movements and are vulnerable to LBP [3]. It is unclear whether dancers exhibit greater active range of motion (ROM) in extension than non-dancers and if this may impact the intervertebral disc and contribute to LBP.

Aim: The aims of the proposed study are two-fold: 1) quantify the spinal ROM of dancers during various dance positions; 2) using the measured ROM data determined in aim 1, assess the mechanical impact of prolonged extension on the intervertebral disc using a porcine model.

Methods: Aim 1: Dancers and age-matched recreationally active non-dancers will be recruited. Thoracic and lumbar spinal ROM will be assessed using electromagnetic sensors (Liberty, Polhemus, Colchester, VT) placed at C7/T1, T12/L1 and L5/S1. Spine motion will also be assessed in the dancers during four dance positions: backbend, cobra, arabesque, and attitude. Aim 2: ROM values for dancers and non-dancers will be scaled to a porcine model for in vitro testing. Porcine C3/C4 and C5/C6 functional spine units (FSUs) will be assigned to one of three conditions: control, cyclic (0.5Hz) extension (non-dancer ROM) or cyclic (0.5Hz) extension (dancer ROM) while also under 1000N compressive load (Criterion C34.304, MTS, Eden Prairie, MN). Following 2 hours of loading, the annulus fibrosus of each FSU will be dissected and subjected to peel (UStretch, Cellscale, Waterloo) and bilayer (Biotester, Cellscale, Waterloo) tests to evaluate interlamellar matrix integrity and holistic annular integrity, respectively. One-way ANOVAs will be used to compare ROM between dancers and non-dancers for Aim 1, and to compare mechanic properties quantified across the three loading conditions in Aim 2.

Expected Results: Aim 1: Dancers are expected to have a greater extension ROM in both the thoracic and lumbar regions due to the frequent extension-based movements involved in dance. Aim 2: cyclic extension (dancers) is expected to show increased weakening of the annulus fibrosus, marked by a decrease in peel stiffness and strength compared to control and extension (non-dancer) conditions. These findings will contribute to knowledge on mechanical LBP relevant to dancers and may support the development of prevention and intervention strategies.

References:

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USING ELECTRICAL IMPEDANCE TOMOGRAPHY AS A TOOL TO ANALYZE VENTILATION IN DIVERS

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Introduction: Lung mechanics during ventilation and breath hold in scuba divers is poorly understood. Current instruments are cumbersome and restrictive. We have begun to research the use of Electrical Impedance Tomography (EIT) for underwater use [1], since it can provide detailed breathing information in a non-invasive manner.

Hypothesis: Submersion-induced changes in respiratory biomechanics can be detected by EIT.

Methods: 3D EIT electrode belts (as per [1]) were placed circumferentially onto each participant's (N=6) chest. Breathing manoeuvres were performed out of pool (*dry*) in postures (left, right, prone, supine, fetal front/back) and subsequently in pool (1m depth, *wet*). Waveforms in regions of interest were analyzed, and tomographic images were reconstructed (Figures C&D, E&F).

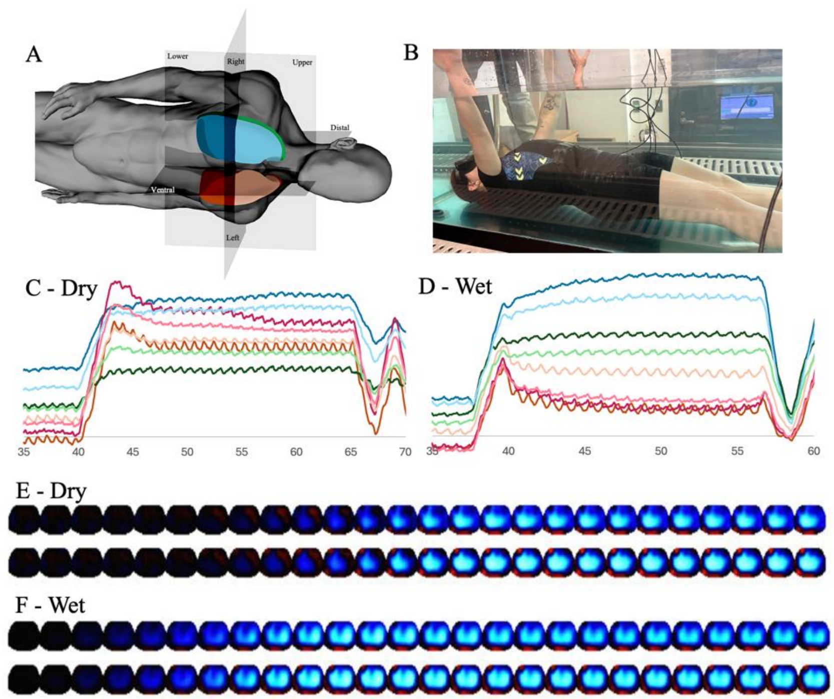

Figure: A: Illustration and B: photo of a participant. C&D: waveforms vs time (s) for an inspiratory hold. E&F: Series of tomographic sections showing upper and lower lung regions during inspiratory hold.

Results: Results demonstrate the feasibility of this method in water. We observed a clear difference between wet and dry signals. In the inspiration and breath hold, air redistributes after inspiration in wet more than in dry. We hypothesize this is due to hydrostatic pressure and larger diaphragmatic force.
We demonstrate that EIT can be used to investigate regional breathing dynamics in submerged participants. This is a promising methodology to understand respiratory biomechanics in divers.

Reference:
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HOW DO JOINT CONTRIBUTIONS TO WHOLE-BODY DYNAMICS AND MUSCLE COORDINATION CHANGE ACROSS SINGLE LEG SQUAT VARIATIONS?

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Introduction: The single leg squat (SLS) is a common exercise used in athletic training and rehabilitation; and is a unique task to examine how whole-body (WB) demands are met at the joint and muscle levels under various conditions. Changing the non-stance limb position changes trunk, pelvis, and stance-leg joint angles and moments [1], as well as the relative joint contributions to mechanical energy expenditure [2]. However, joint contributions to WB centre of mass (COM) dynamics have not yet been examined. Muscle activity is known to vary with position of the non-stance limb, but EMG analyses have been limited to the magnitude of select hip muscles at a single instant in time or averaged over phases of the task [3, 4]. Understanding how muscle coordination differs across non-stance limb positions in the context of joint-level contributions to whole-body dynamics provides insight into multi-joint control strategies and the functional role of muscles.

Aim: To quantify changes in joint work contributions to WB COM work and muscle coordination patterns across non-stance limb positions during single leg squats.

Methods: 3D kinematics, ground reaction forces (GRFs), and EMG of trunk and lower limb muscles were collected from 18 female athletes during SLS tasks with varying non-stance limb positions: front, lateral, and rear. Inverse dynamics on linked segment models enabled joint power to be quantified as the dot product of joint moment and joint angular velocity, then integrated over time to obtain joint work. WB COM power was estimated as the dot product of the GRF and WB COM velocity, then integrated over time to yield WB COM work.

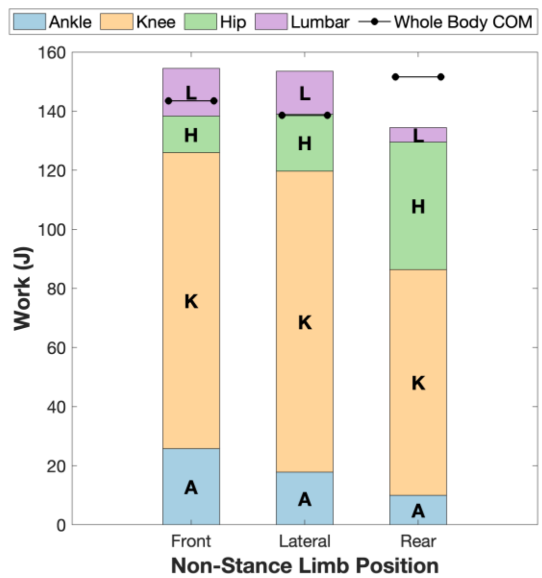

Figure 1: Exemplar participant's joint and WB COM work during ascent of SLS tasks.

Expected Results: Knee and hip joint work are expected to be the largest contributors to WB COM work in all non-stance limb positions. Preliminary results show joint work contributions to WB COM work (Figure 1) align with previous findings [2]. Interestingly, WB COM work in all non-stance limb positions do not equal the sum of joint powers quantified (Figure 1), suggesting that additional joints must be considered in our approach to joint-level contributions to WB dynamics. Muscle coordination is expected to change via alterations to the magnitude and timing of only select muscles to meet the specific demands incurred due to the non-stance limb position, opposed to the primary joint motion requirements of the task.

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THE EFFECT OF RAPID INTERVERTEBRAL DISC PRESSURIZATION ON ANNULUS FIBROSUS STRENGTH IN AN OVINE MODEL

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Introduction: Rapid intervertebral disc pressurization as a result of injury typically causes vertebral fracture. However, previous research has shown that such pressurization weakens the disc even in the absence of fracture [1]. However, this phenomenon has only been shown in a porcine model, which most closely resembles a pre-adolescent human. The purpose of this study was to examine the mechanical consequence of rapid disc pressurization on the annulus fibrosus using an ovine model. The ovine spine contains discs that more closely resemble that of an adult human.

Methods: Five ovine spines (approximately 6-8 months old) were used for the current study (Figure 1). Four lumbar functional spinal units (FSU) were dissected from each spine and randomly assigned to one of two groups: control and pressurized. Pressurized FSUs were rapidly pressurized by injection of hydraulic fluid (standard motor oil) into the anterior annulus. A pressure transducer in series with the hydraulic pump measured pressurization over time. Post-pressurization, anterior annulus samples were extracted from each disc and dissected in a 180° peel test configuration (UStretch, Cellscale) in order to quantify lamellar adhesion. Annular samples were delaminated at a rate of 0.5mm/sec. Lamellar adhesion stiffness and strength of both IVDs from rapidly pressurized FSUs and control (non-pressurized) groups were quantified.

Figure 1: Transverse view of an ovine lumbar function spine unit. Top is posterior.

Results: Pressurized samples reached a maximum pressure of 8.17 (± 2.30) MPa. Despite the high peak pressures, none of the pressurized FSUs fractured. No significant differences were observed between the pressurized and non-pressurized for peel stiffness ($p=0.433$), peel strength ($p=0.609$), and peel variability ($p=0.194$).

Discussion and Conclusions: The results of this study suggest that ovine intervertebral discs may be more resilient to rapid pressurization than porcine models. While previous studies on porcine spines have reported endplate fractures occurring at pressures as low as 7 MPa [1], as well as subsequent decreased lamellar strength, the ovine specimen in this study reached an average peak pressure of 8.17 MPa without obvious fracture or altered annular properties. The increased resistance to endplate fracture may be attributed to differences in hydrostatic pressure within the nucleus pulposus between the porcine and ovine disc.

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VALIDATION OF A WRIST-SUPPORTED GAMING MOUSE FOR REDUCING FOREARM STRAIN DURING FIRST-PERSON SHOOTER TASKS

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Introduction: The rise of competitive gaming has increased prolonged mouse use, thus elevating the risk of musculoskeletal strain due to repetitive hand and wrist motions [1]. Traditional mice often promote sustained wrist extension, which may contribute to muscle fatigue and discomfort [2]. The Vandal Pro™ (North Command, Etobicoke, ON, Canada) is a newly developed gaming mouse with a wrist support designed to mitigate ergonomic risk without sacrificing performance.

Aim: To evaluate the effects of a prototype wrist-supported gaming mouse (North Command Vandal Pro) on upper-limb muscle activity, joint posture, subjective discomfort, and aiming performance during a first-person shooter game. Comparisons will be made against a conventional gaming mouse (Logitech G502 Lightspeed™) and a conventional office mouse in both gaming and non-gaming populations.

Methods: Twenty right-handed participants (10 varsity gamers, 10 non-gamers) will complete a series of 30-second long point-and-click tasks with each mouse in AimLabs (State Space Labs, Inc., NY, USA), aiming to hit as many randomly appearing spherical targets as possible. Participants will perform three blocks of eight trials for each mouse type, in a counterbalanced order, using repeated-measures, within subject design. Muscle activity from 8–12 upper limb muscles will be recorded using a Delsys Trigno surface EMG system (Delsys Inc., MA, USA). A 10-camera Vicon motion capture system (Vicon, Oxford, UK) will track joint angles at the wrist, elbow, and shoulder. Gaming performance metrics (e.g., accuracy, reaction time) and subjective ratings of discomfort will also be collected.

Figure 1: Vandal Pro Gaming Mouse (North Command, Etobicoke, ON, Canada)

Expected Results: It is expected that the Vandal Pro will reduce upper limb muscle activity and promote more neutral joint postures, resulting in lower discomfort ratings with maintained or improved aiming performance. These findings will inform future ergonomic peripheral designs and validate the device's marketing claims with objective data.

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Electromyography Normalization for General, Dynamic and Sport Specific Tasks

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Introduction: Electromyography (EMG) is commonly used to understand muscle activations associated with a task or movement [1]. EMG magnitudes have high inter-individual and inter-sessional variability, thus creating an issue with comparison between individuals or groups [1-2]. To address this issue, researchers normalize EMG signals to a percentage of the participants maximal muscle activation effort, known as a maximal voluntary isometric contraction (MVIC) [2]. One limitation with the use of MVICs is participants are often unable to produce a true maximal contraction/activation voluntarily, thereby underestimating the value [3]. As well, when the muscle is tested in an isometric (static) position, the motor units observed will be displaced during dynamic movements thereby potentially rendering the values inaccurate [3]. These issues are demonstrated in reactive or ballistic dynamic tasks where supramaximal levels of muscle activation are observed when normalized to a participants MVIC, hindering the interpretability of the values.

Aim: Assess five different EMG normalization methods for goaltender-specific and general multiplanar dynamic tasks to understand their impact on interpretability of the EMG output values.

Methods: Elite goaltenders aged 18-29 will be recruited. Wearable EMG sensors (TrignoTM wireless system; Delsys Inc. Natick MA) will be used to collect surface electromyography over the following muscles: rectus abdominis, rectus femoris, biceps femoris, external oblique, internal oblique, gluteus maximus, gluteus medius, tensor fascia latae, and adductor longus. The participants will then perform the following five EMG normalization methods three times in a randomized order per participant: **i)** quiet laying trial; **ii)** goaltender task-oriented MVIC; **iii)** goaltender task specific maximum; **iv)** general task maximum; **v)** classic MVIC. Participants will then perform the following general tasks in a randomized order: i) level ground walking; ii) deep squat; iii) split squat; and iv) hurdle step three times. The goaltender-specific tasks will include: i) butterfly slide; and ii) reverse vertical horizontal (RVH) position (left/right). These tasks will similarly be performed three times in a randomized order. EMG Signals will be averaged across trials per participant and task. Output values will be presented as a percentage of each normalization technique for each task.

Expected Results: It is expected that the ballistic, dynamic normalization techniques will improve the interpretability of the EMG data for tasks that are congruent/similar to this type of normalization. The results of this study may provide investigators with alternative EMG normalization techniques when collecting data on dynamic sport-specific tasks.

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INVESTIGATING THE EFFECTS OF PROPRIOCEPTIVE FEEDBACK IN MOTOR SKILL TRANSFER IN VR TRAINING

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Introduction: Virtual Reality (VR) offers a promising platform for motor skill training, particularly in domains where real-world practice may be costly or risky [1]. However, how well motor learning in VR transfers to real-world tasks remains an open question—especially due to sensory mismatch in proprioceptive feedback in VR due to incongruent haptic and force cues [2]. In this study, we explore how differences in proprioceptive input during VR training impact motor learning and transfer, and whether electroencephalography (EEG) and kinematic data can help identify neural biomarkers associated with proprioceptive feedback.

Aim: To evaluate the influence of haptic feedback on motor skill acquisition in VR and its transfer to real-world tasks, and to identify both biomechanical and EEG-based markers associated with proprioceptive engagement.

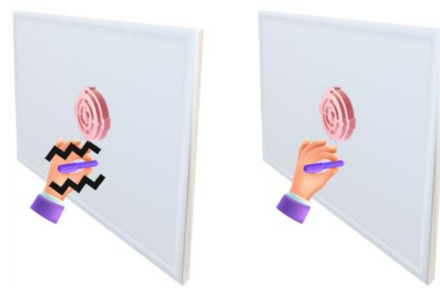

Figure 1: Experimental task in VR in which in one group the vibration substitutes the real-world haptic feeling of touching the board

Methods: 24 right-handed participants (18–35 years) will be randomly assigned to two groups: a haptic feedback group (receiving stylus vibrations upon target contact in VR) and a non-haptic feedback group. Participants perform a pointing task in VR using a stylus tracked in 3D space. After VR training, participants repeat the same task in the real world using physical targets and styluses of varying weights. EEG signals are recorded using a 64-channel cap (ANT Neuro, Hengelo, Netherlands), with event markers synchronized to stylus-screen contact. Eye movements are recorded using the Eyelink eye-tracker (SR Research, Ottawa, Canada), and arm kinematics are captured with the Optotrak Certus™ system (Northern Digital Inc., Waterloo, ON). Analysis focuses on trajectory, timing, endpoint accuracy across VR and real-world tasks, event-related potentials (ERPs), event-related desynchronization (ERD).

Expected Results: We expect the haptic group to demonstrate improved biomechanical efficiency in the real-world transfer task—evident through smoother movement trajectories and faster completion times. EEG markers, particularly in the beta and alpha bands, are anticipated to reflect differences in sensorimotor engagement between conditions.

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EXAMINING MUSCULAR FATIGUE DURING REPEATED GOLF SWINGS AND ITS RELATIONSHIP TO SKILL LEVEL

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Introduction: The golf swing requires whole-body muscular contributions to achieve high performance across several repeated iterations of swings [1]. Over the course of a practice regime or game, the repeated swings may induce muscular fatigue, which may lead to compensation from synergist musculature, and potentially alter swing kinematics [2].

Aim: The aim of this study is to evaluate muscle-specific fatigue across repeated golf swings and determine whether these fatigue responses are related to self-reported exertion level. Further, this study will examine whether muscle-specific fatigue responses are related to skill level.

Methods: Twenty male golfers with a handicap of less than 15 will be recruited for this study. Participants will be instrumented with twenty-six Delsys Avanti surface electromyographic (EMG) electrodes (Delsys, Natick, MA) (Figure 1). Maximal and submaximal (SVIC) voluntary isometric contractions specific to each muscle will be performed prior to swing trials. Participants will then perform repeated golf swings into an impact screen using their own Driver club. After each set of 20 swings, participants will be asked to rate their perceived exertion (RPE) on an 11-pt Borg scale [3]. Once participants reach an RPE ≥ 9 or reach 200 swings, the protocol will be completed. SVICs will then be repeated to assess muscular fatigue.

Figure 1: Surface EMG electrodes will be affixed to the participants bilaterally on their upper extremities and trunk.

Expected Results: The largest fatigue effects are expected in the pectoralis major, latissimus dorsi, and anterior deltoid. These muscles are responsible for the powerful swing exertions at the shoulder and largely contribute to the success of the swing [4]. Further, it is also expected that the measures of RPE will correlate with fatigue-related EMG metrics [5]. Lastly, we expect to see differences in fatigue patterns with varying skill level [6]. Results of this study will be used to design the swing protocol in a larger study evaluating muscular and kinematic variability across a fatiguing golf swing protocol.

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VALIDATING THEIA MARKERLESS SHOULDER ELEVATION ANGLES

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Introduction: Optical motion capture is widely used to analyze human biomechanics, with marker-based systems considered the gold standard [1]. Markerless approaches, such as Theia 3D (Theia Markerless, Inc., Kingston, Ontario), represent a promising alternative, reducing movement artifacts and setup time [1]. Despite its potential, limited research exists on the validity of upper extremity kinematics, specifically shoulder elevation [1]. This study aims to evaluate the validity of Theia motion capture technology for shoulder elevation by comparing joint angles to those computed from a traditional marker-based Vicon system.

Methods: Thirteen female participants were concurrently recorded using both Vicon and Theia cameras. Reflective markers were placed on key anatomical landmarks. Markerless data were collected using 8 standard Sony RX0 II cameras. Participants performed controlled humerothoracic elevation across three planes of elevation (POE): 0°, 45°, and 90°. Humerothoracic elevation angles were calculated in Visual3D for both approaches using International Society of Biomechanics standard conventions. Joint angle differences were compared using Bland-Altman plots and concordance correlation coefficients (CCC).

Results: The Bland-Altman plot demonstrated mean differences of 11.9° (95% CI: ±26.7), 5.16° (95% CI: ±19.7°), and 3.76° (95% CI: ±14.4°) for 0°, 45°, and 90°, respectively (Fig 1). CCC values were 0.79, 0.89, and 0.94 for 0°, 45°, and 90°, respectively.

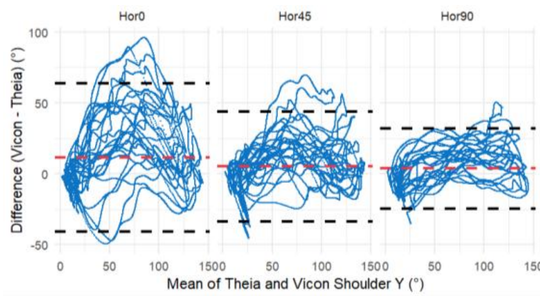

Figure 1: Bland-Altman Plot for Humerothoracic Elevation Angles Comparing Vicon and Theia 3D

Discussion and Conclusion: Theia 3D was less accurate and consistent, compared to Vicon joint angles, as the humerus was rotated from in front of the body to the side (i.e. 90° to 0° POE). Theia tended to overestimate lower humerothoracic elevation angles and underestimate higher elevation angles. When approximating joint angles with the arm in abduction (i.e. 0° POE), a 95% limit of agreement range of -40.6° to 63.9° is functionally relevant and requires further investigation. Future research will investigate other shoulder and upper extremity movements (i.e., elbow, wrist, hand), as well as session-to-session reliability. It is important to note that improvements to the upper extremity joint angle predictions are possible with further model training, so we hope these trials will further improve upper kinematics using markerless computer vision approaches.

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CAN FOOTWEAR MODIFICATIONS IMPROVE BALANCE IN INDIVIDUALS WITH PARKINSON'S DISEASE?

