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GENERAL INFORMATION

Welcome to the 2026 Ontario Biomechanics Conference!

The annual Ontario Biomechanics Conference (OBC) celebrates the diverse and innovative biomechanics research taking place across Ontario, while creating a welcoming, supportive space for students to connect, share ideas, and showcase their work. At its core, OBC is about the student experience—offering opportunities to present research, lead sessions, and engage in meaningful discussions within a friendly and encouraging environment.

Since its beginnings in 2004 with just 41 abstracts, OBC has grown into a vibrant and highly anticipated event, now featuring nearly 150 abstracts and welcoming over 220 attendees. What began as a centrally located gathering has evolved into a rotating conference hosted by universities across Ontario, giving participants the chance to experience different campuses, explore biomechanics programs, and connect with research communities throughout the province.

This year, we are excited to welcome you to Western University in London, Ontario. Conference sessions will be held in the Physics & Astronomy Building and the Natural Sciences Centre, both situated in the heart of Western's beautiful campus. The dinner banquet will take place at Clare Hall, perched atop Brescia Hill—offering a memorable setting to relax, network, and celebrate.

Complimentary parking will be available at Ontario Hall for guests staying in campus residence.

We look forward to welcoming you to an engaging and inspiring OBC experience!

Address:

PA&B and NSC Buildings, Ontario Hall and Clare Hall
1151 Richmond Street
London, ON, Canada, N6A 3K7

Map Links:

Physics and Astronomy Building: https://maps.app.goo.gl/FMyyMiabQRf4Xmfn8
Natural Sciences Centre: https://maps.app.goo.gl/SvTHBibwPtj74dE37
Ontario Hall: https://maps.app.goo.gl/ieWQgKG7afsNTjLw9
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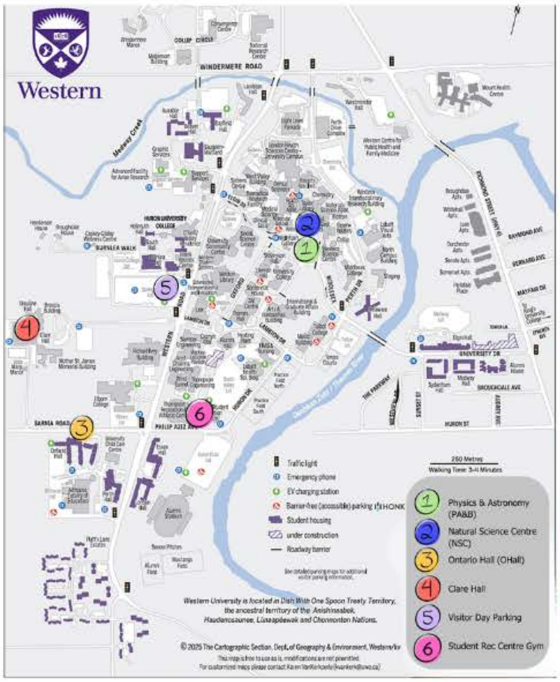
Alibi Roadhouse: https://maps.app.goo.gl/To7jgo87ioHQWY4w7



Registration Ontario Hall - Day Parking - Clare Hall -

Ontario Hall to OBC 2026 Registration

- Depart from Ontario Hall (3)
- Head East and downhill toward Western Road
- Cross to the NE corner at the traffic lights
- Continue North along Western Road to the Main Gates
- Turn right (E) at Lambton Dr (traffic lights)
- At the roundabout, travel north along Oxford Dr. past Lawson & Stevenson Halls
- At the green space just after Stevenson Hall travel across using the path
- PA&B (1) is just behind the small stone gallery
- You may use any of the doors to the building
- Signage in the building will direct you to OBC conference spaces