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Introduction: Falls are the leading cause of accidental deaths and injuries in older adults, with a significant financial burden on the Canadian healthcare system [1]. Fall risk increases in older adults with neurological disorders, such as Parkinson's disease (PD), further compromising balance control [2]. Footwear design has emerged as a potential intervention to improve balance in high fall-risk populations. Footwear has potential to improve mechanical stability and provide enhanced sensory feedback for improved balance outcomes, yet these functional characteristics are often not considered when selecting footwear. Features like stiff heel counters, thin hard soles, and higher insole friction and insole texture have shown promise in enhancing dynamic balance [3]. However, the effects of these features on balance control remain indeterminate, with limited research exploring their impact.

Aim: Assessment of dynamic balance during gait in individuals with PD while wearing footwear with varied levels of insole texture, heel counter stiffness, and midsole hardness.

Methods: Twenty (20) older adults with PD will undergo 10-meter walking tasks, wearing standardized footwear (Converse, All-Star) during medication 'on phase'. Participants will complete 7 blocks of 8 trials, one for each level (typical of common footwear, more or less than typical) of each footwear characteristic. Randomly, 2 trials of each block will be unexpected gait termination trials. Here, participants will be instructed to stop suddenly into a side-by-side stance when cued with an audio buzzer. Force plates (OR6-5-2000, AMTI Inc., MA, USA) will be used to determine foot contact and environmental force application (COP). Base of support (BOS), contact with the environment, and whole-body center of mass (COM), the central point of body mass, will be calculated from kinematic recordings (Optotrak Certus, NDI, ON, Canada). Surface electromyography (Ultium, Noraxon USA Inc., AZ, USA) of the lower limbs will be used to assess muscle activation pattern and magnitude. Intervention effectiveness with be determined by gait and stability measures of spatiotemporal characteristics, COM-COP, and COM-BOS relationships through comparisons within each footwear feature.

Expected Results: PD individuals will show balance improvements during the gait task, as greater COM-BOS and reduced COM-COP distance with the introduction of insole texture, higher heel counter stiffness, and harder midsole material as compared to their normal and less than typical level of characteristic expression. It is also expected that these same characteristics will improve balance responses during gait termination, demonstrating fewer steps before reaching a stable stance, reduced vertical loading rate peak in the steps following termination cues, and reduced COM-BOS and COM-COP distances in the lateral and anterior directions.

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COMPARISON OF NIKE PHANTOM LUNA CLEATs VS. "STANDARD" CLEAT ON LOWER EXTREMITY KINEMATICS AND KINETICS FEMALE ATHLETES

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Introduction: The majority of anterior cruciate ligament (ACL) injuries are non-contact in nature [1]. Non-contact ACL injuries often occur during dynamic movements, such as landing or cutting [2], which place significant demands on the ACL. The risk of injury is heightened in sports involving cleats, as their studded design increases friction at the shoe-surface interface which can adversely affect lower extremity biomechanics [3]. Despite extensive research on footwear engineering, the literature drastically underrepresents female athletes. As such, most cleat designs fail to reflect female-specific anatomy and risk factors [4]. This is problematic given that females are two to eight times more likely to sustain a non-contact ACL injury [5]. The Nike Phantom Luna (NPL) cleats have recently been introduced with the aim of reducing the risk of ACL tears, and other lower extremity injuries, among female soccer athletes [6]. However, there remains a lack of research on the biomechanical efficacy of these designs.

Aim: To quantify the effect of the NPL cleats on lower extremity biomechanics (kinematics, kinetics, and muscle activation patters) in female soccer athletes.

Methods: 20 Healthy participants will be recruited from the University of Toronto Varsity Women's Soccer team and surrounding high-level soccer clubs. The participants will be asked to complete a soccer-specific cutting and jumping task. These tasks will be performed while wearing both the NPL cleat and participant's personal non-NPL cleat on ground that will be covered with artificial turf. Bilateral surface electromyography data will be collected using wearable sensors (TrignoTM wireless system; Delsys Inc. Natick MA; interelectrode distance is 2.5 cm) on eight lower extremity muscles to determine neuromuscular muscle activation. Two AMTI force plates (BP600900; Advanced Mechanical Technology, Inc., Water-town, MA, USA) will measure ground reaction forces, and an eight-camera markerless motion tracking system (Miqus Hybrid Mocap; Gotenborg Sweden and Theia 3D, Kingston ON) will be used to quantify joint kinematics. Data analysis will compare the biomechanical variables between the NPL and personal cleat trials.

Expected Results: Relative to the "standard" cleat, it is expected that the NPL cleats will result in deeper knee flexion, as well as decreases in the valgus knee angle, internal rotation moment, external knee joint moment, and activation of the lower extremity muscles. In soccer, these changes are consistent with reducing the risk of ACL injuries.

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REFINING THE PHYSICAL LITERACY SCREEN: OPTIMIZING MOVEMENT ASSESSMENTS THROUGH VARIABLE REDUCTION

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Introduction: Physical literacy is a multidimensional construct that encompasses physical, psychological, and cognitive factors that contribute to an individual's ability to demonstrate movement competency across various tasks. Consistent movement competency is important for injury prevention, reflects functional movement, and encourages lifelong physical activity. Many movement screening tools, such as the Functional Movement Screen (FMS), assess individuals under a single set of demands and no not consider how movement behaviours might vary across different contexts. This single state-based approach to movement screening makes it difficult to infer more consistent, trait-like behaviours of movement competency. The Physical Literacy Screen (PLS) was designed to assess individuals under multiple states to better predict their movement competency. It evaluates key kinematic features of movement across 15 movements under three different demands: repetitions, tempo, and endurance. Since many exercises share overlapping movement patterns, there is potential redundancy within the screen.

Aim: This study aims to explore whether the Physical Literacy Screen can be streamlined by reducing the number of exercises used in the screen and still maintaining its insights into movement competency.

Methods: Physical Literacy Screen Scores previously collected on 35 varsity athletes were used for this study. The dataset was reorganized into three separate sheets based on the three control domains – Knee Control, Back Control, and Shoulder Control – so that each sheet only contained the exercises pertaining to the respective control group. A Least Absolute Shrinkage and Selection Operator (LASSO) regression was chosen and performed on each control domain – a total of 3 models were run on MATLAB. The independent variables were the scores from individual exercises, while the dependent variable was the total key feature score calculated for each control group. A 10-fold cross-validation approach was used to select the lambda value that minimized prediction error, allowing the model to shrink coefficients and exclude non-informative predictors.

Results: LASSO identified eight exercises that were strongly correlated with the total key feature scores across the three control domains. The selected exercises were lateral lunge, back lunge, jump squat, single-leg squat, one-arm plank, push-up, inverted row, and one-arm row. This streamlined version of the screen captured variation in movement control, with each exercise placing different biomechanical demands on the body, while also minimizing redundancy.

Discussion: The exercises selected by LASSO have a variation of biomechanical demands suggesting that the model selected the exercises that challenged the body the most across different planes of motion and loads. This supports the idea that movement competency is influenced by the task and a well-rounded screen should include exercises that stress different joints, patterns, and neuromuscular strategies.

EVALUATING THE IMPACT OF ECCENTRIC DAMAGE ON ABDOMINAL MUSCLE NEUROMUSCULAR CONTROL

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Introduction: The trunk muscles are important for spine stabilization [1]. When fatigued, their ability to generate force decreases leading to reduced spinal stability, increasing the risk of low-back disorders (LBD) [2] Delayed-onset muscle soreness (DOMS) occurs after repetitive eccentric contractions which lead to muscle fiber damage [3]. Previous research shows that DOMS alters erector spinae muscle recruitment [1], its effects on abdominal wall muscle (AWM) function remain unknown. Understanding AWM function under fatigue in LBD risk could help develop new strategies to reduce this risk. Bipolar surface electromyography (BP-sEMG) has been previously used to investigate trunk muscle activation, providing a measure of global muscle activity, lacking spatial resolution, leading to potential misinterpretation of muscle function [4]. High-density surface electromyography (HD-sEMG), enables the analysis of individual motor units (MU) [4], providing a more detailed understanding of trunk neuromuscular responses to DOMS, particularly in muscles with complex architecture, such as the AWM.

Aim: To assess the effects of eccentric damage, resulting in DOMS on the AWM using HD-sEMG.

Methods: Participants (n = 20) will complete two sessions. In each session, participants will be instrumented with HD-sEMG bilaterally on the rectus abdominis and external obliques. Maximal voluntary isometric contractions (MVIC) will be performed for trunk rotation, lateral bending, and forward flexion. A ramped isometric contraction (25% MVIC) to assess MU recruitment and activation topography of the muscle, and a perturbation protocol to quantify onset latency. Participants will then perform abdominal exercises until failure to induce DOMS. After 48 hours, the tests will be performed again to assess the effects of DOMS on all outcomes.

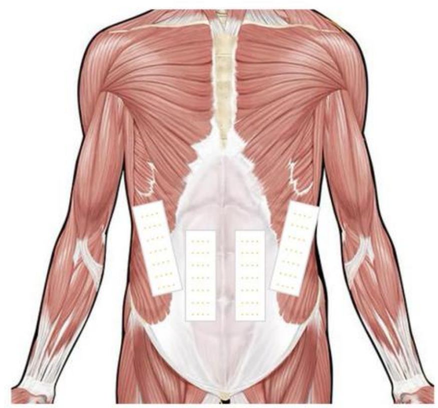

Figure 1. Placement and orientation of HD-sEMG grids on rectus abdominis and external obliques

Expected Results: It is hypothesized that DOMS will 1) decrease the force output of the abdominal muscles, 2) cause a shift in muscle activation topography away from the musculotendinous junction and 3) increase onset latency during the perturbation response.

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LUMBAR SPINE AND LOWER LIMB JOINT CONTRIBUTIONS TO WHOLE-BODY DYNAMICS DURING SINGLE-LEG LATERAL JUMPS

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Introduction: Vertical and forward jumps have been regularly studied and used to quantify lower limb athletic performance, neuromuscular function, and joint mechanics for return-to-sport assessment [1,2]. Despite its relevance to multi-directional movements and sport performance, and distinct mechanical demands from other jump directions, lateral jumps have not been well-studied. Single-leg lateral jumping requires multi-planar, multi-joint coordination and control across the trunk-lower limb linkage to achieve maximal performance. Individual joint contributions to whole-body (WB) dynamics are unknown yet may inform strategies to improve lateral jump performance.

Aim: To quantify lumbar spine and lower limb joint work contributions to WB centre of mass (COM) work during single-leg lateral jumps.

Methods: Eighteen female athletes (20.6 ± 1.2 years, 1.65 ± 0.05 m, 65.2 ± 11.0 kg) performed 3 maximum-distance single-leg lateral jumps from the right and left limbs while full-body kinematics and ground reaction forces were collected. Joint power was quantified as the dot product of the net joint moment and joint angular velocity for the lumbar spine and joints of the takeoff limb, then integrated over time to obtain joint work. WB COM power was estimated from the dot product of the ground reaction forces and COM velocity, then integrated over time to yield WB COM work.

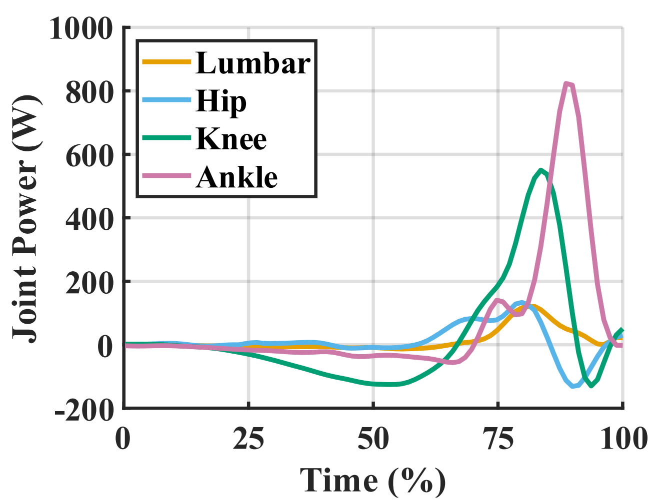

Figure 2: Joint power profiles averaged across all jumps of an exemplar subject.

Expected Results: Preliminary findings suggest the ankle dominates joint power and work contributions. For the exemplar participant shown in Figure 1, ankle joint work was 91 J compared to 16, 14, and 30 J for the lumbar spine, hip, and knee joints, respectively. This distribution differs from vertical jumps in which joint power and work is greatest at the knee [3]. In this individual, the combined work from the lumbar spine, hip, knee, and ankle (of the take-off limb) accounted for only 74% of WB COM work (204 J), indicating that a significant portion of work done on the WB COM is coming from joints of the non-takeoff limb, trunk, and/or upper limbs.

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INCENTIVIZING CHANGES IN GAIT SYMMETRY USING LOWER-LIMB EXOSKELETONS THAT MODIFY ENERGETICS

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Introduction: People prefer to walk in ways that minimize energy expenditure [1, 2]. For example, when lower-limb exoskeletons are used to alter the energetic consequences of gait, people will adapt fundamental gait parameters such as step length, rate, and width to optimize energy in real-time [2, 3]. While these gait parameters are commonly adjusted in naturalistic settings to accommodate changing task demands and terrains, gait symmetry is a near-universal feature of uninjured walking, suggesting it may be less modifiable [4]. Evidence suggests that persons post-stroke can consciously, albeit transiently, reduce gait asymmetries to lower energy expenditure [5]. However, whether gait symmetry can be implicitly, and more permanently, altered using robotic assistive devices like exoskeletons remains unclear.

Aim: The aim of my proposed study is to determine whether healthy individuals can be incentivized to modify their step-time symmetry using robotic lower-limb exoskeletons that manipulate the relationship between step time and energy expenditure.

Methods: Sixteen healthy adults will be instrumented with bilateral lower-limb ankle exoskeletons (Humotech, PA, USA) and indirect calorimetry (Cosmed, Italy) to measure energy expenditure. The exoskeletons will use a feed-forward, time-based controller that scales assistive plantarflexion torque based on real-time step-time symmetry from an instrumented treadmill (Bertec, OH, USA) (Fig. 1A). Maximal assistance will be provided when participants walk with an asymmetric gait (+10% longer right step), making it energetically optimal. We will first assess preferred step-time symmetry and metabolic cost during a 10-minute *Baseline* trial where the exoskeletons are unpowered (and symmetric gaits remain energy optimal). Next, in a 10-minute *Pre-Exploration* trial, we will turn on the exoskeletons (making an asymmetric step-time energy optimal) and assess gait adaptation. Participants will then complete an *Exploration* trial, where they will walk at seven gait symmetries (baseline, ±5%, ±10%, ±15%) for five minutes each in randomized order. An auditory metronome with alternating tones and visual feedback will be provided to assist participants in exploring the range of target asymmetries. Finally, a 10-minute *Post-Exploration* trial will assess whether preferred step-time symmetry has changed. Preferred step symmetry, as well as metabolic cost, will be compared across *Baseline*, *Pre-Experience*, and *Post-Experience* trials.

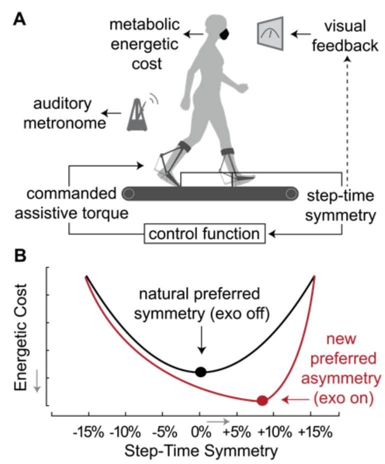

Figure 1. (A) Participant instrumentation. (B) Hypothesized energetic landscapes

Expected Results: I hypothesize that when an asymmetric gait is made energetically optimal, individuals will forgo their naturally symmetric gait to adopt an asymmetric gait (~ +10% with our controller) (Fig. 1B). If we find that preferred step symmetry can be manipulated using energetic incentives, this paradigm could have significant applications in clinical rehabilitation.

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THE EFFECTS OF LUMBAR EXTENSOR MUSCLE FATIGUE ON TRUNK NEUROMUSCULAR CONTROL DURING MEDIO-LATERAL PERTURBATIONS IN CONTACT-COLLISION ATHLETES

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Introduction: Contact and collision sports expose athletes to high-velocity impacts requiring efficient trunk stability to maintain performance and prevent injury. While most studies focus on trunk response to anterior-posterior (A-P) loading, contact-collisions in sports typically involve multidirectional forces, including medio-lateral (M-L) loading [1]. Efficient trunk neuromuscular control is needed to maintain stability in such exposures, and this can be compromised by muscle fatigue from dynamic and repetitive actions in sport. Neuromuscular control has been explored in the presence of muscle fatigue [2], however, findings from A-P perturbations should not be generalized to M-L, due to the increased complexity of the response to lateral bend moments [3]. More understanding of lumbar fatigue's effects on trunk neuromuscular control in M-L perturbations is needed.

Aim: The primary purpose of this study is to investigate the impact of lumbar extensor muscle fatigue on the ability to control one's trunk in response to M-L perturbations, through assessing kinematic and muscle activation variables. Results from this study will provide fundamental understanding of fatigue's effect on trunk control in M-L directions, providing research avenues and insights into injury mitigation and training.

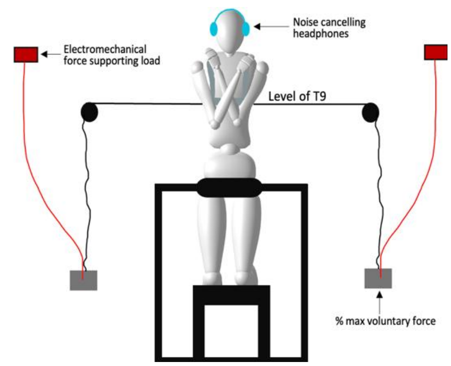

Figure 1: **M-L perturbation device. When the electromechanical force is shut off, the load will be applied to the cable, creating a perturbation to that side.**

Methods: Twenty-four contact-collision athletes (12F) will undergo a series of randomized M-L perturbations before and after a dynamic lumbar fatigue protocol. Participants will be instrumented with passive motion capture (Arqus9, Qualisys AB, Göteborg, Sweden) and electromyography, to assess trunk flexion and lateral flexion angles, muscle activation amplitude, and latency. Perturbations will be completed in a semi-seated apparatus with cables attached to the participant's chest harness, oriented through a pulley system (Figure 1). A lumbar fatigue protocol will be completed on a 45-degree Roman chair, where the participant completes sets of trunk flexion-extensions until they can no longer achieve 60% of their unfatigued maximum trunk extension strength. Post-fatigue perturbations will be completed as soon as possible after lumbar muscle fatigue has been met.

Expected Results: It is hypothesized that trunk angular displacement in the A-P direction and muscle reflex peak will be greater after lumbar muscle fatigue, but muscle reflex latency will not differ. Additionally, males will display a larger change in trunk muscle reflex peak compared to females.

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ARE BIOMECHANICAL OUTCOMES USING QUADRICEPS TENDON GRAFT IN ANTERIOR CRUCIATE LIGAMENT SURGERY RECONSTRUCTION AS GOOD AS PATELLAR TENDON?

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Introduction: The anterior cruciate ligament (ACL) controls the relative movement of the femur with respect to the tibia and is often ruptured during sports involving cutting movements, requiring ACL reconstruction (ACLR) [1]. ACLR using patellar tendon (PT) autografts is the gold standard due to superior patient-reported outcomes, knee stability, and faster return to sport [2]. However, PT grafts are linked to anterior knee pain during high flexion [2]. Quadriceps tendon (QT) autografts, a newer technique, offer comparable outcomes and return-to-sport times without the anterior knee pain associated with PT [3]. However, it is unclear whether the functional performance after ACLR using QT is comparable to PT.

Aim: To objectively compare the neuromuscular and biomechanical outcomes of ACLR using QT to PT grafts during functional movements. We hypothesize that quadriceps strength and force during movement in the QT group in comparison to control group are similar or higher than the PT group, due to lack of anterior knee pain in the QT group.

Methods: Participants: Forty young adults (20 with QT and 20 with PT) who underwent ACLR in Kingston, ON, ≥24 months prior, with a BMI 18.5–24.9. A control group of 20 matched healthy individuals will also be included. Exclusion criteria include neuromuscular disease, prior lower limb injuries, or non-QT/PT grafts. Protocol: Participants will complete AQoL, KOOS, and ACL-RSI questionnaires. Reflective markers will be placed on key bony landmarks of the lower limb. Participants will perform several activities including walking, running, single- and double-legged jumps, and sit-to-stand. They will then perform maximum voluntary isokinetic contraction testing to assess quadriceps strength using a HUMAC dynamometer. Data Analysis: Motion data of the markers (VICON, USA) and ground reaction forces (AMTI, USA) during the activities will be used as input to a musculoskeletal model in OpenSim (4.4, 2022) to estimate joint angles, moments, and quadriceps forces during various activities. Statistical Analysis: One-way ANOVA with a Tukey's post hoc test will be used to compare quadriceps strength, knee angles and moments, and quadriceps force onset timing and amplitude during various activities between QT, PT, and control groups.

Expected Results: We expect that quadriceps strength and force during gait will deviate less from the control group in the QT group compared to the PT group. Similar or better performance for the QT group would provide objective evidence for more widespread use of QT for ACLR, leading to better functionality and quality of life.

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ESTIMATING COMMUNITY-BASED PERSONAL SUPPORT WORKER SPINE MOMENTS: DEVELOPING A WEARABLE TECHNOLOGY-BASED METHOD

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Introduction: Community-based personal support workers (PSWs) experience a high prevalence of low back musculoskeletal disorders due to the taxing nature of their physical demands. To develop effective intervention strategies, there is a need to understand PSWs' physical demand exposures when providing patient care, which is inherently difficult in a patient's home. Consequently, while biomechanical models have been increasingly used, PSWs' exposures have either been captured in-field using static models (underestimating exposures) or in laboratory simulations using dynamic models (less generalizable). Having been successful (r^2=.89) for manual material handling tasks [1], artificial neural networks (ANNs) may provide means of estimating PSWs lumbar extensor moments dynamically in-field, if key variables can be measured.

Aim: To develop a wearable technology-based method for estimating lumbar extensor moments.

Methods: First, to estimate ground truth time-series L4/L5 lumbar extensor moments, a secondary analysis will be conducted on laboratory collected data captured by Ho et al. [2] to develop bottom-up inverse dynamic rigid link models in Visual3D x64 Professional™ (C-Motion Inc., Boyds, MD, USA). Models will be developed from a dataset of 20 PSWs (17F, 3M) who each performed 12 common and physically demanding tasks while tracked using a 12-camera Vicon© motion capture system (Vicon, Centennial, CO, USA) and Loadsol® pro-mlp (Novel Electronics Inc., St. Paul, MN, USA) to measure ground reaction forces (GRFs). Bilateral center of pressure will be calculated using a weighted algorithm developed by Davidson et al. [3], which will be used to apply the GRFs to the Visual3D model for kinetic analysis. A feed-forward ANN will then be developed using MATLAB® R2023a (MathWorks Inc., Natick, MA, USA) Neural Network Toolbox™ to predict the calculated time-series extensor moments (assigned output). For all tasks, time-series GRFs and thoracopelvic flexion angles, as well as the PSWs' height and weight, will be used as inputs. Data for all tasks from 14 (70%), 3 (15%), and 3 PSWs (15%) will be used to train the model, validate the model, and test the accuracy of the network, respectively.

Expected Results: Due to Matijevich et al.'s [1] success in estimating lumbar extensor moments using wearable data from 10 participants, it is anticipated that the developed ANN in this study will also be successful (r^2>.8). Therefore, the developed ANN may enable lumbar extensor moments to be predicted from data that can be collected in-field, including GRFs and thoracopelvic flexion angles. Therefore, the development of a wearable technology-based method may improve spine loading estimates in patient home environments.

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IMPROVING JOINT COORDINATION AND MUSCLE CAPACITY UTILIZATION WITH A 16-WEEK EXERCISE PROGRAM FOR SEDENTARY ADULTS

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Introduction: Analyzing coordination patterns provides information about the characteristics of human movement that cannot be solely determined from discrete metrics (e.g. peak joint angles)[1]. An inability to coordinate the multiple joint and muscle activations during a task may lead to a greater effort to complete a task and potential injury[2]. Previous cross-sectional studies show that individuals trained through repeated practice of specific movement patterns demonstrate biomechanically favourable coordination compared with untrained individuals[3], yet no prospective data show training can improve coordination and reduce the effort required to complete tasks. Muscle capacity utilization (MCU) quantifies the relative effort related to completing a task[4]. Currently it is unknown if training can improve one's lower limb coordination; it is also unknown if improved coordination reduces the relative effort needed to complete tasks.

Aim: To determine if 16 weeks of lower limb resistance training improves lower limb coordination variability and MCU from baseline in sedentary adults. We hypothesize that following training coordination variability will increase and MCU will decrease. We also hypothesize that there will be a negative relationship between coordination variability and MCU.

Methods: A prospective pre-post study design will be used and 32 healthy sedentary adults (16M and 16F) between the ages of 25-44 with no lower limb injury will be recruited. Participants will undergo 16 weeks of a supervised lower body resistance training program implemented three times per week, emphasizing quadricep strength using body weight squats and lunges. At baseline and post-training program, participants will perform peak knee extensor maximum voluntary isometric contractions (collected using a dynamometer)[4], and lunges and squats while instrumented for motion capture (Optotrak Certus, NDI, Canada) synchronized with force plates (AMTI, Germantown, MD, USA). Lower limb coordination will be quantified using angle-angle plots of the thigh and shank segments angles from motion capture. Vector coding will create a line between adjacent data points on the angle-angle plots to create coupling angles for each percentage of the task[5]. Coupling angles will be averaged throughout the task using circular statistics and the standard deviation of the mean coupling angles will represent coordination variability[6]. MCU will be quantified by dividing peak external knee flexion moment (collected using motion capture and force plates) by peak knee extensor maximum voluntary isometric contractions. Repeated-measures analysis of covariance will be used to determine the change in coordination variability and MCU pre- and post-training program after adjusting for covariates (i.e. age and body mass). Regression analyses will evaluate the associations of coordination and MCU.

Expected Results: Following the 16-week exercise program, we expect lower limb coordination variability to increase, indicating a more adaptable and flexible system. MCU will decrease following training, indicating that it takes less effort to complete these tasks.

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EFFICACY OF COGNITIVE VERSUS MOTOR + COGNITIVE TRAINING ON DUAL-TASK PERFORMANCE IN VIRTUAL REALITY: IMPACT OF AGING

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Introduction: Vision plays a critical role in feed-forward motor control and adaptive locomotion [1]. Dual-task paradigms, which combine motor and cognitive tasks, have shown that motor and/or cognitive performance declines as task complexity increases, particularly in older adults [e.g., 2]. The Simon effect illustrates how automatic spatial processing can interfere with cognitive control, highlighting the impact of dual-tasking on attention [3]. These performance declines are linked to increased risk of falls and dementia, and it is thought that shared neural resources may underlie these deficits [4]. However, training using cognitive or combined cognitive-motor tasks may improve dual-task performance, leading to more consistent and accurate performance [5]; further research is needed to optimize these interventions.

Aim: The purpose of this study is to investigate age-related performance differences between young (18-35 years old) and older adults (60-75 years old) for completion of a Simon effect task in a virtual reality (VR) environment. Then, the project will explore how training in either the cognitive or cognitive + motor task affects dual-task performance for the same Simon effect task.

Methods: In pre-training, participants will complete a VR-based Simon effect task (Vive Pro 2, HTC Corp., Taoyuan, TW). Participants will wear a head mounted VR display and navigate a virtual "sinkhole" based on direction of an arrow that appears in different locations; they must respond to the arrowhead's direction, not spatial location, creating congruent (direction matches location, i.e., right arrow on right side of scene) and incongruent trials (direction mismatches location, i.e., right arrow on left side of scene). Gait and task performance will be recorded using motion capture (OptiTrack, Oregon, USA). Participants will be randomly assigned to one of three groups. Training groups will undergo lab-based training twice weekly for four weeks (30 min/session); control group will receive no training. The cognitive group will complete online Posner tasks (PsyToolkit); the motor-cognitive group will complete various walking obstacle navigation tasks while responding to audio cues. Participants will repeat pre-training assessment post-intervention with an optional one-month follow-up for training groups to assess retention.

Expected Results: In line with previous research [e.g., 5], we hypothesize that the virtual Simon effect task will reveal significant dual-task interference (e.g., lower cognitive accuracy, slower gait) in older adults compared to young adults, and will highlight those with reduced cognitive-motor integration capacity. Following training, those undergoing motor-cognitive training will show greater improvements in dual-task performance compared to those receiving cognitive-only or no training. However, it is anticipated the cognitive-only group will outperform the controls.

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INVESTIGATING EFFECTIVENESS OF LANDMARKING TECHNIQUES IN YOUNG AND OLDER FEMALES OF DIFFERENT BODY COMPOSITIONS

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Introduction: Shoulder injury related to vaccine administration (SIRVA) may occur when a vaccine is administered into a tissue other than the bulk of the middle deltoid muscle, including the glenohumeral capsule and the axillary nerve.[1] SIRVA differs from typical symptoms of pain and swelling following a vaccine, and can include bursitis, unilateral shoulder pain, loss of range of motion within two weeks of receiving the vaccine which doesn't go away within 48 hours and often gets worse.[2] One of the main suspected risk factors for SIRVA is faulty administration of the vaccine to adjacent structures to the deltoid, potentially resulting from sparse training information surrounding injection technique. There are currently four different options of landmarking deltoid IM injection sites, which are: 1-3 fingers below the mid-acromion, a triangular injection site, the middle third of the deltoid and the mid deltoid site[3], however no consensus exists for which is best. Beyond landmarking techniques, the patient being female, having small deltoid muscle bulk, and being of a thin body build[4] increase risk of SIRVA, but little research has been done looking at the intersection of landmark placements and these and additional risk factors.

Aim: Compare effectiveness of the 4 different landmarking deltoid IM injections between young (aged 18-39) and older (aged 65 and older) females with different body compositions.

Methods: Two groups of females will act as vaccinated persons and the sample size will be determined though the G*Power software. A transverse ultrasound image of each participants' middle deltoid will be taken using a B-mode ultrasound imaging device (M-Turbo, SonoSite) to measuring the thickest part of the middle deltoid. A 3D optoelectronic motion tracking system (Qualysis Miqus, Sweden) will be used to capture the patient's upper arm segment from the elbow to the shoulder, using 3 landmark markers (acromion, medial and lateral epicondyles). 4 different landmarking techniques (described in the introduction) will be marked with a washable marker by several pharmacy trainees. A cluster of 3D markers will be placed on the marker to track needle orientation and skin location relative to the upper arm markers. Motion capture data will be processed using Matlab (v.R2024a, Matick, MA, USA) and filtered using a low pass Butterworth filter with a cutoff frequency of 3 Hz. Local coordinate systems of the upper arm will follow ISB standards (Wu et al., 2005). The ultrasound images and 3D motion capture data will be inputs to a simulation model to determine effectiveness (success) as a binary outcome (yes or no) of if needle would insert into the middle deltoid, and its linear distance from the deltoid target. Vaccine placement effectiveness and accuracy will be contrasted across landmarking method, vaccinated person age and vaccinated person body composition.

Expected Results: Older females with less muscle volume will be associated with lower success rates and lower accuracy across the different landmark placement methods. It is unknown which landmarking method will perform best.

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DOES PREFERRED RUNNING SPEED MINIMIZE COST OF TRANSPORT OR MAINTAIN EXERCISE INTENSITY?

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Introduction: Humans tend to move in ways that minimize energy expenditure [1]. For example, we prefer to walk at a speed that burns the least possible calories per unit distance traveled (minimizes the cost of transport, CoT). Surprisingly, in free-living environments, recreational runners appear to prefer a particular running speed regardless of the distance they run, and this speed is also consistent with a speed that minimizes CoT [2]. Here, speed *preference* is distinct from *performance* and reflects a speed one selects when out for a recreational run, not a competitive race. Although preferred running speeds appear consistent with energy minimization, it is possible that other coincident objectives are driving speed preferences. One leading candidate is exercise intensity, where runners may prefer a speed that corresponds with a particular level of exertion or effort (i.e. a %VO_2max, related to anaerobic threshold or critical power). Interestingly, when weight is added to the body, the running speed that minimizes CoT is expected to remain unchanged, but exercise intensity necessarily increases [3]. Therefore, in weighted running, the speed that minimizes CoT should be distinct from the speed that maintains exercise intensity, allowing us to directly test which better explains running speed preferences.

Aim: Our aim is to test if preferred running speed minimizes CoT or, instead, maintains exercise intensity using weighted and unweighted running.

Methods: We will recruit healthy recreational runners (n=12). Participants will run on a treadmill while instrumented with indirect calorimetry (K5, Cosmed, Italy) to quantify energy expenditure and a smart watch (Ultra 2, Apple) to track heart rate. Across three visits, participants will complete a $VO2_{max}$ test and run at 70%, 80%, 90%, 100%, 110%, and 120% of their preferred running speed for five minutes each, both with and without a weighted vest (10% bodyweight). We will compare runners' preferred speeds with speeds that minimize CoT and maintain exercise intensity during weighted and unweighted running using paired t-tests (alpha = 0.05).

Expected Results: One hypothesis (CoT Hypothesis) is that runners' preferred speeds will not change when weight is added, meaning CoT will continue to be minimized (despite an increase in exercise intensity) (Fig. 1). A competing hypothesis (Exercise Intensity Hypothesis) is that runners' preferred speeds will decrease when weight is added, to match an exercise intensity comparable to unweighted running (and CoT will no longer be minimized). This study will shed light on what fundamental objectives drive human locomotor preferences and behaviour.

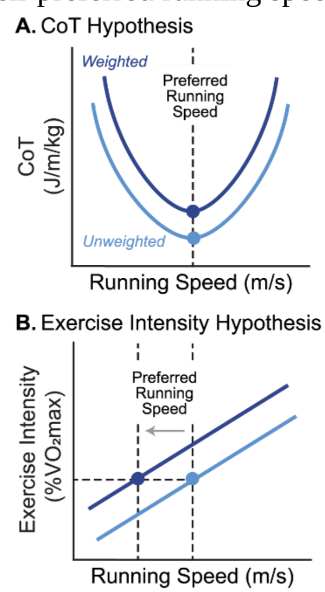

Figure 1: Study hypotheses.

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NEUROMUSCULAR DYSFUNCTION AND ATROPHY AS FACTORS IN ANTERIOR CRUCIATE LIGAMENT REINJURY

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Introduction: Following ACL reconstruction (ACLR) and successfully passing return-to-sport (RTS) criteria, the risk of sustaining a subsequent ACL injury increases six-fold compared to healthy populations [1]. Patients commonly present with inhibited activation [2], decreased strength, and reduced cross-sectional area of the quadriceps muscles of the injured limb [3] compared to the contralateral limb. Recent literature has suggested that ACLR patients have an increased susceptibility to fatigue, exacerbating muscular impairments and possibly influencing reinjury. The relative contributions of quadriceps dysfunction and atrophy to the increased risk of reinjury, however, is currently unknown.

Aim: i) to quantify kinematic differences in ACLR patients and healthy controls pre- and post-fatigue; ii) to quantify neuromuscular control in ACLR patients and healthy controls pre- and post-fatigue; and iii) to quantify the cross-sectional area (CSA) of the hamstrings and quadriceps muscles in ACLR populations and healthy controls.

Methods: Eighteen patients (9 male, 9 female) who have undergone ACLR, and 18 age-, sex-, and activity level-matched healthy controls will be recruited. Data collection will take place across two sessions. For the first testing session, quadriceps and hamstrings muscles will be imaged bilaterally via ultrasonography (GE Vivid E9 Imaging System, GE Medical; Horten, Norway) and CSA will be measured by two independent raters. For the second testing session, participants will perform a joint angle reproduction (JAR) task to two target knee flexion angles (15º and 75º), followed by a dynamic exercise fatiguing protocol. Lower extremity kinematics will be quantified pre- and post-fatigue using eight inertial movement units (IMUs; Xsens, Enschede, NL), and electromyography (EMG) sensors (Delsys Inc.,Natick, MA) will be placed bilaterally over the quadriceps muscles to monitor the mean power frequency (MnPF) of the EMG signal. A 10% decrease in MnPF from baseline will indicate the onset of neuromuscular fatigue. Once fatigued, the participants will immediately reperform the joint angle reproduction task. Neuromuscular function will be quantified pre- and post-fatigue using the frequency content (i.e., latencies) of limb accelerations collected via IMUs during the JAR task, in addition to measures of relative and absolute error.

Expected Results: It is expected that the ACLR patients will have decreased quadriceps CSA, greater fatigue-induced kinematic changes, and reduced measures of neuromuscular control. Deficits in CSA and neuromuscular control are both expected to contribute significantly to fatigue-induced kinematic changes.

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COMPARING REAL-TIME JOINT ANGLES FROM AN IMU-BASED MOTION CAPTURE SYSTEM AND A DIGITAL HUMAN MODEL

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Introduction: Accurate joint angle measurements are important for conducting ergonomics risk assessments. To facilitate a proactive approach, kinematic data from inertial measurement units (IMUs) can be streamed into digital human modeling (DHM) software (e.g. Process Simulate [PS]) to offer real-time analyses of ergonomic risk [1]. However, differences in how these systems report their joint angles may impact the accuracy of biomechanical analyses. This pilot study aims to compare joint angle outputs directly from an Xsens IMU system vs. a DHM postured with real-time Xsens IMU motion data.

Methods: Two participants performed a dynamic shoulder elevation task at 3 different plane of elevation angles (0°, 45°, and 90°), as well as trunk, neck and elbow flexion with an Xsens Awinda system used to track full body kinematics. Xsens sensor data were streamed into PS to drive participant-scaled DHMs using both the joint angle (JA) and hand location (HL) posturing methods. DHM angles were compared to the ISB angles calculated within the Xsens MVN software, with root mean square error (RMSE) used to quantify differences between models.

Results: For shoulder elevation, the HL method consistently showed greater errors across 0°, 45° and 90° abduction levels (8.80°, 5.67°, 24.1°, respectively), compared to the JA method (6.42°, 5.19°, 11.4°, respectively). For neck and elbow flexion, RMSEs were 8.44° and 13.2° for JA, whereas 13.3° and 26.1° for HL, respectively. Although for trunk flexion, RMSE for JA and HL were 9.77° and 6.27°, respectively.

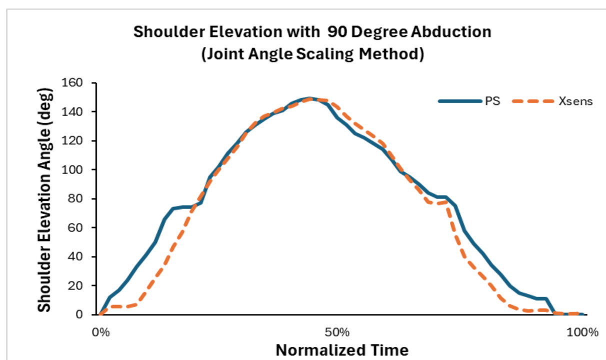

Figure 1: Shoulder Elevation Angles with 90-degree Abduction with JA Scaling Method

Discussion and Conclusion: The results showed close alignment between PS and Xsens, particularly at lower abduction angles. Larger errors were observed at higher flexion angles. The differences were most prominent at 90° abduction and during elbow flexion. Overall, the JA method provided more consistent results, while posturing by matching hand locations (HL) had higher variability, especially in tasks involving larger joint ranges. These results show relatively good alignment between DHM and actual joint angles that can be used to conduct initial posture-based screening for proactive and virtual DHM analyses.

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VALIDATION OF INTERNAL CALIBRATION METHODS FOR CT-BASED MUSCLE DENSITY ANALYSIS IN SHOULDER OSTEOARTHRITIS PATIENTS FOLLOWING ARTHROPLASTY

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Introduction: Computed Tomography (CT) remains widely used due to its accessibility and practicality in clinical settings. CT can be used to assess muscle cross-sectional area and infer density using Hounsfield Units (HU) [1,2,3]. Many CT scans are performed for unrelated clinical reasons (e.g., chest or abdominal imaging) and repurposing these "opportunistic" scans for muscle density analysis could provide valuable insights [1,2,3]. However, there are inconsistencies of current CT-based approaches using HU values that are influenced by factors like scanner settings, object positioning, and beam hardening artifacts, making them inconsistent across different machines and protocols [1]. Calibration phantoms (external devices used to standardize density measurements) are not typically included in routine clinical CT scans, limiting their utility for precise muscle density analysis [1,2,3]. The development of internal calibration methods for CT enhances its reliability and makes it a more viable option for muscle density analysis when other imaging technologies (eg. MRI or DXA) are not available or feasible [1,2,3].

Aim: The objective of this study is to validate the internal calibration methods using reference phantom calibration to assess density of the rotator cuff muscles (supraspinatus, infraspinatus and subscapularis) of patients with shoulder osteoarthritis who have undergone arthroplasty surgery

Methods: Clinical CT scans from two surgeons for the same cohort of patients who have undergone shoulder arthroplasty for end-stage OA will be assessed. The CT images will be used in Materalise Mimics software to create a 3D model mask of the supraspinatus, infraspinatus and subscapularis. The model will then be calibrated using a reference phantom while testing combinations of internal calibration regions of interest (e.g., air, blood, bone, muscle, adipose) to quantify each muscle's density.

Expected Results: We expect that the internal calibration method which uses two regions of interest, air and adipose or blood, to yield accurate muscle density values (< 1% error) when compared with the reference phantom [1]. The muscle density values derived from the internal and reference phantom calibration methods should be highly correlated [1].

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USING THE ABOVE-SHOULDER TOOL TO ESTIMATE MAXIMUM ACCEPTABLE DUTY CYCLES

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Introduction: Awkward working postures and vibration consistently demonstrate significant associations with WMSDs of the shoulder [1]. Both commonly occur in overhead automotive assembly processes, like when using an electric drill to install automotive parts under a vehicle. A frequently used ergonomics intervention involves restricting the time spent with the hands above-shoulder level to a certain percentage of the total work cycle time. In many cases, this is the same as duty cycle, which represents the portion of a task cycle during which effort is exerted. Despite widespread use of duty cycle limits, most existing ergonomic tools are ineffective for guiding ergonomists and industrial engineers, as they cannot directly estimate the Maximum Acceptable Duty Cycle (MADC) for a specific overhead task. Rempel & Potvin [2] recently developed the Above-Shoulder Tool to estimate maximum acceptable manual arm forces for above-shoulder work.

Methods: Using the Arm Force Field (AFF) method [3], Maximum Acceptable Duty Cycle (MADC) is calculated from force requirements, manual arm strength of a 25th percentile female, and scaled by factors for subacromial impingement and repetitive exertion. A case study tested this model in the sagittal plane relative to the shoulder. K-means clustering (k=6) was used to identify regions within the reach envelope where MADC values clustered, and force demands were increased until only one overhead work zone met a 33% duty cycle threshold.

Results: The K-Means clusters reflect known ergonomic risk patterns, identifying reach zones where overhead postures and high joint moments are most likely to contribute to fatigue and injury. An optimal zone for overhead work was identified (Figure 1, dark blue), where limiting overhead work to 33% of the cycle would be acceptable for a 5 N upward push. Overhead tasks performed in this region may be more sustainable compared to other overhead task locations.

Discussion and Conclusions: This study proposes a novel method to estimate MADCs based on hand location within the reach envelope. Future research will aim to experimentally validate these thresholds.

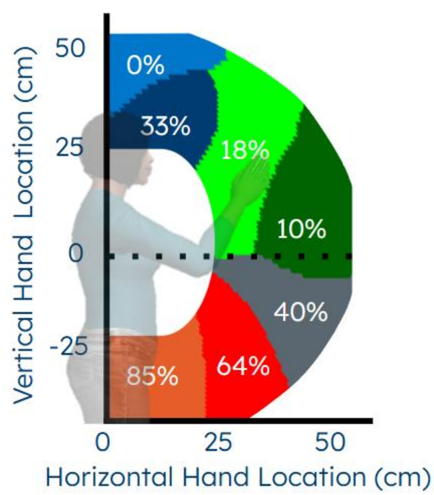

Figure 1: Median MADC by Cluster

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THE POWER OF FLEX: EFFECT OF A FLEXED BOOT ON MARKERS OF SKATING EFFICIENCY IN ICE HOCKEY PLAYERS

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Introduction: Evolution of the current hockey skate boot has been primarily driven by the concept of light and stiff; however, there is no scientific evidence supporting the relationship between boot design, material properties and optimal skating mechanics. Preliminary research investigating skating mechanics suggests that the primary motion required for efficient skating mechanics is forward flexion of the ankles and knees. Equipment manufacturers are challenged with boot designs and material properties that limit forward flexion.