CONFERENCE PROGRAM

Wednesday May 20th

4:00pm – 6:00pm	Registration and Poster Set-up (Poster Session A)	P&AB Atrium
6:00pm – 6:15pm	Welcome & Opening Remarks	NSC 145
6:15pm – 7:15pm	Keynote Speaker – Dr. Julie Cote (University of Ottawa)	NSC 145
7:15pm – 7:45pm	Pizza Reception	P&AB Atrium Lower
7:45pm – 8:45pm	Poster Session A	P&AB Atrium Upper
8:45 pm – 10:00 pm	Student-Led Social	Alibi Roadhouse

OBC 2026 Keynote Speaker

Dr. Julie Côté

University of Ottawa

The OBC 2026 Keynote Lecture will be delivered by Dr. Julie Côté, Professor in the School of Human Kinetics at the University of Ottawa and will take place on the evening of Wednesday, May 20, 2026. Dr. Côté's talk will focus on advancing our understanding of muscle fatigue in both occupational and sport settings. Titled *"Personalized muscle fatigue research in work and sport: A moving target,"* the presentation will explore how repetitive movements and sustained loading contribute to fatigue, altered neuromuscular control, and the development of musculoskeletal injury.

The talk will highlight a research program that integrates experimental biomechanics, electromyography, and applied real-world approaches to examine how fatigue develops and how injury risk can be better understood. Particular attention will be given to the role of individual differences—such as sex and task demands—in shaping fatigue responses and injury susceptibility.

By connecting fundamental mechanisms with practical applications, the keynote will offer insight into how research findings can be translated into improved injury prevention strategies across both workplace and athletic environments. Attendees can also expect reflections on key lessons learned through diverse research and leadership experiences.

Thursday May 21st

7:30am – 8:30am	Breakfast	Ontario Hall
8:00am – 8:45am	Registration, Coffee & Poster Set-up (Poster Session B)	P&AB Mezzanine
8:45am – 9:45am	Podium Session 1	NSC 145
9:45am – 10:00am	Coffee Break	NSC 145
10:00am – 11:00am	Podium Session 2	NSC 145
11:00am – 11:15am	Coffee Break	NSC 145
11:15am – 12:15pm	Podium Session 3	NSC 145
12:15pm – 1:15pm	Lunch	P&AB Mezzanine (Lower)
1:15pm – 2:15pm	Podium Session 4	NSC 145
2:15pm – 2:30pm	Coffee Break	NSC 145
2:30pm – 4:00pm	Retro OBC	NSC 145
4:00pm – 6:00pm	**Laboratory Tours, Demo/Basketball & Free Time**	Student Rec Centre
6:00pm – 7:00pm	Poster Session B	P&AB Mezzanine (Upper)
7:15pm – 10:00pm	Conference Dinner & Social	Clare Hall

Friday May 22nd

7:30am to 8:30 am	Breakfast	Ontario Hall
8:30am – 9:30am	Podium Session 5	NSC 145
9:30am – 9:40am	Coffee Break	NSC 145
9:40am – 10:40am	Podium Session 6	NSC 145
10:40am – 10:50am	Coffee Break	NSC 145
10:50am – 11:50am	Podium Session 7	NSC 145
11:50am – 12:00pm	Closing Remarks	NSC 145
12:00pm – 1:00pm	Faculty Future Planning Meeting	NSC 145

Podium Session 1

Thursday May 21 (8:45-9:45AM)

NSC 145

Co-Chairs: Stephen Boulanger, Aurora Battis

8:45 AM	8:55 AM	**Ryan Chhiba** McMaster University	Effects of Work Organization and Demand on Upper Limb Motor Variability
8:55 AM	9:05 AM	**Chris Vellucci** Brock University	A Deep Learning Pipeline to Extract Clinical Gait Metrics from a Single Camera
9:05 AM	9:15 AM	**Bianca Simone** University of Waterloo	Predictive Musculoskeletal Simulation of Explosive Movements
9:15 AM	9:25 AM	**Emilie Kuepper** University of Ottawa	Gait Phenotyping in MS Using Smart Insoles
9:25 AM	9:35 AM	**Madalyn Richards** Western University	Development of An Experimental Framework for Designing Virtual Knee Ligament Models
9:35 AM	9:45 AM	**Adeline Leddy** Wilfrid Laurier University	Impact Loading Negatively Affects the Annulus Fibrosus