Aim: To investigate how a flexible boot design can affect select markers of skating efficiency (stride length normalized to leg length of the participant (SL;-), stride frequency (SF;strides/s), push time (PT;s), and recovery time (RT;s) during forward skating on a skating treadmill.

Methods: A quasi-experimental research design was conducted to contrast four markers of skating efficieny (SL, SF, PT,RT). Five competitive male hockey players were recruited based on skate size and treadmill experience. Participants completed three skating trials of forward skating on a skating treadmill executed in two skate boot conditions (flexed and rigid). Skate blades profile and sharpening were held constant and the participants tied skates to their preferred lace tension for game-like conditions. Ten consecutive steady-state strides were selected from each skating trial and boot condition, a total of 60 strides per participant. Boot flex data were collected using an electro-goniometer (Ultium Goniometer SmartLead, NORAXON®, AZ, USA) secured to the skate boot tongue, sampling at 2000 Hz, to measure boot flex angle (deg) during static and dynamic skating trials. Kinematic data were collected using an Inertial Measurement Unit (IMU) motion capture system (Xsens AWINDA, Movella™, NV, USA), consisting of 17 wireless IMUs secured to the body sampling at 60 Hz, to measure and describe lower body kinematics including ankle, knee and hip joint angles (deg) and velocities (deg/s). Specific kinematic data were used to calculate the four markers of skating efficiency (SL, SF, PT, RT). Paired comparison t-test were performed to determine if significant differences existed in the four markers of skating efficiency between boot conditions ($p < 0.05$). Pearson Product Moment correlations were conducted to investigate the relationship between SL/SF and PT/RT ($p < 0.05$).

Results: During static trials, the flex boot provided a greater range of motion in flexion-extension in comparison to the rigid boot. During skating trials, ROM of the ankle utilized by players were similar across boot conditions. However, the differences in ROM became more pronounced as the motion traveled up the kinematic chain; there were more noticeable decreases in ROM at the hip and knee joint skating in the flexible boot compared to the rigid boot. Significant differences in push time (s), recovery time (s), as well as minimum flexion angles at the hip and knee joints (deg) were revealed between boot conditions ($p < 0.05$). Significant relationships were also revealed between push time and recovery time ($p < 0.05$).

Practical Implications: Outcomes suggested that the flex boot has the potential to enhance skating efficiency by providing an opportunity for greater ankle flexion and reducing the demands of knee and hip joint flexion angles while maintaining the same skating velocity. Examining the impact of boot design on these variables offers valuable insights into innovations in boot design to support skating efficiency and technical performance.

INTRALAMELLAR MATRIX STRENGTH OF THE ANNULUS FIBROSUS FOLLOWING VERTEBRAL FRACTURE

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Introduction: Endplate fractures are more common in adolescents than adults due to the unique biomechanical properties of the developing spine [1,2]. Incomplete fusion of the apophyseal ring combined with high hydrostatic pressure within the nucleus pulposus make the endplate vulnerable to injury [3,4]. Such fractures seem to predispose the spine to disc disorders later in life [5] by weakening the annulus. Maintaining annular strength is critical in preventing disc disorders because it helps resist protrusion or herniation of the nucleus pulposus. While previous studies have examined the effects of fractures on the interlamellar matrix [6,7], or adhesion between layers of the annulus, it remains unclear whether endplate fractures impact the intralamellar matrix; the matrix within a single annular layer.

Aim: The aim of this study is to quantify the interlamellar matrix and intralamellar matrix properties of the annulus fibrosus following vertebral fracture.

Methods: Porcine cervical spines will be used for the current study. Following overnight thawing, spines will be dissected into C3/4 and C5/6 motion segments (vertebra-disc-vertebra). Each specimen will undergo a preconditioning compression protocol of 300 N for 15 minutes. Segments will then be randomized into one of two conditions: experimental: segments will be compressed until failure at 1.0 mm/s using a material testing system (MTS C43, Eden Prairie, MN), and control: specimens will be unloaded (excluding preconditioning). Following compressive loading, two anterior annular samples will be dissected from each disc and mechanically tested: 1) Single-layer samples will be tested in tension at 2% strain/sec (BioTester, CellScale, Waterloo ON, Canada) until failure to quantify intralamellar matrix properties; 2) Multilayer samples will be delaminated using a 180° peel test at a rate of 0.5mm/sec (UStretch, CellScale, Waterloo, ON, Canada) to quantify interlamellar matrix properties. One-way ANOVAs will be used to compare annular mechanical properties between control and experimental (fractured) FSUs.

Expected Results: Previous studies have documented decreased annular adhesion (interlamellar matrix) strength following fracture. Therefore, it is also expected that the intralamellar matrix will also be negatively affected by the fracture exposure.

References:

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INJECTING A NUCLEUS PULPOSUS HYDROGEL INTO THE INTERVERTEBRAL DISC COMBINED WITH ANNULAR CLOSURE TO ADDRESS DISC HEIGHT LOSS

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Introduction: Low back pain (LBP) is a primary cause of disability, impacting the quality of life, mobility, and productivity of adults[1]. Intervertebral disc degeneration (IVDD) accounts for an estimated 40 % of all LBP cases[2]. Currently, there is no established method for repairing annular defects to reduce the re-herniation rate and limit the progression of disc degeneration[3].

Aim: This study aims to evaluate the effectiveness of combining nucleus pulposus hydrogel injection with annular closure in preventing re-herniation, compared to hydrogel injection alone. This research focusses on assessing the additional benefits of annular closure in enhancing the long-term stability of the spinal disc.

Methods: Six-month-old porcine spines will be obtained from a common source, stored at −20 °C, and thawed at room temperature for 12 hours before testing. Two functional spine units will be dissected from each spine (C3/4 and C5/6) and will be randomly assigned to one of three groups: (1) hydrogel injection with annular closure, (2) hydrogel injection only, and (3) control. Specimens will be loaded under 1200N compression and simultaneously cyclically rotated in flexion-extension at 0.5Hz for 3000 cycles (Figure 1). Pre and post disc height will be determined from the actuator position from the MTS Model 43™ (MTS Systems Corporation, Eden Prairie, MN, USA) and nucleus pulposus migration will be assessed visually. Post-testing, annular mechanical properties will be quantified in each condition using the BioTester™ 5000 system (CellScale, Waterloo, ON, Canada). One-way ANOVAs will be used to compare annular mechanical properties between the three experimental conditions.

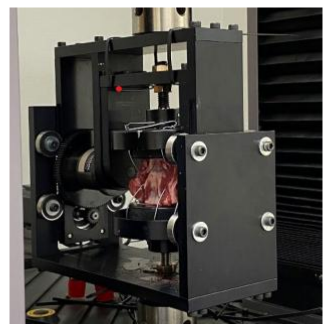

Figure 1: Specimen mounted in a mechanical testing system with custom rotational jig.

Expected Results: We anticipate that hydrogel-injected spines without annular closure will demonstrate significant loss in disc height compared to both the hydrogel + annular closure group and control group.

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EVALUATING THE EFFECTS OF CALISTHENICS ON NEUROMUSCULAR CONTROL AND PROPRIOCEPTION OF THE SHOULDER COMPLEX

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Introduction: Proprioception of the shoulder complex is essential for overall shoulder function, specifically for effective motor control and maintaining shoulder stability [1-2]. Further, it helps prevent musculoskeletal damage arising from proprioceptive deficits, poor coordination, and impaired joint position sense [3]. Calisthenics, a form of bodyweight training, may improve general physical performance and functional capacity. However, its influence on improving joint proprioception by enhancing neuromuscular control in the shoulder complex remains uncertain.

Aim: This research will quantify the specific effects of calisthenics-based physical exertions and traditional strength training on the adaptation of the nervous and muscular systems for upper-limb motor control in young and middle-aged adults, providing novel insights that can refine our understanding of neuromuscular interactions.

Methods: 32 untrained adults (16M, 16F, 18–40 yrs) will be randomized to a 3-month training program of calisthenics or general resistance training. Both programs (3x/week) will target the shoulder complex to initiate neuromuscular adaptations via dynamic, weight-bearing shoulder exercises. Proprioception will be tested at baseline, 1 month, and 3 months using threshold to detection of passive motion (TTDPM) and joint position reproduction (JPR). TTDPM involves passive, controlled shoulder movement (0–90° forward flexion/abduction) via an investigator-controlled Biodex System 4 (Biodex Medical Systems, NY, US) at different speeds [4]; participants press a button upon detecting motion. JPR involves passive positioning to 45°/90° flexion/abduction, with participants attempting to reproduce the target joint position bilaterally and pressing a button when position is perceived [1]. Simultaneously, motion capture data will be collected using Qualisys motion capture (Qualisys AB Gothenburg, Sweden) with reflective passive markers on the chest, shoulder, and arm to measure angular displacement. Blindfolds will eliminate visual input. Mean perceived displacement and RMSE of shoulder position reproduction will be analyzed between the two groups and sexes using mixed analyses of variance (ANOVAs).

Expected Results: The calisthenics group is expected to demonstrate enhanced sensorimotor integration and proprioceptive abilities by perceiving smaller angular changes in position. More accurate reproduction of limb placement during dynamic tasks is expected due to the focus of calisthenics exercises on bodyweight movement. Sex-based comparison will also highlight potential differences in neuromuscular adaptations between males and females, leading to practical implications for tailoring training and rehabilitation strategies to enhance proprioceptive capabilities and improve shoulder function in both sexes.

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[2] Salles et al. (2015). *Journal of Athletic Training*, 50(3); p. 277–280.
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USING RCRA TO ASSESS RISK FOR AN AUTOMOTIVE ELECTRICAL HARNESS INSTALLATION TASK: A SENSATIVITY ANALYSIS OF RCRA INPUTS

Hailey M. Nestor[1], Steven L. Fischer[1]
[1]Department of Kinesiology, University of Waterloo, Waterloo, ON

Introduction: Electrical wire harnessing on an automotive line consists of routing a harness through a car's engine, successfully securing retention clips to keep the harness in place and fastening electrical connections. This task is complex and multi-axial in nature. Additionally, this task is highly repetitive, with workers having to route up to 500 engines per shift. Anecdotal evidence is emerging that some wiring harnessing work may lead to workplace musculoskeletal disorders of the hand and wrist. Due to the complex nature of the task, and difficultly in measuring internal exposures in-field (i.e., detailed musculoskeletal modeling), surrogate risk assessment tools that only consider external exposure may be used instead. The Recommended Cumulative Rest Allowance [1] may be a useful tool to analyze this task, however, it is important to determine how sensitive the RCRA is to varying inputs given the dynamics of wiring harness work.

Aim: This study aims to investigate how RCRA ratio output differs when inputs include percent-effort estimated from applied force, wrist extensor and wrist flexor muscle activity.

Methods: Participants will be recruited to simulate engine wiring (10 repetitions) in the lab. Each repeat consists of three subtasks with a total cycle time of 45s. Electromyography (EMG) was recorded from three extensor and two flexor muscles of the right forearm to assess muscular activation. A force plate captured real-time force applied to the engine. EMG and force data were normalized to maximum voluntary contractions/forces, and exertion durations were determined using threshold detection from the force and EMG signals respectively. Normalized EMG and force efforts were input into the RCRA tool to evaluate rest requirements (i.e., RCRA ratio <1).

Expected Results: Preliminary RCRA analyses from three participants indicate that mean RCRA ratios were acceptable (<1) when using flexor EMG (0.28) but exceeded recommended thresholds (>1) when using extensor EMG (7.07) or applied force (1.46) inputs. The high RCRA ratio for when using extensor EMG likely results from prolonged activation durations. Similarly, the high RCRA output for force may be attributed to compromised maximum voluntary force application required for in-field measures, influenced by posture constraints and discomfort from pressing against engine pins and electrical connections.

References:
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Table 1: Normalized percent-effort inputs into the RCRA equation.

	Flexor Activity	Extensor Activity	Force
Subtask 1	16.9% ±6.9	17.0% ±4.7	34.1% ±10.4
Subtask 2	15.0% ±4.4	36.6% ±20.4	39.1% ±13.8
Subtask 3	23.7% ±7.3	34.5% ±17.5	44.3% ±8.9
RCRA Ratio	0.28	7.07	1.46

Poster Session B

Thursday, May 22 (6:00pm – 7:00pm)

Science Building UA Atrium

DEVELOPMENT OF NEXT-GENERATION SUBJECT-SPECIFIC SHOULDER FEMS USING ADVANCED EXPERIMENTAL TESTING METHODOLOGIES

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[1]Kinesiology and Health Sciences, University of Waterloo, Waterloo, ON

Introduction: Shoulder osteoarthritis (OA) is a progressive joint disease characterized by the degeneration of cartilage and surrounding soft tissues, ultimately impairing joint function and stability. While finite element (FE) models are widely used to study joint mechanics and guide surgical interventions, most shoulder FE models are based on retrospective imaging datasets and literature-derived material properties, which limits their clinical accuracy and applicability [1], [2]. The integration of experimentally measured mechanical properties into subject-specific models offers a promising direction to overcome these limitations and improve the biomechanical fidelity of simulations [3].

Aim: This study aims to develop and validate subject-specific shoulder FE models by integrating advanced imaging techniques with direct mechanical testing of cadaveric tissues, enabling more accurate predictions of joint mechanics and surgical outcomes.

Methods: Fresh-frozen cadaveric shoulders will be acquired and stratified based on OA severity. Specimens will undergo mechanical testing using a six-degree-of-freedom robotic system to simulate physiological loading scenarios. Simultaneously, detailed anatomical and density data will be captured using dual-energy CT (DECT) and microCT imaging [4]. These datasets will inform subject-specific FE models incorporating density-modulus relationships and anisotropic tissue behavior. Mechanical validation of the FE models will be achieved through comparison to experimentally acquired force-displacement curves [5].

Expected Results: We expect that FE models incorporating directly measured material properties and high-resolution imaging data will yield improved agreement with experimental joint mechanics compared to traditional models using population-averaged parameters [3], [6]. Additionally, the models are anticipated to capture inter-subject variability in tissue composition and structure, which is critical for personalized implant design and surgical planning [7]. These validated models will support the development of phenotype-specific treatment strategies, offering improved decision-making tools for orthopedic surgeons [8].

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FOOT ORTHOTICS IN CHRONIC ANKLE INSTABILITY TREATMENT

Mitchell Brydon, Kelly A. Robb, Stephen D. Perry

Department of Kinesiology & Physical Education, Wilfrid Laurier University, Waterloo, ON

Introduction: Chronic ankle instability (CAI) is a condition characterised by either a subsequent sprain of the affected ankle following a significant lateral ankle sprain or an instance of the previously injured ankle "giving way", which does not result in an acute lateral ankle sprain [1]. Current clinical treatment guidelines for CAI suggest the use of external supports such as ankle bracing in conjunction with a rehabilitation exercise program. These programs are not 100% effective, sometimes requiring surgical intervention. Literature on the usage of foot orthotics in CAI treatment is sparse, though some significant benefits have been identified.

Aim: To understand whether changes in ankle kinematics during activities of daily living and sport-specific movements following a six-week foot orthotic intervention correlate with reductions in swelling and ankle-specific pain rating in individuals with CAI.

Methods: This study will follow a single blind, pretest-posttest design. An intervention group of 12 individuals with CAI following an exercise rehab program using custom foot orthotics will be compared to a control group of 12 individuals also with CAI, following a rehab program, but instead using a sham orthotic over 6 weeks. Data will be collected in a series of trials, including activities of daily living such as walking and sport-specific movements, including jumping. Kinematic data of the foot and lower leg will be collected using an Optotrak Certus^{TM} 3D motion capture system (Northern Digital Inc., Ontario, Canada) to determine ankle joint motion. Surface EMG will be used to collect muscle activation data for the ankle invertors and evertors. Ankle swelling will be measured using the figure-of-8 method. The foot and ankle ability measure (FAAM) will be the main tool used to assess ankle function and pain.

Expected Results: Previous research has identified increased ankle and rearfoot inversion and ankle plantarflexion in the gait of individuals with CAI [2]. A reduction in these metrics following the 6-week intervention should result in reduced swelling and pain.

Conclusion: Ankle sprains are one of the most common injuries which occur during physical activity. Current clinically recommended rehabilitation plans are not 100% effective. The use of foot orthotics alongside exercise rehabilitation programs may provide the missing link in optimising conservative treatment, providing patients with a better standard of care.

References:

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CENTER OF MASS EXCURSIONS DURING BACKWARD WALKING IN CHILDREN

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[1]Department of Kinesiology, Brock University, St. Catharines, ON

Introduction: Physical literacy (PL) is key for developing movement skills and postural control in children [1]. Dynamic movements, such as backward walking, provide insight into coordination, balance, and motor skills, with center of mass (CoM) excursion playing a critical role in stability [2].

Aim: This study will examine CoM excursion during backward walking between gender and pre and post 7 weeks of PL programming. This study will also examine the relationship between performance accuracy, Physical Activities Questionnaire (PAQ), and gender on CoM excursion during backward walking.

Methods: Data from 32 children (aged 6-12) who were video recorded (Sony Handycam HDR CX405, Fs: 25Hz) completing the Physical Literacy Assessment for Youth backward walk task pre and post PL programing will be analyzed. Demographics including age, PAQ scores and gender (15 boys, 17 girls) are summarized in Table 1. Videos were processed in FreeMoCap.org to derive joint coordinates (Figure 1) and medial-lateral (M-L) CoM data; a custom MATLAB script will be used to determine M-L CoM excursion (|max-min|) in pre and post backward walks. A repeated measures ANOVA-RM will examine the effect of time and gender on M-L CoM excursions; path analysis will explore the relationship between task accuracy, gender, PAQ, and CoM excursion.

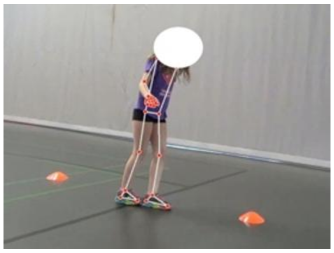

Figure 1: Two-dimensional reconstruction of the PLAY-basic backward walk task kinematics

Expected Results: There will be higher task accuracy, higher PAQ scores and less M-L CoM excursion observed in males post PL program compared to pre PL program testing.

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Table 1: Demographic information for participants in the study, including the number of boys and girls, mean ±Standard Deviation (SD) age and Physical Activity Questionnaire (PAQ) scores.

Gender	**Age (y** ± SD)	**PAQ (Score**± SD)
Boys	7.87 ± 1.77	2.84 ± 0.88
Girls	7.88 + 1.45	2.92 ± 0.40

FRACTAL PATTERNS IN GAIT WHILE NAVIGATING OBSTACLES MEASURED USING A SMARTPHONE ACCELEROMETER SYSTEM

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Introduction: Non-linear analyses such as detrended fluctuation analysis (DFA) have gained popularity in posture and gait research. By their nature, they require relatively large amounts of data [1]. Although the literature contains conflicting reports [2,3], preliminary testing conducted in our lab [unpublished data] has suggested short segments of related gait data can be stitched together to accurately calculate fractal scaling index (FSI). Previous work in our lab has validated the use of cellphone accelerometer system custom software for non-linear gait analysis [4,5].

Aim: This study seeks to explore how obstacle avoidance during gait effects fractal scaling.

Methods: Data collection has started and is ongoing. In two separate walking conditions, university-aged volunteers walk for 15 minutes at a comfortable, self-determined pace along a pre-determined 200m indoor hallway loop. In one walking condition, cylindrical foam obstacles (approximately 36 inches tall and 18 inches in diameter) are placed every 3 to 4 meters in one hallway segment, comprising roughly one-third of the route. There are no obstacles placed in the remaining hallway sections (washout). Participants are asked to avoid the obstacles. In the other walking condition, there are no obstacles. The order of the conditions is being counterbalanced. Participants are provided with a cellphone, which they place in the front pocket of their pants prior to starting the walking trials. Software on the phone records their movements using the internal accelerometer. Offline signals processing will be used to identify strides based on right heel contact and calculate FSI for each segment (obstacles; washout; no obstacles).

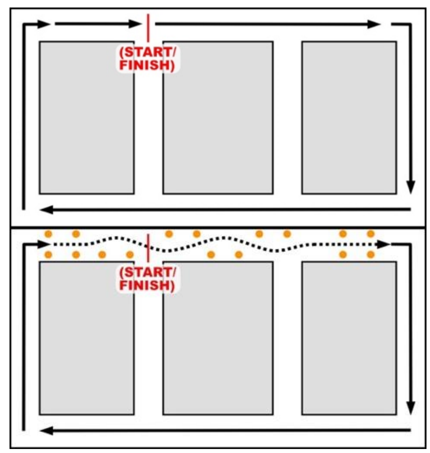

Figure 1: Walking route map, without obstacles (top) and with obstacles (bottom).

Expected Results: We hypothesize that FSI will be increased in the obstacle-avoidance condition.

References:

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TRAINING INTERVENTIONS EXPLORING COGNTIVE MOTOR DUAL TASK PERFROMANCE IN YOUNG ADULTS AND CHILDREN

Julia De Oliveira[1], Lori Ann Vallis[1]
[1]Human Health and Nutritional Sciences, University of Guelph, Guelph, ON

Introduction: Our daily lives often involve dual-tasking (DT) which requires our central nervous system to coordinate motor actions while simultaneously process external information [1]. The execution of tasks simultaneously, often results in impaired performance in one of the tasks due to prioritizing central cognitive resources for one task over the other [1,2]. However, in line with the Principle of Neural Overlap, when we regularly execute concurrent tasks, DT performance can improve due to enhanced abilities in integrating shared neural processes [3]. Previous work in our lab used a brief single training session with young adults and found improvements in the concurrent practice group [4]. To date research exploring different training approaches for DT performance in school aged children is limited.

Aim: The proposed study will investigate the effects of single-task versus DT short-term training interventions on cognitive-motor DT performance in children 7-12 years of age and young adults 18-25 years of age. This research will advance our understanding of the role that cognitive resources play in the execution of motor control strategies in children and will help identify optimal intervention strategies to improve concurrent performance of motor and cognitive tasks.

Methods: The participants will be instrumented with 57 retroreflective markers placed on anatomical landmarks (e.g. head, trunk, feet) and tracked using a 3D motion analysis system (OptiTrack., Corvallis, OR). An auditory Stroop test, stimuli consisting of prerecorded words (e.g. “high” and “low” spoken in a low, or high pitch), will be triggered when crossing a laser gate along a walkway. Participants will identify the pitch of the word spoken while stepping over an obstacle along their path in Baseline testing. Participants will then be assigned to one of three groups: no training condition (will watch educational nature video, ~20 min duration), a single task (ST) cognitive training condition (20 trials; auditory Stroop only) or a DT training condition (20 trials; concurrent obstacle + auditory Stroop tasks). Following a brief period of rest, experimental trials will be repeated (20 DT trials; obstacle + auditory Stroop tasks). Using Visual3D software measures of gait including approach and obstacle crossing velocity, minimum lead and trail foot clearance, toe-obstacle distance and heel-obstacle distance, will be calculated. Variability and cognitive task accuracy and response time will also be assessed.

Expected Results: Based on the theoretical Principle of Neural Overlap [3], we hypothesize that there will be a reduction in variability for adaptive locomotor outcome measures (e.g. toe clearance) and improved cognitive performance (e.g. higher accuracy), in the DT compared to the ST and no training group. This research will expand our knowledge of visuomotor control mechanisms, and the cognitive processes involved in adaptive locomotor behaviours.

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ARE EFFORT DURATIONS FOR AUTOMOTIVE MANUFACTURING TASKS AFFECTED BY WORKER EXPERIENCE?

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Introduction: Many ergonomics tools require knowledge of force, frequency and effort durations to estimate acceptable limits [1]. In automotive ergonomics, the frequency of each exertion is easily obtainable, but estimating the precise time for each exertion is much more difficult to obtain, despite being a crucial factor in preventing fatigue. An additional problem is that many ergonomics studies utilize student participants and assume results will be generalizable, but this may not be true for automotive manufacturing tasks, where training and experience can influence task performance [2]. The purpose of this study was to quantify effort durations and peak force magnitudes for common automotive assembly tasks, focusing on the impact of worker experience and mode of effort duration calculation (EMG vs. dynamometry).

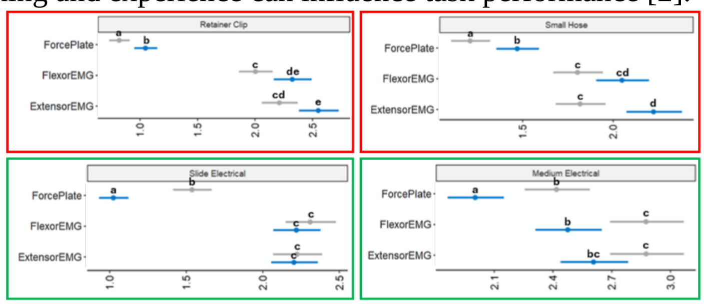

Figure 1: Three-way interaction plot (experience), pairwise comparisons are shown between experience (Student = Blue). Estimates that share the same letter were not sig different.

Methods: 33 participants (19M, 14F) were recruited in two distinct groups: 16 experienced workers and 17 from a university student population. 14 hand-intensive tasks were identified from an automotive assembly operation. Female ends of the parts were affixed to a 6 DOF force plate and tasks were completed against the apparatus. sEMG from the wrist flexors and extensors were collected. For all force and EMG signals, a single-threshold algorithm was used to calculate on-off effort durations and peak forces from each trial were obtained. Mixed effects models used to evaluate factors of experience group (2), collection method (3) and part type (14).

Results: A three-way interaction was found between experience, collection method and part type. Effort durations depended on part type and method, with no clear bias found between groups. For peak forces, a two-way interaction existed between part type and experience. On average, the experienced group had 15% higher peak forces compared to the students (higher in 11 of 14 tasks).

Discussion and Conclusion: This study showed no definitive evidence that the level of experience systematically affected effort durations. It was interesting that the experienced group generally produced higher peak forces. This is likely attributable to quality concerns and this group ensuring that the parts were seated properly, where the students did not have this type of training. Further research will continue to examine the relationship between duration and peak forces.

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THE EFFECT OF ECCENTRIC MUSCLE DAMAGE ON THE TOPOGRAPHICAL ACTIVATION PATTERNS OF THE BICEPS BRACHII MUSCLE

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Introduction: Delayed-onset muscle soreness (DOMS) typically arises after intense eccentric or unfamiliar exercise and is characterized by muscle pain, tenderness, and temporary reductions in function [1]. Additionally, although DOMS has been shown to alter muscle activation strategies in the trunk and lumbar regions, the impact of eccentric muscle damage on muscle activation topology remains understudied, particularly within the upper extremity [1]. Since eccentric exercise has been shown to result in regional damage in Z-line streaming to the effector muscle, it is possible that topographical activation of a muscle may be altered following eccentric damage [4]. High-density surface electromyography (HD-sEMG) provides a detailed spatial representation of muscle activity and has revealed region-specific adaptations to pain and fatigue [3]. Though pressure pain threshold (PPT) testing is commonly used to quantify localized muscle tenderness, no study has yet examined the spatial relationship between pain sensitivity and muscle activation topography in the biceps brachii following eccentric muscle damage.

Aim: To investigate how eccentric damage influences the spatial distribution of biceps brachii activation, specifically if muscle activity shifts away from areas of increased pain sensitivity and leads to greater heterogeneity in activation topography.

Methods: 20 healthy young adults (10M/10F) who are recreationally active will be recruited for a two-visit study. During the first visit, participants will complete PPT testing across the surface of the biceps brachii muscle, as well as trapezoidal submaximal exertions at 15%, 25%, and 50% maximum voluntary force. HD-sEMG signals will be recorded from the biceps brachii using a 96 channel HD-sEMG grid (0.5 cm IED, Novecento+, OT Bioelecttronica, Turin, IT). Following the submaximal contractions, participants will complete a muscle damage protocol consisting of an eccentric-focused contraction paradigm to elicit DOMS. After 48 hours, participants will return for a second visit where they will repeat PPT testing and the submaximal trapezoidal exertions. HD-sEMG data will be analyzed to yield spatial activation topographical maps across both sessions and PPT will measure areas of heightened pain. These will be compared across sessions using a two-way ANOVA, such that independent variables are represented as study visit, and muscle region, while the dependent variables are regional muscle activation and PPT values.

Expected Results: Eccentric damage will increase the heterogeneity of biceps brachii activation and shift activity away from regions of heightened DOMS, consistent with the protective adaptations observed in other muscles under painful conditions [1–3]. Exploring this relationship could offer valuable insight into how neuromuscular control adapts in response to localized pain.

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INVESTIGATING MUSCLE ACTIVITY ACROSS VARYING VIOLIN STRING HEIGHTS

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Introduction: Performing artists place unique demands on their bodies, yet their health challenges often go unnoticed. Among professional instrumentalists, the lifetime prevalence of musculoskeletal complaints ranges from 62 to 93% [1], with overuse injuries being the most reported [2]. Violinists are especially at risk, often playing for an average of 2 hours with only a 15-minute break. Additionally, violins are held on the left shoulder in an awkward posture and played with a bow in the right hand. Due to this asymmetrical position and repetitive movement, bilateral overuse injuries of the hands and wrists, along with aching in the neck and shoulder region have been recorded [3]. Activity in the left forearm muscles exceeds that of the right, with the extensor carpi radialis peaking at 30% of its maximal contraction [4]. Due to limited options for customizations such as shoulder rests, chin rests and string types, the musician must adapt to the instrument. One alteration that is less commonly seen is changing the string height by modifying the bridge. An increase in bridge height can improve the sound of the violin but would require more force to press the strings down and a greater distance for fingers to travel. In contrast, a low bridge would make string pressing easier but may compromise sound quality.

Aim: The purpose of this work is to determine the effect of varying violin string heights on muscle activity in the forearm and neck. This may give insight into a possible intervention for violinist injury.

Methods: Males and females over the age of 18, at or above the grade 4 violin level in the Royal Conservatory of Music (RCM), without any pain preventing a normal ROM will be recruited (10M, 10 F). Surface electrodes (Ag/AgCl electrodes (Grass, Astro-Med Inc., Warwick, RI) will be placed over six forearm muscles (flexor carpi radialis, flexor carpi ulnaris, flexor digitorum, extensor digitorum, extensor carpi radialis and extensor carpi ulnaris), and bilaterally on the upper trapezius and cervical extensors. Kinematic data will be acquired through three Sony RX0 II cameras (Sony, Minato City, Tokyo, JPN). Two identical violins with different bridge heights will be used to alter string height during trials. The protocol will require the violinist to be seated in a comfortable position, repeating the four octave G-major scale 5 times on each violin at a tempo of 55 beats per minute. EMG data will be analysed offline using MATLAB (MathWorks Inc., Natick, MA). Raw EMG will be linear enveloped at 3 Hz and normalized to muscle specific maximum voluntary exertions (%MVE). Mean and peak muscle activity during different parts of the scale, as well as the co-contraction index will be evaluated. Video coordinates will be extracted using MediaPipe (Google, Mountain View, California, USA), and filtered using a Butterworth filter with a 17 Hz cut-off. Total Euclidean distance travelled for the middle knuckle will be converted from pixels to metres using known distances recorded in each video.

Expected Results: This research will help determine whether string height affects the muscle activity of violinists. Previous studies have evaluated ergonomic interventions to aid violinists, but none have considered how altering a part of the violin itself can affect the musician. Currently there is no standard for the bridge height of the violin and corresponding string height, but a desired outcome would be recommending a target string height which yields lower muscle activity. Currently, violin makers have no feedback other than personal preference of musicians, but this study will provide evidence-based recommendations to aid in the construction of violins while considering longevity of a violinist's career.

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A NOVEL METHOD FOR IN-VIVO LUMBAR SPINE NEUTRAL ZONE QUANTIFICATION

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Introduction: The neutral zone (NZ) is commonly referred to as the subset of spinal range of motion in which there is limited resistive activity of the passive tissues and muscles [1,2]. This ideal range of motion for the spinal passive tissues prevents excessive strain that can lead to tissue failure and injury [2]. NZ is used as a sensitive biomechanical measure for prediction of passive tissue injury [3,4]. While in-vitro studies use NZ stiffness metrics of ±0.05 Nm/° to define NZ limits [4,5], most in-vivo studies have focused on broader stiffness areas (e.g., the low stiffness zone) or utilized a larger cutoff limit than what is typically used in traditional in-vitro work [2]. Therefore, to more accurately calculate the NZ in-vivo, a motorized passive jig was developed to record lumbar spine flexion and extension in one complete controlled trial [4].

Aim: To compute the in-vivo lumbar spine NZ. A secondary aim was to report upright standing lumbar spine angle and peak lumbar spine angle during a perturbation with respect to NZ limits.

Methods: Twenty healthy participants will complete a 5-minute static standing trial and three perturbation trials followed by quantification of their NZ via a motorized, frictionless jig. Participants will be instrumented with EMG (Noraxon Ultimum, AZ, USA) over the lumbar erector spinae and abdominal muscles, while motion of the trunk and pelvis will be tracked using motion capture (Vicon Nexus, Oxford, UK). The passive jig will include a stationary lower body cradle with a dynamic upper body cradle attached to a controller, which will maintain a constant speed of 0.5°/sec. A torque transducer mounted in line with the motor will be attached to a sliding rail system allowing for movement of the pivot point from the participants' estimated L4-L5 joint. Moment angle curves will be developed, NZ length, stiffness, and upright standing angle and perturbation responses relative to individual NZ will be computed computed [5].

Expected Results: It is anticipated that NZ parameters collected in this study will compare to metrics previously reported in-vitro. Given that current work suggests healthy individuals stand within their computed NZ, these results could be compared across clinical populations (e.g., low back pain, disc degeneration) to provide valuable information on standing position(s) relative to NZ.

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INFLUENCE OF INTERVERTEBRAL DISC PRESSURE ON VERTEBRAL FRACTURE MORPHOLOGY

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Introduction: Intervertebral discs are comprised of a central nucleus pulposus, made mostly of water, and a surrounding collagenous annulus fibrosus. A functional spinal unit (FSU) contains two adjacent vertebrae and the intervertebral disc in between. Vertebral fractures occur when the nucleus rapidly pressurizes – its hydrostatic nature allows for expansion superiorly, inferiorly, and radially against the endplate and annulus fibrosus [1,2] ultimately leading to failure. Rapid pressurization has also been shown to weaken adhesion between annulus layers. Mechanistically, pressurization of the nucleus deforms the annulus outward; however, it is most likely the subsequent depressurization that damages the annulus via rapid inward buckling which separates the lamella [3,4].

Aim: The purpose of the study was twofold: 1) to determine if depressurization of the disc via puncture changes how it responds to compressive loading and consequent endplate fracture, and 2) to see if annular mechanical properties differ between puncture and non-puncture groups post-fracture.

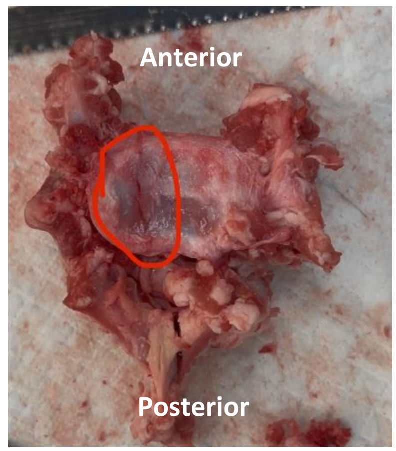

Figure 1: Axial view of C5/C6 FSU after undergoing fracture protocol, with endplate fracture

Methods: Porcine C3/C4 and C5/C6 FSUs will be used, which are analogous to adolescent human lumbar spines, and will be randomized into one of two groups: control and punctured. All FSUs will be preloaded for 15 minutes under 300N compression followed by compression at a rate of 1mm/sec until failure (Figure 1). The control FSUs will be left intact while the punctured FSUs will be punctured using a number 11 scalpel before the fracture protocol. Post-fracture, two anterior annulus samples will be dissected: one will undergo a 180° peel test to quantify lamellar adhesion properties, the second will undergo a single layer test to determine intra-lamellar matrix properties. One-way ANOVAs will be used to compare annular mechanical properties between control and punctured FSUs.

Expected Results: Depressurization of the intervertebral disc is expected to result in less visual endplate damage. This is expected because the nucleus pulposus can no longer pressurize and deform the endplate. The annulus is also expected to sustain less damage since the depressurization would inhibit radial deformation of the annulus and subsequent inward buckling [3,4].

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EXAMINATION OF DIFFERENCES IN SELF-REPORTED PHYSICAL LITERACY BETWEEN MALE AND FEMALE CHILDREN

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Introduction: Females report a decline in enjoyment of physical activity and a lower perceived physical ability over time [1], which may be related to physical literacy (PL). PL can be self-assessed using the Physical Literacy Assessment for Youth (PLAY).

Aim: The aim of this study was to 1) examine the effects of gender and a PL intervention on PLAYself total and subsection scores and 2) determine if age is correlated to PL self-assessment.

Methods: This study was a secondary analysis of data from a larger study. Thirty-four participants ($n = 18$ females; $n = 16$ males) completed the PLAYself, pre and post a 7-week PL intervention. Repeated measures ANOVAs ($p<.05$, IBM SPSS v.29) with gender as the between factor and time as the within factor for the total PLAYself score and subsection scores and Pearson Product Moment Correlations for association between age and PLAYself score were performed.

Results: Changes in PLAYself total and subsection scores are reported in Table 1. There were no significant differences in the total scores (time: $p=.53$; gender: $p=.86$; time x gender: $p=.09$), the Environment subscale (time: $p=.18$; gender: $p=.30$; time x gender: $p=.37$), the Self-Description subscale (time: $p=.53$; gender: $p=1.0$; time x gender: $p=.13$), the Rank of Literacy subscale (time: $p=.51$; gender: $p=.48$; time x gender: $p=.50$), or the Rank of Numeracy subscale (time: $p=.23$; gender: $p=.93$; time x gender: $p=.16$). In the Rank of PL subscale, there was a significant time x gender interaction ($p=.04$), but not for time ($p=.46$) or gender ($p=.94$). However, post-hoc pairwise comparisons were not statistically significant ($p=.09$). There was no significant correlation between age and gender in total or subsection scores.

Discussion and Conclusions: In this sample, there were no perceived PL differences between males and females before or after a PL intervention. While not significant, it is worth noting that the mean total PLAYself score increased for females and decreased for males post intervention.

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Table 1: Changes in PLAYself total and subsection scores. All values reported as mean±SD.

PLAYself Subsection	Females Pre	Females Post	Males Pre	Males Post
Total Score	70.2 ± 11.3	74.9 ± 17.0	73.0 ± 9.0	70.7 ± 9.9
Environment	408.3 ± 73.3	415.3 ± 102.9	366.1 ± 101.6	399.0 ± 80.3
Self-Description	800.5 ± 196.0	884.7 ± 349.3	861.4 ± 166.1	826.6 ± 192.3
Rank of Literacy	220.7 ± 54.0	235.5 ± 50.4	237.9 ± 49.8	237.8 ± 46.9
Rank of Numeracy	231.8 ± 46.4	233.7 ± 42.9	241.9 ± 47.9	221.1 ± 51.4
Rank of PL	232.7 ± 51.2	252.2 ± 42.9	262.8 ± 45.0	225.3 ± 73.5

FROM DESK TO AUGMENTED REALITY: EVALUATING THE PHYSICAL DEMANDS OF COMPUTER TASKS IN AR

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Introduction: Virtual Reality (VR) and Augmented Reality (AR) technologies are rapidly evolving. As a result, VR and AR tools have the potential to revolutionize the modern office environment. Such devices have traditionally been associated with gaming and entertainment; however, these devices show promise for professional settings to improve productivity, enhance collaboration, and support mental health [1]. Advances in technology (including resolution and computing power) have allowed traditional computer work to be possible in AR [2]. As the boundary between physical and digital spaces narrows, VR and AR are emerging as powerful tools for office workers, offering immersive experiences that stretch beyond the traditional desk-bound setup. It is currently unknown how effectively users can manage and organize a virtual environment. Research on the impact of these devices on office workers is lacking, and the full potential of these technologies remains underexplored, despite end user adoption.

Aim: To better understand the physical demands of immersive technologies during computer tasks, with an emphasis on office set up (sit and stand).

Methods: 20 young adults (10 M, 10 F; 18-30 years) will be recruited. Muscle activity will be measured using surface electromyography (sEMG) bilaterally on the upper extremity. Kinematics will be measured using a 10-camera motion capture system with reflective markers placed bilaterally on the hands, forearms, upper arms, head and thorax. Three accelerometers will be placed along the spine (L1, S1, T1) to track spine angles during each trial. The comparison of two VR/AR headsets (Meta Quest 3 & Apple Vision Pro) will be completed during simulated office work in both sit and stand conditions. Two 60-minute sessions will be completed. Alternating 5-minute blocks of two tasks on a virtual screen in AR: 1) typing and 2) text editing (Figure 1) while using physical peripherals.

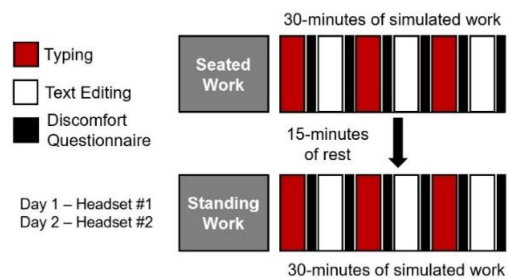

Figure 1: Experimental protocol.

Expected Results: It is expected that the Meta Quest 3 headset will generate lower muscle activity in the neck, shoulders, and upper back than the Apple Vision Pro, due to weight differences in the headset. The sitting protocol will show a decrease in discomfort for the neck, shoulders, and upper arms compared to standing, with the standing protocol showing an increase in discomfort in the legs and lower body compared to seated.

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ASSESSING THE EFFECT OF INTER-ATHLETE SPATIOTEMPORAL COORDINATION ON PAIRS ROWING PERFORMANCE TIMES

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Introduction: The rowing stroke is a cyclical, full body motion translating biomechanical power through an oar into the water, propelling a boat forward. Biomechanical analysis to maximize multi-athlete crew performance has been limited to use of power meters which have high potential error and substantial stroke-to-stroke variability [1]. Coordination and its impact on stroke rate have only investigated individual athletes [2], and prior research on interpersonal coordination between multiple athletes has utilized relative oar angles and subjective perception of coordination from the athlete [3]. Until recently, it has been impossible to track multiple athletes simultaneously, but with the advent of 3D markerless motion capture (3DMMC) [4], it is now feasible to analyze multiple athletes rowing together.

Aim: To assess the effect of inter-athlete spatiotemporal coordination on sweep pair rowing performance times.

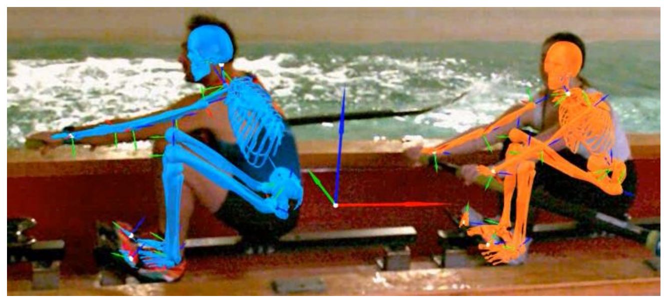

Figure 1: THEIA3D analysis of rowers during indoor rowing tank trial.

Methods: 10 varsity collegiate rowers have been recruited for this study (8 M/2F). All pairs are same-sex athletes who are free of musculoskeletal and neurological disorders. Pairs have completed a 1-minute indoor rowing tank trial at race pace. Eight Miqus cameras (Qualisys AB, SE) captured video data for the duration of the trial. Post-processing will utilize THEIA3D (Theia Markerless inc., ON, CAN), Visual3D (V3D LLC., USA), and MATLAB (v. R2024b MathWorks Inc., USA) to model and analyze the variability of oar kinematics and athlete center of mass, lower (ankle, knee, hip), and upper (shoulder, elbow, wrist) extremity joint and lumbar spine kinematics. 3D kinematics and joint angles for each pair will be compared with on-water time trial data of 2-kilometer race segments for each athlete pair. Bivariate linear regression analysis will compare on-water times with kinematic outcomes.

Expected Results: We hypothesize higher inter-athlete oar and joint coordination between rowers will yield faster on-water times. The findings will probe the effect of spatiotemporal coordination between athletes on pairs performance, providing insights into utilizing 3DMMC for the purpose of analyzing rowing biomechanics in both multi-person crew and individual athlete performance.

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THE INFLUENCE OF ARM POSTURE ON WRIST PROPRIOCEPTION AND HAND TACKING ABILITY: IMPICATIONS FOR ROBOTIC SURGERY

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Introduction: Robotic surgery is one of the fastest-growing fields in healthcare, revolutionizing surgical procedures by providing surgeons with tools that enable accurate and efficient operations. A key component of success in these procedures is fine motor control, which is crucial for performing delicate tasks such as suturing and tissue manipulation. Proprioception, or the body's sense of its own position and movement, plays a vital role in this fine motor control [1]. The wrist, with its broad range of motion and multiple degrees of freedom, is particularly susceptible to changes in posture, which can influence proprioceptive feedback. Research has shown that even small adjustments in wrist angles can affect proprioceptive sensitivity [2]. Furthermore, joint positioning, especially at the elbow, impacts proprioception and overall motor performance. Studies on wrist posture have shown that deviations from neutral angles can alter proprioception, affecting motor control [3,4]. By understanding how these angles impact proprioception, we can refine ergonomic strategies for tasks requiring high precision, such as robotic surgery, where joint-specific posture can affect both proprioception and performance [5].

Aim: To investigate the effects of elbow angle on wrist proprioception and hand tracking ability.

Figure 1: Edusa PRO-r.

Methods: 30 right hand dominant participants will be recruited. While seated, participants will place their right forearm in a three DoF wrist manipulandum (Edusa PRO-r, Genoa, Italy) with their hand grasping the handle (Figure 1). Participants will undergo single-hand fine motor control tests that 1) evaluate wrist proprioception and 2) track the accuracy of hand movements. Blindfolded and with noise cancelling headphones, wrist proprioception will be evaluated with a joint repositioning task where the robot positions the user at a predetermined joint angle and then moves the user back to neutral. The participant then recreates the previously presented angle. Tracking accuracy will include tracking a 3:2 Lissajous curve on a computer monitor. The participants will complete these tests across 3 elbow angles (60°, 90°, 120°). Joint position matching will assess errors, calculated as mean error, eccentric bias, and variability. Tracking accuracy will be assessed using tracking error and figural error.

Expected Results: Output measures will be compared to determine statistical differences between or within each condition. It is expected that as elbow angles deviate from neutral (90°), both tracking accuracy and proprioceptive awareness will decrease.

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MAXIMUM VOLUNTARY PELVIC FLOOR MUSCLE CONTRACTIONS ARE IMPACTED BY AGE BUT NOT PARITY

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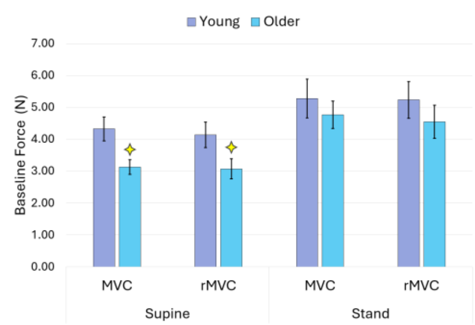
Introduction: The estimated prevalence of pelvic floor disorders shifts from 1 in 4 for the general female population to 1 in 2 for those over 80 years of age [1]. While impairments in pelvic floor muscle (PFM) function have been associated with the development of several pelvic health conditions (e.g., pelvic organ prolapse), there is a lack of consensus within scientific literature regarding the effect of age on PFMs. The aim of this study was to determine the effect of age on maximal voluntary PFM contraction (MV-PFMC) while accounting for parity and body position.

Methods: Females aged 18-45 and ≥55 years attended a single laboratory assessment. MV-PFMCs were captured using a custom mechatronic intravaginal dynamometer [2] in both standing and supine positions under two instruction paradigms, one to achieve maximal force (MVC) and the other to achieve maximal force as rapidly as possible (rMVC). Three trials were performed of each contraction in each position, with median values of baseline force, peak force and rate of force development retained for analysis. Separate two-way ANOVAs ($\alpha = 0.05$) were used to determine the effect of age and parity status on each outcome in each position.

Results: Twenty-nine participants completed the protocol (n_{young} =15, $n_{nulliparous}$ =9). There were no parity by age interactions. Older participants demonstrated significantly lower baseline forces in supine (Hedge's g effect size= 1.385 for MVC, 0.940 for rMVC), but not in standing. Peak and relative peak forces were not different between age groups. In both positions, older participants tended to generate force more slowly, which was only significant for rMVCs performed in standing (g = 0.896) (Figure 1).

A



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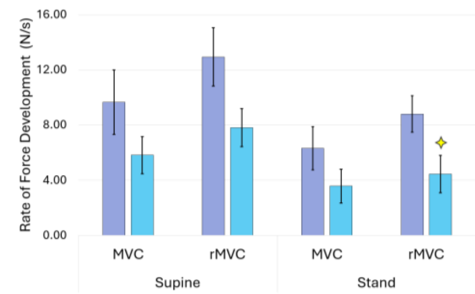

Figure 1: A) Baseline force and B) rate of force development for MV-PFMCs in young (≤45 yrs) vs older (≥55 yrs) participants. Error bars represent standard error. Stars represent significant difference at α=0.05.

Discussion and Conclusions:
Older females appear to produce similar MV-PFMC forces compared to younger females, however force is generated more slowly. Future investigations should examine the potential association between rate of force development and the manifestation of pelvic floor disorders among older females.

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DETERMINING THE MAXIMUM FEASIBLE BOX DIMENSIONS AND BOX WEIGHTS FOR ONE-HANDED BOX TRANSFERS FROM VARYING HEIGHTS

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Introduction: Workers in logistics and warehousing industries are constantly exposed to repetitive motions of lifting and lowering loads [1]. Despite the strong prevalence of one- and two-handed lifting behaviors in different industries, task factors that drive decisions to use one or two hands while lifting are currently not well understood. Digital Human Modeling (DHM) enables proactive ergonomics by predicting how a worker would perform a virtual work task, yet the use of one or two hands needs to be pre-determined by the user. A better understanding of the maximum determinants for performing one-handed lifts/transfers will inform DHM users on human-object interactions and guide companies on the work design for stock-picking tasks.

Aim: We aim to determine the maximum feasible box dimensions that would permit a one-handed box transfer from varying shelf heights. Secondly, we aim to determine the maximum box weight that participants would transfer from varying shelf heights using one hand when the box dimensions are set at the maximum feasible grip span from aim one.

Methods: Participants will complete a series of box transfer tasks from varying shelf heights to a table behind them with their dominant hand. For the first part of the study, minimally weighed retractable box was used. Participants were instructed to grab the box from either front or top and expand/collapse its dimension until they perceived that they could no longer transfer it with only one hand. For the second part of the study, the box will be set at the maximum feasible grip span determined from study one. Participants will be instructed to add/remove lead shots to the box that has a randomized starting weight until they determine the maximum weight that they can transfer with only one hand comfortably and safely.

Preliminary Results: Perceived maximum box dimensions (70-74% hand length) generally stayed constant when grabbing the box from the front regardless of shelf height but decreased with higher shelf height when grasping the box from the top (Figure 1), this discrepancy is likely due to limited line of sight at shoulder height. Findings from part 1 will inform the preferred grip span for part 2. It is expected that the perceived maximum box weight will decrease with higher shelf heights.

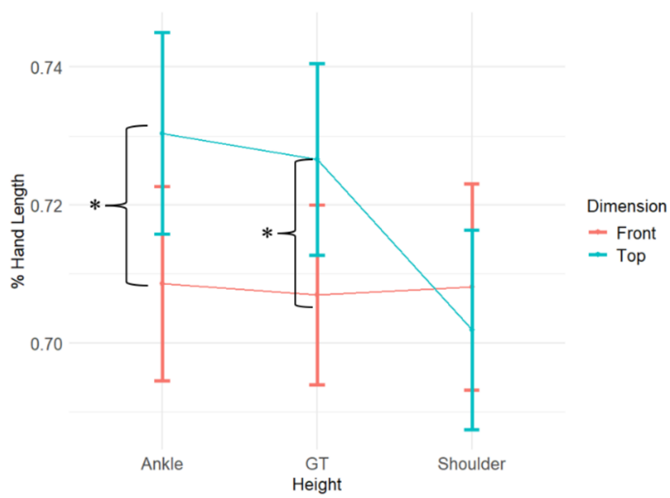

Figure 1: grip side x height interaction

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HAND-ARM VIBRATION EXPOSURE PREDICTION USING MACHINE LEARNING

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Introduction: Hand-arm vibration syndrome (HAVS) is associated with the use of handheld power tools. To mitigate injury risk, ISO 5349-1 provides guidelines on the allowable hand-arm vibration exposure using a metric called the A8 which quantifies exposure from acceleration data extrapolated over an 8-hour workday [1]. The A8 is a measure of the daily average vibration exposure and can be captured as a combination of multiple vibration sources such as would occur when multiple handheld power tools are used over the course of a work shift [1, 2]. Historically, workplace vibration exposures have not been tracked using triaxial accelerometers due to the expense and expertise required to analyze and interpret the data, making A8 quantification impossible [2]. The advent of smartwatches provides the opportunity to easily collect tri-axial acceleration data from the wrist. Machine learning (ML) using triaxial accelerometer data to identify tools and tasks has been used in past studies [2], however, ML studies have yet to be developed to provide A8 values. Developing a model that assesses cumulative vibration risk will allow workers and employers to monitor vibration exposure paving the way to a safer workplace.

Aim: To develop a ML model that can identify individual tools and tasks from anthropometric measurements and triaxial acceleration data obtained from the tool and a smart watch. These findings will inform an algorithm to predict cumulative vibration exposure using the A8 metric.

Methods: Riveter and bucking bar tri-axial vibration data were obtained from the National Institute for Occupational Safety and Health (NIOSH) Morgantown [3]. Separate datasets were collected from a factory using experienced workers, and the NIOSH Morgantown laboratory on novice participants [3]. Initial work has used these data to develop several machine learning and deep-learning models to identify which of nine tools or four tasks the vibration data profile originated from. Future work will involve new data collection from a variety of power tools and tasks. Tri-axial acceleration will be monitored on the tool as well as on the wrist. The developed deep-learning model will be expanded to identify tools and tasks and will also predict cumulative A8 dose exposure from anthropometric and triaxial acceleration data [1].

Expected Results: Initial modelling has shown traditional machine learning to be inadequate for identifying tools or tasks (~60% accuracy). Improvements were obtained with deep learning models that used LSTM (long short-term memory) to assess sequential data. The LSTM improved tool identification to ~90% accuracy. Based on performance using the NIOSH Morgantown data, it is expected that new data will be classified with similar accuracy. By identifying which tool is used and for how long, an algorithm can be developed using known tool properties and measured acceleration data to predict a worker's cumulative vibration exposure (A8) in real time.

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THE INFLUENCE OF MENTHOL AND CAMPHOR ON ANKLE PROPRIOCEPTION: A PROPOSAL

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Introduction: Proprioception refers to the body's ability to sense its position, movement, and actions in space. Cutaneous mechanoreceptors provide information about joint position sense (proprioception) at the ankle, which is key for successful balance [1-2]. Temperature has been shown to impact feedback from skin receptors; heating the foot has been shown to improve postural control [3], while cooling the foot has been shown to evoke decreased sensitivity of cutaneous afferents and postural control [4]. These cutaneous sensitivity changes may be due to temperature-induced changes in blood flow and/or the activation of thermosensory ion channels (Transient receptor potential (TRP)). TRP ion channels, expressed in the epidermis, are closely associated with cutaneous mechanoreceptors and can modulate their activity. For example, TRPV3 and TRPV4, can be directly activated by both external heat and chemical ligands, such as camphor [5]. Another important temperature channel, TRPM8, responds to external cold stimuli and has been shown to respond to topical menthol application [6]. We have seen the influence of direct external heating and icing the foot on proprioception; however, it is unclear how chemical compounds that activate these thermosensitive ion channels influence proprioception.

Aim: Through the potential activation of TRP channels, we aim to examine the effect of menthol and camphor on ankle proprioception during passive joint position matching (JPM).

Methods: Participants will perform a passive JPM task on 3 different days; receiving base cream (sham), 10% menthol, or 10% camphor applied to the dorsum of their foot. The control ankle will be passively rotated to reference positions of 6°, 12°, and 18° in both dorsiflexion (DF) and plantarflexion (PF) at a velocity of 10°/s using a servomotor and then returned to a neutral position. Participants will then match their test ankle to the reference position of the control foot. The matching velocity will be set to 2°/s to remove timing markers of position. The protocol includes two testing blocks. In the first block (baseline), participants complete five repetitions of each target angle (DF and PF) in a randomized order, yielding 30 baseline trials. Following the baseline trials, the base cream, menthol, or camphor is applied, and participants immediately complete a second block of 30 randomized trials.

Expected Results: Menthol is expected to decrease proprioceptive accuracy compared to control, due to the activation of TRPM8 receptors, increasing the sensitivity threshold and thus decreasing cutaneous afferent sensitivity. Alternatively, camphor is expected to improve proprioceptive accuracy, compared to control due to TRPV3 and TRPV4 activation, inducing calcium influx, causing enhanced cutaneous sensitivity and ultimately, proprioceptive feedback.

Significance: These results may inform proprioception developments that specifically target sensory input in isolation through chemical compounds.

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THE EFFECTIVENESS OF ROCKERED FOOTWEAR ON REDUCING FOREFOOT PLANTAR PRESSURES IN METATARSALGIA

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Introduction: Metatarsalgia is a common foot condition characterized by pain in the forefoot, typically caused by abnormal weight distribution and biomechanical alterations that increase stress on the metatarsals [1]. Rockered footwear has emerged as a potential therapy, offering the ability to redistribute pressure from the metatarsals [2]. Research suggests that certain footwear characteristics, such as a rigid rearfoot platform and forefoot rocker, may help distribute plantar pressures more evenly during the gait cycle, potentially alleviating pain [3]. However, rockered footwear may negatively impact stability as has been shown with negative affects on the limits of stability after an extended period of use [4]. While rockered footwear may offer some relief for forefoot pain, it also raises concern about its effect on stability during movement.

Aim: This study aims to explore the effectiveness of rockered footwear in reducing forefoot plantar pressures and assesses its impact on stability in individuals with metatarsalgia.

Methods: Twenty-five participants over 18 years old with a clinical diagnosis of metatarsalgia are being recruited for the study. Plantar pressure and centre of pressure (COP) displacement will be measured during both static and dynamic tasks across three conditions: low-rocker, high-rocker, and barefoot. Static tasks include double-leg stance with eyes open and closed, and single-leg stance with eyes open and closed, while dynamic tasks include walking 8 meters back and forth across a straight path. Block randomization will be used to assign the sequence of conditions. Plantar pressure data will be collected with the Footscan V9 platform (Materialise, Leuven, Belgium) embedded flush with the walking surface (200Hz). Static stability will be assessed by measuring COP displacement, percentage of forefoot load, and COP velocity, while dynamic stability will be assessed by forefoot loading rate, forefoot pressure, and center of pressure displacement. Pressure data will be divided into three anatomical regions (forefoot, midfoot, and heel) to allow for detailed analysis. A two-way repeated measures ANOVA will be used for statistical analysis, comparing footwear conditions and task types.

Expected Results: Data collection is ongoing; it is hypothesized that high-rockered shoes will effectively reduce forefoot pressure and shift COP from the forefoot to the midfoot and heel, increasing pain relief, compared to the low-rockered shoes or barefoot conditions.

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FOOT ORTHOTICS ON TREATING CHRONIC LOW BACK PAIN

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Introduction: Chronic low back pain (CLBP) is a prevalent musculoskeletal condition that has been associated with altered gait mechanics. The literature suggests that this may be a compensatory strategy causing less time spent in single-limb support during gait [1]. However, limited research has explored the effects of footwear or orthotics on dynamic stability during gait for individuals with CLBP.

Aim: To investigate the effects of custom foot orthotics on dynamic stability in CLBP individuals, specifically assessing stability by measuring changes in the relative relationship of the centre of mass (COM) to lateral limit of the base of support (BOS) over 6 weeks of orthotic wear.

Methods: Twenty (20) participants with CLBP will be recruited and assessed for dynamic stability during gait. The Optotrak™ Certus motion capture system (Northern Digital Inc., Ontario, Canada) will be used to measure 3D kinematics and calculate COM displacement relative to the lateral limit of the BOS of the foot. Force plates (AMTI., Massachusetts, USA) will be used to assess center of pressure (COP) displacement during secondary measures of assessing stability during static and dynamic conditions. Participants will perform trials in 3 conditions: walking, standing, and a standing rotational task (reaching to the left/right). All the protocols will be performed with and without custom foot orthotics. The effects of the intervention will be assessed over the duration of 6 weeks with assessments during the 1st, 3rd, and 6th weeks. Surveys including a Visual Analog Scale (VAS) for pain rating measures and Oswestry Disability Index (ODI) for overall functional disability will be administered at these benchmarks as well.

Expected Results: It is hypothesized that foot orthotics will enhance dynamic stability indicated by an increase of the COM to lateral BOS relationship. Additionally, secondary findings may indicate improvements in static and rotational stability based on smaller COP displacements addressing a risk factor for low back issues as these movements are prevalent in occupational exposure. Improved gait stability may correlate with reduced CLBP symptoms, supporting the role of foot orthotics as a neuromechanical intervention for CLBP management.

Discussion/Conclusion: This study will contribute to the understanding of foot orthotics as a non-invasive intervention for CLBP by targeting dynamic stability during gait. This research may inform clinical practices and rehabilitation strategies aimed at reducing CLBP-related impairments to consider foot orthotics as a relevant treatment. Further studies should explore long-term effects and low back pain patient-specific responses to foot orthotic interventions.

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A COMPARISON OF THA TECHNIQUES ON POST-SURGICAL MUSCLE STATE

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Introduction: Total hip arthroplasty (THA) is among the most common orthopaedic operations, with approximately 60,000 surgeries performed yearly in Canada [1]. As the population ages there will be increased demand for THA and revision surgeries [2]. Among other factors, the sarcopenic state of patients directly influences outcomes following THA. As such, surgical approaches that enhance muscle health / sarcopenic status are desirable. While there exist novel computer-assisted THA techniques that may improve leg length parity and optimize hip center of rotation, their influence on sarcopenic status have never been assessed. **Aim:** The aim of this study was to determine if THA method influenced post-surgical sarcopenic state.

Methods: Nine participants were randomly assigned to a THA method (4 computer-navigation-assisted, 5 Standard of Care.). B-mode ultrasound images (LOGIQ E10 Ultrasound Imaging System, GE) were obtained at 3 time points (Pre-surgery, 6 weeks post-surgery, 6 months post-surgery) from 7 sites of the upper and lower limb. These images were used to calculate muscle thickness (MT) at each site, and regression equations were used to calculate appendicular lean tissue mass (ALTM) at each time point [3]. ANOVA was used to test for interactions or main effects of THA method and surgical time point.

Results: For ALTM there were no effects of time (p=0.298), THA method (p=0.125), or interactions (p=0.546) (Figure 1). Analyses of site-specific MT revealed limited effects of surgical type, but several significant effects of time. For example, MT of the lower leg (calf-region) increased from 6-weeks to 6-months post-THA by 3% for the non-surgical limb (p=0.001) and by 3.5% for the surgical limb (P=0.008).

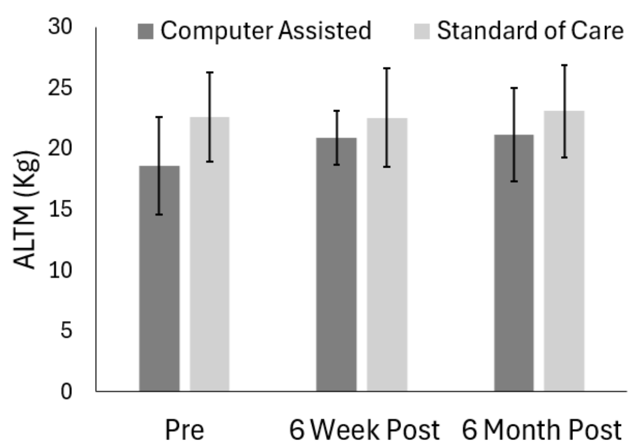

Figure 3: Appendicular lean tissue mass (ALTM) for Computer Assisted vs. Standard of Care THA methods across surgical time-points.

Discussion and Conclusion: While overall ATLM did not differ between THA methods or time points, site-specific MT differences were observed in the lower limb plantar-flexors which are critical for weight-bearing and balance control during activities of daily living including standing and reaching tasks. Towards informing pre- and re-habilitation approaches, future research should investigate how muscle mass and thickness in THA patients influence functional outcomes.

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DEVELOPMENT OF A PROGRESSIVE CYCLICAL LOADING PROTOCOL TO SIMULATE CHRONIC ACL DEFICIENT PATHOLOGY: A CADAVERIC MODEL

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Introduction: Anterior cruciate ligament (ACL) injuries are one of the most common knee injuries among active people. For various reasons, individuals either do not undergo reconstructive surgery or go undiagnosed entirely, leading to chronic ACL deficiency (CAD). A CAD knee presents significant clinical challenges due to a lack of optimal treatment options (Gopinathan, 2017). There are currently no cadaveric models that mirror the anatomical and biomechanical changes of this condition.

Aim: This study aims to develop a cadaver model that replicates CAD knee pathology through a progressive cyclical loading protocol. A valid and standardized approach will be developed that simulates the clinical presentation of CAD. advancing our understanding of progressive joint deterioration and informing clinical intervention strategies.

Methods: 12 fresh-frozen cadaveric knee specimens will undergo sequential testing phases including: i) intact assessment; ii) ACL transection to simulate ACL injury. The ACL transected specimens will be exposed to the following staircase loading protocol: with the knee positioned at 22° of flexion and a predetermined anterior tibial translation of 10mm a 1Hz cyclical loading protocol will be applied for 1000 cycles initially at 900N. After 1000 cycles the anterior translation will be increased to 13mm, at a load of 1200N. A final set if cyclical testing will occur with 16mm of anterior translation and 1500N of force. At baseline, and after each 1000 cycles of the transected ACL condition, a static 750N loading trial will be utilized and the resulting anterior translation and tibial plateau pressure distribution (via Tekscan) will be quantified. A specimen will be deemed as reaching CAD knee status if there is a minimum 30% increase in anterior tibial translation (ATT) during the static trial compared to the acute ACL-transected state (McDonald et al., 2017). The specimens will also be arthroscopically inspected after each set of cycles to quantify clinically relevant changes (e.g., meniscal damage).

Expected Results: We anticipate an increase in ATT after the ACL is transected, with further incremental increases as cyclic loading is progressed. We expect to see a higher incidence and more severe tears in the posterior horn of the medial meniscus with increasing cyclic loads. With increasing load, we predict a rise in the average contact pressure within the knee joint, along with shifts in the center of pressure and changes in contact area. These alterations in joint mechanics are expected to reflect the impaired stability and altered load distribution during cyclical loading following ACL transection that are consistent with a CAD knee.

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DETERMINING KINEMATIC JOINT VARIABILITY FOR AUTOMOTIVE ASSEMBLY WORKERS

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Introduction: Manufacturing workstations are generally designed to include short cycle repetitive tasks, where a worker will complete the same job throughout their shift to optimize production. Repetitive tasks have been associated with work-related musculoskeletal disorders as the required joints to produce the human movements are exposed to same motions leading creating mechanical stress to human tissue. This work explores the variability in joint kinematics during automotive assembly tasks completed by experienced operators over a series of work cycles. Previous work has shown that novice workers with different anthropometrics exhibit between and within subject movement variability in a lab setting [1]. However, there remains a lack of evidence to support the amount of movement variability that is experienced by automotive assembly plant workers in the workplace.

Aim: The aim of this study is to explore the kinematic variability of experienced automotive operators while they complete their repetitive work tasks.

Methods: Data was collected from an automotive assembly plant. Workers were instrumented with Xsens (Movella, Nevada, USA), a 17-sensor inertial measurement unit (IMU) system to record their movements and completed at least 30 cycles at their workstations. The recorded movements were then transferred to Process Simulate (Siemens, Texas, USA) and parsed into five tasks; two hand carry, two hand reach with push down, two hand reach near, right hand reach to side and two hand far reach. The tasks will be assessed for within participant kinematic variability to determine if the workers showed movement variability. Joint angles from the following segment/direction will be examined for variability: trunk flexion, right and left shoulder flexion, and right and left elbow flexion. Within task variability will be examined using Statistical Parametric Mapping [2].

Expected results: While this is an ongoing project we expect results to show that experienced workers to not vary their movements significantly when performing their tasks to optimize their performance while attempting to reduce fatigue.

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CUTANEOUS STIMULATION OF THE FOOT SOLE MAY MODULATE RATE OF TORQUE DEVELOPMENT IN FATIGUED FEMALES DURING PLANTARFLEXION

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Introduction: Rate of torque development (RTD), the rate at which one can generate torque, is important for balance control; with increased RTD related to increased performance and reduced fall risk [1]. Cutaneous stimulation of the foot sole evokes reflex responses in muscles that act about the ankle, with evidence of a location-dependent effect [2]. Cutaneous stimulation has also been shown to alter the recruitment threshold of high threshold motor units (MUs) [3,4]. Previous work from our lab has shown that cutaneous stimulation to the foot sole did not elicit changes in RTD in rested females [5]. It remains to be determined whether cutaneous stimulation can increase RTD in a compromised capacity (e.g. fatigue). Thus, our purpose was to explore whether cutaneous stimulation to the foot sole, alters RTD during explosive plantarflexion contractions in fatigued females, in a location dependent manner.

Methods: On a dynamometer, healthy, young females (n=3), taking a monophasic oral contraceptive, performed a series of explosive, maximal isometric plantarflexions, with instruction to contract "as fast and hard as possible." Fatigue was induced by a sustained maximal voluntary contraction (MVC) until the participant dropped below 30% of MVC and was assessed with the interpolated twitch technique (ITT). The explosive isometric plantarflexions were performed before and immediately after the fatiguing task. ITT was used to assure a fatigued state, pre and post the fatigued explosive isometric plantarflexions. Data collection was completed on three separate days, block randomized by stimulation condition: no stimulation (CON), heel stimulation (HEEL), and metatarsal stimulation (MET). Stimulation was delivered at 2× perceptual threshold. RTD was measured by the slope of torque over time, in cumulative 25ms epochs, with a focus on neural components; 0-75ms [1].

Results: As expected, in all conditions RTD decreased in the fatigued state compared to the rested state. In the 0-75ms epoch, with no stimulation, fatigue decreased RTD by 24.8%, which was, on average, mitigated with HEEL, seen by a reduction in RTD by 19.3% after fatigue, but exacerbated with MET, with a reduction in RTD by 33.0% after fatigue. This mitigated reduction with HEEL (32.1 ± 26.9%) and the increased reduction with MET (-26.3 ± 18.2%), compared to CON, suggests that participants are better able to maintain their RTD with HEEL, and are less able to maintain RTD with MET. However, there was high individual variability across conditions. For example, each of the three participants elicited a different response for HEEL: one improved, one showed no change, and the final worsened.

Discussion: Our preliminary findings suggest that cutaneous foot sole stimulation may modulate plantarflexion RTD in fatigued females. Although initial trends support a location-dependent response, clear patterns have not emerged. In addition to increasing participant numbers, we will explore individual fatiguing patterns and contraction strategies as sources of variability.

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ADVANCED MASSAGE APPLICATION IN AUTOMOTIVE SEATING

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[2]Leggett & Platt Automotive Group, Windsor, ON

Introduction: Individuals engaged in prolonged periods of motor vehicle operation face an elevated risk of developing musculoskeletal disorders, as well as mental and physical fatigue [2, 3, 4]. Maintaining a fixed, static posture during prolonged sitting requires the continuous engagement of back, neck, shoulder, and arm muscles, leading to static muscular tension [1, 2, 3, 4]. Fatigue has been linked to decreased reaction times and an increased risk of motor vehicle accidents [4]. In order to mitigate these negative side effects and create safer driving conditions, vibration solutions are being explored. The purpose of this study was to determine whether calculated vibration pulsing could help energize users and promote alertness.

Methods: Participants underwent three conditions to evaluate the effectiveness of a biometric vibration pulse function while seated in an instrumented car seat. In each condition, participants watched a driving video that included a 5-minute baseline and a 5-minute cool down period. In Condition 1, a 20-minute pulsing vibration massage was applied, with the pulse rate starting at each participant's baseline heart rate and increasing linearly by 50%. Condition 2 used the same temporal pattern as Condition 1, over a 5-minute period. In Condition 3, the 20-minute massage featured a vibration pulse rate that increased in 10% increments of the baseline heart rate, holding each increment for 3 minutes and 33 seconds until reaching a 50% increase. Multiple physiological measurements were collected to determine the effectiveness of the massage system. Heart rate was monitored using a Polar Verity Sense (PPG) sensor (Polar Electro Oy, Kemple, Finland) and a Shimmer3 ECG unit (Shimmer, Boston, USA). Respiratory rate was measured with the BIOPAC RSP100C (BIOPAC Systems Inc., Goleta, California). Subjective feedback was collected through surveys to assess the effectiveness of the different conditions.

Results: Contrary to our initial hypothesis, participants' heart rates did not gradually increase over time during the biometric massage sessions in any of the three conditions. Repeated measures ANOVA showed no significant effect of time on heart rate in Condition 1 $F(19, 266)=0.546$, $p=0.940$), Condition 2 $F(4, 52)=0.535$, $p=0.711$), or Condition 3 $F(19, 171)=1.096$, $p=0.359$). Despite the lack of measurable response, subjective feedback from Condition 1 and Condition 2 indicated that 73% of participants rated it as at least somewhat energizing overall.

Discussion and Conclusions: Although tailored to participants' baseline heart rates, the biometric massage system, as implemented in this study, did not produce measurable changes in cardiovascular activity. Future studies should explore its effects in varied environments.

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COMPARING DIGITAL HUMAN MODEL OUTPUTS BETWEEN SEVERAL BODY TRACKING MODALITIES IN VIRTUAL REALITY

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Introduction: Digital human models (DHMs) enable proactive ergonomics assessments for tasks not yet realized in physical environments. While posture prediction and manual joint manipulation of DHMs are common, integrating immersive virtual reality (VR) and motion capture into DHMs offer a more efficient alternative [1]. Real-time joint angle tracking accuracy remains a barrier to widespread adoption. This study evaluates DHM-driven spine compression, as well as torso, shoulder, and elbow joint angles, using different motion capture systems in VR-based task simulations.

Methods: 16 participants (8M, 8F) were instrumented with Vicon reflective markers, XSens sensors, and HTC Vive 3.0 trackers. An HTC Vive Pro 2 VR headset was used to visualize a grasp-and-place task created within the *Process Simulate* DHM software. Nine equidistant grid targets were set on three table heights in VR. Motion data from the three systems were streamed into *Process Simulate* to dynamically posture a participant-scaled DHM. Mixed effects models were used to compare interactions between each system and target locations for joint angles, and spine compression with the three motion capture systems, table heights, and target locations as fixed effects.

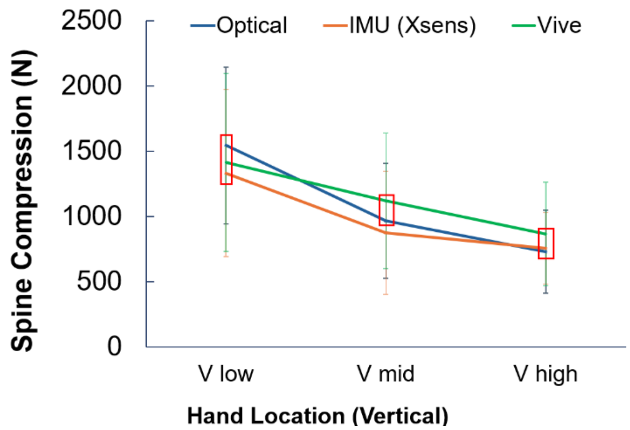

Figure 1: Spine compression DHM comparisons across 3 virtual table heights.

Results: Spine compression (Fig. 1) was most affected at the lowest table heights. The IMU-driven spine compression was 82 N lower than the Vive-driven model (6% difference). The IMU-driven model underestimated shoulder and elbow flexion angles up to 40° compared to the Vive-driven model, specifically at the furthest horizontal and tallest targets.

Discussion and Conclusions: This study concludes that the IMU-driven models consistently underestimate joint angles and spine compression for VR-based ergonomics simulations when compared to optical and Vive-driven DHM models. Future work is needed to verify validity of the DHM joint angles in comparison to a gold-standard.

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CAN ABDOMINAL BRACING AND HIP MOTION COACHING ACUTLEY REDUCE LUMBAR FLEXION ANGLES AND EXTENSOR MOMENTS DURING LIFTING?

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Introduction: Lifting is common in activities of daily living, recreation, and exercise. High magnitudes of lumbar spine flexion while under load can reduce the failure tolerance of the lumbar spine, alter load distribution across tissues, and compromise extensor muscles' capabilities to resist anterior shear forces; and is therefore linked to greater low back injury risk [1,2]. Increasing lumbar spine stiffness through abdominal bracing, while redistributing motion and load demands to the hips, may help minimize lumbar spine flexion angles and extensor moments during lifting [3,4].

Aim: To determine if abdominal bracing and hip motion coaching while quadruped performing heel rocks can acutely reduce lumbar spine flexion angles and extensor moments during lifting.

Methods: 14 female athletes participated (20.6 ± 1.3 years, 1.63 ± 0.05 m, 65.1 ± 11.9 kg). Passive motion capture and force plates collected full-body kinematics and ground reaction forces. Linked segment models and bottom-up inverse dynamics were used to calculate 3D joint angles and net joint moments of the trunk and lower extremities. Participants performed three repetitions of floor-to-waist lifting and lowering of a box under two randomized load conditions: light (1 kg) and heavy (15 kg). Next, participants were coached how to abdominal brace to minimize spine motion and facilitate hip motion while quadruped performing heel rock movements [5]. Following coaching, participants performed light and heavy lifting tasks again with no other instructions.

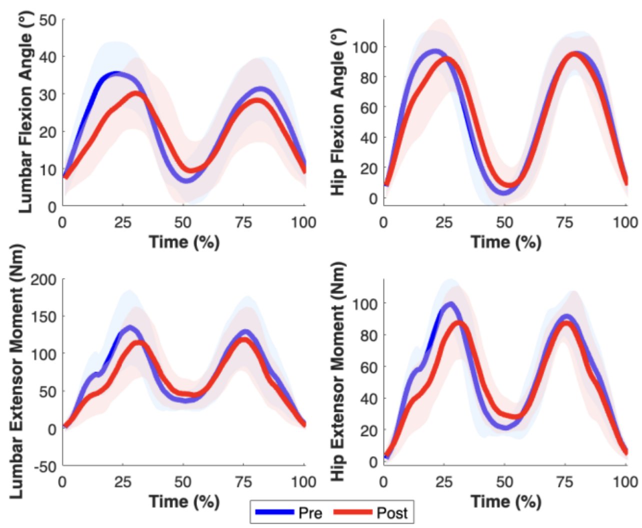

Figure 4: Group ensemble averages of lumbar spine and hip angles and moments for pre- and post-coaching during the heavy lifting condition (shaded area = standard deviation).

Preliminary Results: Qualitatively, peak lumbar spine flexion angles and extensor moments appear to slightly decrease post-coaching during the lifting phase (0-50%) but not the lowering phase (50-100%). Unexpectedly, hip flexion angles were unchanged while peak hip extensor moments decreased in the lifting phase. Changes in movement strategy to reduce lumbar spine angles and moments do not appear to be coming from the hips, suggesting motion and load demands could be shifted elsewhere, such as the knees. Next steps will include characterizing movement strategy considering all joints of the lower extremities, analyzing trunk and hip muscle activation patterns, and performing repeated measures MANOVA on the variables of interest.

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EXPLORING MAXIMAL SHOES AS A VIABLE INTERVENTION FOR MITIGATING LOW BACK PAIN DURING PROLONGED STANDING IN HEALTHCARE PROFESSIONALS

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Introduction: Low back pain (LBP) costs Ontario on average $330 million annually and is a leading workplace-developed musculoskeletal disorder (MSD) [1]. One industry that is largely affected by LBP is the medical field. In a survey completed by nurses 27.8% attributed their LBP to prolonged standing, highlighting the concern surrounding prolonged standing and LBP development in this population [2]. It is well established that a 50% of individuals are susceptible to acute LBP during prolonged standing [3-5]. In response, many workplaces have adopted improvised standing positions and standing aids. However, these interventions typically require remaining in a fixed position making them impractical for healthcare workers who must remain mobile. Thus, there is a need for investigations into possible interventions to mitigate LBP development without compromising healthcare workers ability to perform their jobs.

Aim: This thesis aims to evaluate the effectiveness of maximal shoes as an intervention to mitigate LBP development in healthcare professionals.

Methods: Twenty (N=20) female healthcare workers will be asked to complete two collections: a control shoe day and a maximal shoe day. On both days, participants will be instrumented with EMG (Noraxon Ultimum, AZ, USA) and full body motion capture (Vicon Nexus, Oxford, UK). They will complete five “Pre-Standing Gait Trials”, 75min of prolonged standing, then five “Post-Standing Gait Trials”. Gait trials will monitor peak lumbar flexion angle, peak knee adduction moment, and knee flexion angle upon initial contact. The prolonged standing trial will monitor: pain, lumbar spine angle, co-contraction index (CCI), and cross correlation of all trunk muscles.

Expected Results: We hypothesize that maximal shoes will decrease LBP in health care providers during prolonged standing, driven by a decrease in muscle co-activation and a shift toward a less lordotic posture.

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QUANTIFYING UPPER EXTREMITY DEMAND IN HIGH AND LOW SKILL E-SPORT GAMERS DURING COMPUTER GAMES

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Introduction: E-sports is a fast-growing global industry. Elite and professional e-sports gamers are playing upwards of 10 hours every day [1]. Health care professionals have identified the development of tendinopathies and other overuse upper extremity injuries, including carpal tunnel syndrome and De Quervain syndrome as an increasing concern for e-sport gamers [2]. Quantifying the demands placed on the upper extremity during gaming is necessary for the design of chairs and workspaces which mitigate the risk of these disorders, while maintaining or improving performance.

Aim: This study aims to quantify the upper extremity demands in low skill and high skill e-sport gamers during training and competitive gameplay, completed in two different gaming chairs. Specifically, shoulder and hand postures, upper extremity movement strategies, and game productivity and performance will be evaluated.

Methods: Sixteen participants will complete twenty-minute blocks of two training games (osu! and Aimlabs) and a block of competitive gameplay (Valorant) in two commercially available gaming chairs (Herman Millar Embody and Secretlab Titan Evo). Shoulder (thoraco-humeral) postures will be calculated from the position of markers on the thorax and upper arm (Qualisys). Hand postures will be calculated from an overhead 2D video camera processed in MediaPipe. The contribution each joint to hand motion, will be evaluated by comparing the total distance traveled by each joint (shoulder, elbow, wrist) and the total distance travelled by the hand. Productivity will be quantified with mouse and keyboard inputs, including mouse distance travelled and mouse and key clicks (WhatPulse). Game performance will also be quantified from game-specific score metrics. Three-way mixed ANOVAs will be used to compare between game blocks (3 levels), chairs (2 levels), and skill groups (2 levels).

Expected Results: Low skill gamers will demonstrate increased use of the upper extremity and lower game productivity and performance, as they will make more correctional movements than high skill gamers [3]. Moreover, compared to high skill gamers, low skill gamers are expected to exhibit more proximal joint contributions, thereby indicating that for low skill gamers, the proximal segments provide a less 'stable base' for hand movement.

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ASSESSING MOTION CAPTURE ACCURACY IN AUTODESK MAYA'S QUICK RIG: THE IMPACT OF ANTHROPOMETRIC VARIABILITY

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Introduction: Marker-based motion capture accurately describes human kinematics but requires extensive calibration, controlled environments and costly infrastructure. To address these challenges, industry may integrate digital twins to simulate and analyse ergonomic performance early in the design phase to identify issues (1). Integrating biomechanical data into these digital twins allows virtual testing of human performance during complex simulated tasks. A key step in this process is translating motion capture data into industry-standard platforms like Autodesk Maya's MotionBuilder, which, while developed for entertainment and animation, is now being used in ergonomics and industry simulations (2). This research investigates MotionBuilder's performance in animating humanoid avatars across a diverse participant group with varying anthropometric profiles using its Quick Rig function. The work will evaluate how accurately it maps motion capture data across different body types and motions of the upper extremity.

Methods: Thirty university age participants (20m/20f) will be observed, based on prior motion capture validation studies (3). Exclusion criteria will include a history of upper extremity or torso disorders or pain within the past year. Upper body kinematic data for 12 markers and 4 marker clusters on the upper limbs and torso will be captured using a Miqus M5 optoelectronic system (Qualisys, Gothenburg, Sweden), and then will be translated to Maya MotionBuilder Quick Rig (Autodesk Inc., San Rafael, CA, USA) standard function for all participants. Participants will complete three desk-level, and three overhead movement tasks designed to simulate common factory activities encountered in manufacturing environments. Joint angle accuracy of the digital twin movement will be evaluated using Mean Absolute Error (MAE) and Root Mean Square Error (RMSE) (3) compared to the motion capture data. Statistical parameter mapping (SPM) will identify time-series differences in motion profiles, allowing for a frame-by-frame statistical comparison of movement trajectories (3).

Expected Results: This study will examine how deviations from standard anthropometric models affect joint angle accuracy in markerless motion capture. We expect errors to increase as limb proportions diverge from the default rig, especially in overhead tasks involving complex shoulder mechanics. Findings will highlight the limitations of generalized models that ignore link co-variance which can distort motion tracking in non-average body types. Results will inform when customized rigs or subject-specific calibration are needed to preserve biomechanical realism in ergonomic assessments within industrial settings.

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FINITE ELEMENT MODELING TO SIMULATE GYMNASTICS-TYPE LOADING IN ADOLESCENT WRISTS

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Introduction: Skeletally-immature gymnasts are at increased risk for distal radial epiphysitis, otherwise known as Gymnast Wrist (GW), due to their repeated exposure to compressive and torsional loads at the hyperextended wrist [1,2]. Finite element (FE) modelling has proven valuable for advancing knowledge on injury biomechanics in a manner that is safe and ethical. However, previous FE models have neither examined gymnastics-type wrist loading nor have they modelled the distribution of loads across the open distal radial physis of an adolescent with GW.

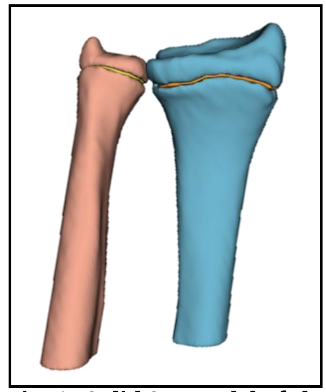

Fig. 1: Solid 3D model of the radius (blue) and ulna (pink)

Aim: To develop an FE model of the GW affected wrist to estimate the magnitude and distribution of the loads experienced across the open physis of patients during a common gymnastics task.

Methods: A CT scan of a GW affected wrist was obtained from a single adolescent female gymnast (age = 14 years). The solid 3D geometry of the distal radius and ulna were developed in 3D Slicer (The Slicer Community, Boston, MA; Fig.1). A semi-automatic threshold-based technique was applied to segment each bone and subsequently separate the cortical, trabecular, and physeal bone regions. The model was further smoothed and meshed in 3-Matic (Materialise, Leuven, BEL). The forces experienced at the wrist during a handstand, measured from a current in vivo study, will be applied to the meshed model in Abaqus (Dassault Systèmes, Vélizy-Villacoublay, FRA; Fig. 2). The principal stresses and strains through the radius and ulna, as well as the contact pressures experienced at both the epiphyseal-physeal and metaphyseal-physeal interfaces, will be estimated.

Fig. 2: Smoothed and meshed model of the radius and ulna

Expected Results: High magnitudes of wrist stress and strain are expected to occur across the open physes of the distal forearm. As clinical reports for GW often cite damage to the volar ulnar corner of the distal radial physis [3], the stresses and strains are expected to be concentrated in this region. This will help to explain the pathological findings common in those with GW, as well as the increased risk for patients to develop various sequalae.

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THE EFFECT OF MENTHOL ON SKIN SENSITIVTY OF THE FOOT DORSUM

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Introduction: Cutaneous mechanoreceptors are important for balance and posture [1]. Temperature has been shown to alter the firing of cutaneous afferents, with cooling causing a decrease in afferent firing rate [2] and heating increasing afferent firing [3]. Changes in temperature are known to activate temperature sensitive ion channels (Transient receptor potential (TRP)) [2]. TRPM8, in particular responds to cold environmental temperatures [3] and icing of the foot sole has been shown to decrease skin sensitivity. Menthol, an agonist for TRPM8 channels, is known to induce a cold sensation. Interestingly, 10 minutes after topical menthol application, there is a vasodilation of cutaneous blood vessels [4], which has been shown to increase skin sensitivity [5]. Therefore, we aimed to use topical menthol application to examine changes in skin sensitivity as a result of direct TRPM8 activation. We hypothesize that the application of menthol will affect skin sensitivity in a time-dependent manner, specifically, by decreasing skin sensitivity in the first 10 minutes after application, before increasing again due to increased cutaneous blood flow.

Methods: 11 healthy participants (7F; Mean age 21.2±1.1) were tested. Two testing sessions were conducted on separate days for all participants; base cream (sham) or 10% menthol mixture applied to the dorsum of their foot. Perceptual threshold was tested using Semmes-Weinstein monofilaments, conducted before, 5, 10, 20, 30 and 40 minutes after cream application. Cream was applied to a 2x4 cm square across the ankle. The temperature of the foot dorsum was measured along with the participant's perception of temperature at these time points.

Results: Currently, no significant differences were found between the two testing creams across time points. At 5 minutes following cream application, a slight increase in sensitivity was observed for the menthol versus the base cream, which was contrary to our hypothesis with later time points trending toward a decrease. The variability of the results to date are likely due to our study being underpowered.

Discussion and Conclusion: We aimed to understand if TRPM8 was involved in the changes in sensitivity of the skin via channels or blood flow based on timing. Monofilaments are designed to assess changes in sensitivity of cutaneous mechanoreceptors, specifically targeting dynamic receptors. While our results are not conclusive, this may be due to the limited effect of menthol on this receptor type. As such, while there might be limited effects of menthol on monofilament perceptual thresholds, further research may need to explore other sensory tests to target other cutaneous receptors.

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EXPOSURE EFFECTS OF BIOFEEDBACK ON QUIET STANCE

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BACKGROUND & AIM: Balance control requires the multisensory integration of visual, vestibular, and somatosensory systems. Providing individuals with biofeedback, such as in the form of vibrotactile feedback or enhanced optic flow, has been shown to improve postural control [1,2,3]. However, there is limited work on the combined effects of vibrotactile and visual biofeedback on postural control. The purpose of this study was to identify the relationship between exposure time, vibrotactile feedback, and modified optic flow gain during quiet stance.

METHODS: Forty-five young adults stood on a foam pad for 70 seconds with their stance width standardized to their foot length. Participants wore a single inertial measurement unit strapped at the level of the L5 vertebrae to record trunk movement. A virtual reality head-mounted display displaying an art gallery to the participants was used to modify visual optic flow (i.e., the amount of visual motion relative to head motion), while vibrotactile units were strapped to their upper right arm, upper left arm, upper abdomen below the xiphoid process, and at the level of the T6 vertebrae to provide tactile biofeedback. Participants completed three baseline trials to obtain their quiet stance threshold for vibrotactile feedback. There were six experimental trials in which vibrotactile feedback (on vs. off) and optic flow gain (nulled 0x, unaffected 1x, or amplified 4x) were manipulated. Vibrotactile feedback was provided when participants swayed beyond a threshold of ±40% of their 90% range [4]. After removing the first 5 seconds of data, the first (early) and third (late) 20 second windows were analyzed and compared to quantify the effects of biofeedback exposure. The amplitude of angular displacement and velocity, and regularity of velocity, were analyzed and used to quantify balance behaviour.

RESULTS: The amplitude of angular displacement and angular velocity were affected by time and gain, while only velocity was affected by tactile biofeedback. In the late window compared to the early window, both angular displacement and velocity decreased. In addition, angular displacement and velocity decreased in the amplified (4x) condition compared to the nulled (0x) condition. Finally, angular velocity was increased when tactile biofeedback was on (compared to off) while angular displacement was not affected. There were no significant main or interaction effects on regularity.

CONCLUSIONS: Angular velocity and displacement decreased when visual biofeedback was amplified, while the addition of tactile biofeedback only increased angular velocity. The lack of interaction effects between tactile feedback and visual gain suggest that combined tactile and visual biofeedback do not improve postural stability. In addition, exposure time did not improve the effects of either biofeedback type on postural stability. Practice trials and training may aid in familiarizing participants with biofeedback sensations, which may improve postural stability. Further work is needed to examine the interaction between vibrotactile feedback and augmented optic flow in populations who may have balance deficits.

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THE INFLUENCE OF FOREARM SUPPORT AND FOREARM POSTURE ON UPPER ARM MUSCLE ACTIVITY DURING ISOMETRIC WRIST CONTRACTIONS

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Introduction: Despite no direct attachments crossing the hand or wrist, the muscles of the upper arm exhibit elevated muscle activity during isometric wrist contractions [1]. This behaviour suggests that upper arm muscles may be at risk of developing musculoskeletal disorders in workplace tasks with frequent and/or intense wrist actions. Although supportive devices have been shown to reduce muscle activity [2], it is not yet clear how effective supporting the forearm might be at reducing upper arm muscle activity. It is also unclear how this reduction might be influenced by the orientation of the support (either below, above, or to the right or left of the forearm).

Aim: The purpose of this study is to determine how forearm supports influence upper arm muscle activity during isometric wrist contractions in different contraction directions.

Methods: Muscle activity will be collected from the biceps, triceps, and brachioradialis. Participants will be seated with their forearm in supination, pronation, or neutral with a force transducer placed either above, below, or to the right/left of the hand. In each posture, participants will perform isometric wrist flexion, extension, and radial/ulnar deviation at 25, 50, and 75% of maximal wrist extension. Conditions will be repeated with the forearm supported and unsupported. For the supported conditions, the forearm will be supported in opposition to the contraction direction (ex: for upwards wrist actions, support will be provided below the forearm). Supported muscle activity will be subtracted from the muscle activity produced in the unsupported conditions.

Preliminary Findings: Forearm support appears to reduce upper arm muscle activity in most postural conditions, although the magnitude of this reduction is strongly influenced by wrist contraction direction. For the biceps brachii, the largest reductions occur when the wrist is exerting force upwards or to the left (Figure 1). For the triceps brachii, these reductions are largest when wrist forces are exerted downwards or to the right.

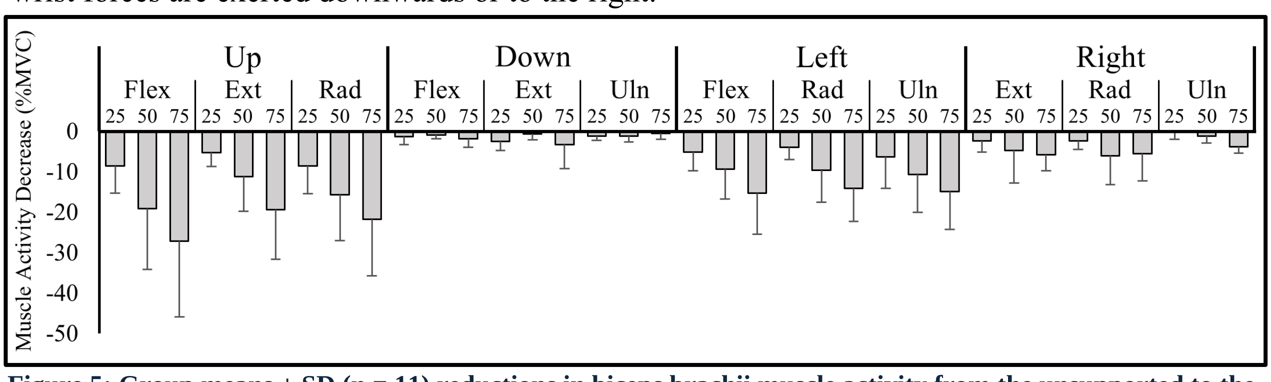

Figure 5: Group means ± SD (n = 11) reductions in biceps brachii muscle activity from the unsupported to the supported conditions. Directional terms describe the direction of the exerted wrist force.

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VALIDATING A FORCE MEASURING GLOVE FOR USE IN DISTAL UPPER LIMB ERGONOMIC ASSESSMENT TOOLS

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Introduction: Work-related musculoskeletal disorders (WMSDs) of the upper limb result from repetitive force and awkward upper limb postures causing cumulative damage to soft tissues [1]. Measuring hand and finger forces in the field poses a challenge as instrumenting objects with force transducers is not always feasible. For this reason, ergonomists must rely on subjective ratings of exertion when using upper limb assessment tools such as the Strain Index [2]. This lack of objectivity can lead to inconsistency between raters and tasks as these assessment tools are highly sensitive to small changes in force [3]. Attempts have been made to estimate hand forces using compact pressure mapping systems however, this technology is prone to limited range, drift, and low sampling rates making them inadequate for measuring force reliably [4].

Aim: To determine the validity and reliability of a novel force-measuring glove compared to traditional lab-grade force transducers during complex gripping tasks.

Methods: Twenty participants will complete a series of trials across two experimental sessions while wearing the AXS Force Glove (AXS Motion System Kft). In Session 1, participants will perform a total of 136 isometric contractions involving finger flexion (digit sensors) and wrist flexion (palmar sensors) against a load cell (DSHW-108, Desnete, Guangdong, China). For each sensor, participants will begin with three maximum voluntary contractions (MVCs), followed by three trials at 20% MVC, 50% MVC, 10 N, and 50 N. Additionally, participants will complete two 2-minute static contractions at 30% MVC for each sensor. Next, participants will perform five complex grips, including power grip, lateral pinch, chuck, tip pinch, and pulp pinch, in a neutral wrist position using a grip load cell (MIE Medical Research Ltd, Leeds, UK). For each grip, participants will perform five MVCs (totalling 25 MVCs) and two ramp protocols from 0 to 50% MVC (totalling 10 ramps). In Session 2, participants will replicate the full protocol from Session 1 to assess test-retest reliability. Sensor accuracy and hysteresis will be evaluated using intraclass correlation coefficients and Bland-Altman analysis, while within-subject reliability across sessions will be assessed using repeated measures ANOVA.

Expected Results: It is expected the glove and load cell will be in strong agreement with a good-excellent ICC value (0.75-0.95). It is expected differences between the glove and load cell will be represented by a regular “bias” which can be adjusted through calibration. Referring to dynamic gripping, it is expected grip force will be best represented by a dynamic weighting of each sensor value into a cumulative sum that is task specific. Session-session values are not expected to be significantly different indicating reliability in line with lab grade-load cells.

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INVESTIGATING THE SENSITIVITY OF LUMBAR MICROMOVEMENT ALOGORITHMS IN SITTING AND STANDING OFFICE WORK

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Introduction: Sedentary exposures are characterized by relatively small spine movements, termed shifts and fidgets [1]. Shifts are defined as step-like angular changes in lumbar angle and fidgets as small rapid changes of the lumbar angle about the same average position. Shifts and fidgets facilitate load and fluid distribution in sedentary exposures, which may be linked to a reduction in low back pain. Algorithms to characterize such micromovements differ across sedentary exposures (i.e., sitting vs. standing) and current algorithms were developed in controlled laboratory settings, and therefore may not reflect the kinematics of sitting and standing in more dynamic contexts (i.e., field work) [2].

Aim: The objective of this study is to assess the sensitivity of lumbar micromovement algorithms with respect to detecting postural movement patterns during computer work completed in both sitting and standing.

Methods: Sixteen participants (8 females, 8 males, age: 18-35 years) will complete two-hours of seated and standing office work. Participants will perform 15-minute blocks of reading comprehension, typing, and data entry tasks on a computer each hour. Triaxial accelerometers (ADXL335, Analog Devices, MA, USA) will be fixed at the first lumbar and sacral and be used as tilt sensors to measure the relative inclination of the thorax and pelvis to calculate lumbar flexion angles. The shift micromovement algorithm [1] will be applied in an iterative manner to the time-varying lumbar spine flexion angles with different combinations of parameters (window size: 2, 4, 8, 16, 32 seconds; absolute difference threshold: 1-10 degrees; gap size: 1-3 seconds) for both sitting and standing blocks. In the same manner, the fidget algorithm [1] parameters will also be varied (window size: 15, 30, 45, 60 seconds; maximum duration: 1-5 seconds) and used on the sitting and standing lumbar angle time series data. Mixed ANOVAs (α= 0.05) will be used to examine the effects of posture, window size, absolute difference threshold, and gap size on the total number of detected shifts and the effects of posture, window size, and maximum duration on the total number of detected fidgets.

Expected Results: It is hypothesized that as window size and absolute difference threshold increases, the number of shifts identified will initially decrease, then plateau. This may lend itself to characterizing movements of different durations and magnitudes. Since the fidget algorithm relies on the standard deviation of a moving window, it is hypothesized that larger window sizes and longer maximum durations will yield large variability in the moving windows and hence, fewer fidgets.

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A DESCRIPTIVE ANALYSIS OF TACKLING TECHNIQUES IN YOUTH FOOTBALL

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Introduction: American football has come under scrutiny due to the heightened risk of concussions and head injuries present in the game. While much research on head injuries in football has been focused on high school, college and professional athletes, there is limited understanding of how youth players respond to head impacts. Improper tackling techniques, such as leading with the head or using poor body alignment, are major contributors to the high rates of head injuries, including concussions, in football [2]. This study aims to describe the tackling techniques used by youth football players across three age groups (9-12, 13-14 and 15-16 years).

Methods: Tackling events from video records of football games (2018-2019) involving players from three different age groups [9-12 years: ATOM (A), 13-14 years: Bantam (B), and 15-16 years: Junior Varsity (JV)] were evaluated [1] on criteria such as contact method, head position, balance, rib protection and anticipation. Video data were captured using an 11-camera GoPro system [1] which provided comprehensive multi-angle views of tackling events. Tackling techniques were evaluated using validated frameworks, the Qualitative Youth Tackle Scale [3] and grading scale [2].

Results: Sixty-eight tackles were analyzed across the age groups [A(9), B(47), JV(12)]. Over 87% of tackles across the three age groups were in a head-up position. A head-across-the-bow technique was observed in 44.4%, 25.5%, and 41.7% of A, B, and JV tackles, respectively. JV strikers (those executing the tackle) exhibited significant improvements in hip and knee alignment compared to A players ($p=0.016$). There was a greater tendency for tacklers to strike below the waist in A players compared to JV players ($p=0.043$). There were no significant differences in balance, rib protection and anticipation across the age groups ($p>0.05$).

Discussion and Conclusions: These results suggest that, while positive tackling fundamentals were present across all three levels evaluated, tackling technique execution improved with age. The frequent use of the head-across-the-bow technique by all age groups is a concern, as it is associated with more frequent and severe head impacts [2]. This study highlights the importance of reinforcing proper tackling technique through targeted coaching programs. It also underscores the need for further research evaluating tackling techniques in real-game contexts to better inform injury prevention strategies in youth football.

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QUANTIFYING PASSIVE ELASTIC MODULUS IN ERECTOR SPINAE FIBRE BUNDLES FROM CANINES TREATED FOR INTERVERTEBRAL DISC EXTRUSION

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Introduction: The passive mechanical properties of spinal musculature play a role in spinal stability and movement control. While much research has been conducted on human and rodent models [1][2], limited data exist on the elastic modulus of canine erector spinae (ES) muscles. Understanding these properties in canines suffering from lumbar spine injuries is valuable for both veterinary applications and comparative biomechanical studies.

Aim: To quantify the passive elastic modulus of canine ES muscle fibre bundles in dogs undergoing surgery to treat intervertebral disc extrusion.

Methods: ES muscle biopsies will be collected from dogs undergoing emergency hemilaminectomy surgery for the treatment of intervertebral disc extrusion. The muscle samples will be permeabilized and stored at -80°C. When ready for testing, the samples will be placed in a relaxing solution and further dissected into bundles of 6–10 fibres ensheathed in their extracellular matrix. These bundles will then be secured to both a force transducer and a high-speed motor using suture ties. Each fibre bundle will undergo a series of 8–11 rapid cumulative stretches of ~0.2 μm/sarcomere increments with a 120-second relaxation period before recording force outputs and beginning the following stretch. Sarcomere length will be measured using laser diffraction at slack length and after each stretch-relaxation period. A quadratic curve fit will be applied to the stress-sarcomere length curves. The slope of this curve will be used to determine the passive elastic modulus at varying sarcomere lengths.

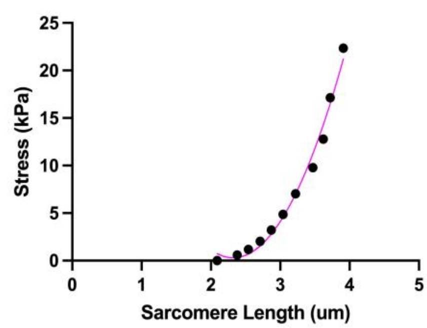

Figure 1: A representative stress-sarcomere length curve of a fibre bundle with a 2nd -order polynomial line of fit.

Expected Results: The stress-strain relationship in these canines is expected to follow the non-linear curve observed in other skeletal muscle models. Differences in elastic modulus between dogs may be seen due to variation in dog breed and medical history.

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ESTABLISHING THE INFLUENCE OF UPPER EXTREMITY KINEMATICS ON COMMAND ACROSS PITCH TYPES IN ELITE LEVEL BASEBALL PITCHERS

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Introduction: Little is known how kinematic variability may affect pitch command (precision). Primarily, past pitching research explored kinematic influences on velocity development [1], injury prevention [2], skill level differences [3], and pitch types [4]. These studies neglected to assess command, or the ability to throw pitches in the strike zone. Ignorance of factors affecting command may negatively affect career outcomes as athletes progress (Table 1) [5].

Aim: To investigate how upper extremity kinematics influence command for multiple pitches.

Methods: Participants will be screened, to ensure they are actively playing, have not had an arm injury, and throw a fastball variant (FF, FT, FC, FS), an off-speed variant (CH, SP, FK) and a breaking ball variant (CB, SV, SW, SL). They will provide baseline average velocity from a max intensity bullpen within the last 2 months. In each session, participants will do their individual warm-up and up to 8 warm-up pitches prior to collection. 24 pitches (8 each of Fastball, Breaking Ball, Off-Speed), will be thrown in a randomized order (to emulate game scenarios) from an indoor pitching mound to a target at the centre of a strike-zone projection, 60"6' from the pitching rubber. All pitches must be thrown within 5% of their self-reported average velocity, or they are discarded from analysis. Kinematic data will be collected using 12 Qualisys Miqus M3 Hybrid Cameras (Qualisys Inc., Gothenburg, Sweden). Thoracohumeral, scapulothoracic, elbow and low back joint angles and angular velocities for each pitch will be calculated from motion data using Matlab. Data for each pitch type will be normalized to percent pitch time. Statistical parameter mapping (SPM) will be used to compare time-series kinematic parameters across each pitch type in the context of strike percentage and command score, with particular focus on the discrete times of arm cocking, maximum external rotation and ball release. Variability in kinematics will also be documented.

Expected Results: Three groups will likely emerge: those struggling to throw strikes (low command), those who can throw strikes with one pitch (middle command), and those who can throw strikes for multiple pitches (high command). All groups will demonstrate variability across and within pitches, with most in the low command group, and least in the high command group.

Level [5]	Complex (Rookie)	All Leagues (A)	Midwest League (A+)	Texas League (AA)	Major League Baseball
Walks per 9 innings pitched	**5.32**	**4.48**	**3.97**	**3.85**	**3.07**

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QUANTIFYING SPINE AND SHOULDER KINEMATICS DURING TWO PERSON PATIENT HANDLING TASKS

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Introduction: Nurses are a vital piece in healthcare systems worldwide, but their jobs are often disrupted by musculoskeletal injuries that are sustained during complex patient handling tasks. 1 in 3 nurses reported that they experienced pain that affected their ability to complete tasks required for their job [1]. Patient care activities account for 80% of the cumulative compression force on the lumbar spine and cause peak spinal loads of up to 4700 N [2]. Many ergonomic interventions have been explored to reduce loading on the spine during patient handling. Safe lifting guidelines and practices vary across hospitals, demonstrating little consistency both between hospitals, and governing organizations. There is extensive research on patient handling biomechanics, however there is very little focus on multi-person transfer tasks in the healthcare realm. A study that evaluated 6 different patient transfer techniques with 2 anthropometrically different female nurses (150cm/64kg vs.178cm/95kg) found that the taller nurse had an average of 19% more compression force when compared to the smaller nurse [3]. Many tasks completed during patient care, including repositioning in bed, bed to chair and sit to stand in bed require >1 nurse to complete.

Aim: To assess spine and shoulder kinematics on two nurses during patient handling tasks. This work will take both nurse and patient anthropometrics into account through repeated sampling.

Methods: Nursing students from Brock University will be recruited for this study. Approximately 80% of the 2025 student cohort will be sampled. The participants will attend three sessions (S1-3). Anthropometric data regarding height, mass, age, and lifting capacity will be collected at S1. S2 will consist of participants performing 5 trials of 3 distinct patient handling tasks with a partner of similar stature. S3 will mirror S2, however partners will have varying statures. As such every participant will complete lifting tasks twice. Representative patient height and weights will vary. Kinematic data will be acquired through eight RX0 II cameras (Sony, Tokyo, JPN) and data will be post-processed through Theia3D (Theia Markerless, Ontario, CAN) and Visual 3D (Has Motion, Kingston, Ontario, CAN).

Expected Results: There will be a lifting imbalance between the pair in each condition. It is anticipated that the larger nurse will have more spinal flexion and support more load during each task. Meanwhile the smaller nurse is expected to have more shoulder flexion to maintain the load. As for the anthropometrically matched nurses, the weight of the patient will be evenly distributed across both nurses, such that neither nurse is disproportionally burdened.

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