EFFECTS OF WORK ORGANIZATION AND DEMAND ON UPPER LIMB MOTOR VARIABILITY

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

Introduction: Prolonged repetitive upper limb work is a leading cause of workplace musculoskeletal disorders [1]. While stereotyped repetition repeatedly stresses the same tissues, the neuromuscular system can generate multiple movement solutions for the same task through motor redundancy, or abundance [2], which may be a protective strategy for overuse injuries [3]. Little is known about the modulation of motor variability in response to task demands such as frequency and force. Many studies have used a fixed cadence, despite the widespread use of quota-driven work which prescribes a set amount of work in a specified time. This study aims to evaluate the influence of task demands (force, frequency, work organization) on motor variability.

Methods: Thirty participants completed eight randomized 5 minute weighted pushing trials under varied work demands. Participants were instructed to push two handles between targets (10% and 80% of forward reach). EMG, motion, potentiometers, and perceived exertion captured motor variability, task accuracy, and muscular effort. Bilateral shoulder, elbow, wrist and trunk flexion angles and shoulder abduction angles along with bilateral activity of biceps (BIC), triceps (TRI), anterior deltoid (ADEL), posterior deltoid (PDEL) and upper trapezius (UT) were segmented to capture cycle-to-cycle variability. A linear mixed effects model tested the main effect of Work Organization (set pace, quota) and Side (left, right), with adjustments for Force (2 kg, 4 kg) and Frequency (15/min, 30/min), and their interactions on metrics of motor variability and performance.

Results: On average, quota trials were completed faster than the 5 minute set pace trials (15/min, 125 ± 20 s; 30/min, 217 ± 49 s) ($p < 0.05$). Participants overshot the 80% target by more during quota work (14.4 mm ± 7.6) than set pace (11.4 mm ± 5.7) ($p < 0.05$) while the closer target (10%) performance was the same ($p > 0.05$). Across all muscles, quota conditions had higher muscle activity variability than the set pace (BIC left - 3.0%, right - 2.3%; TRI 7.6%, 6.2%; ADEL 9.3%, 7.2%; PDEL 1.7%, 1.2%; UT 3.2%, 2.6%) ($p < 0.01$). Left side ADEL, PDEL and TRI variability was significantly higher than the right side ($p < 0.05$) while right side BIC variability was larger than the left side ($p < 0.05$).

Discussion: Results suggest that quota-driven work increased muscular demands irrespective of force and frequency demands, while motion and performance criteria remained similar to set pace work. Larger variability in muscle activity during the quota trials suggests that motor redundancy may help prevent muscular fatigue and preserve performance while completing the task faster. Understanding the effects of work demands on upper extremity function can provide insights into dysfunction and potential risk of injury.

References:[1] Keir, PJ et al., Human Factors, 2021. [2] Bernstein, N. Oxford: Pergamon Press, 1967. [3] Srinivasan, D & Mathiassen, SE, Clinical Biomechanics, 2012.

A DEEP LEARNING PIPELINE TO EXTRACT CLINICAL GAIT METRICS FROM A SINGLE CAMERA

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Department of Kinesiology, Faculty of Applied Health Sciences, Brock University, St. Catharines, ON

Introduction: Single camera markerless motion capture offers an accessible, low-cost option for clinical gait assessment, but technical limitations increase model error and constrain clinical utility [1]. This project aimed to (1) develop a method for predicting 3D gait kinematics from consumer-grade video, and (2) evaluate its accuracy against ecologically relevant perturbations including camera location, body size, and clothing characteristics.

Methods: 46 healthy participants (mean ± SD; height (m): 1.70 ± 10.32, mass (kg): 68 ± 12.58, BMI: 22.92 ± 4.72, age: 20.6 ± 4.75; Female =27) were recruited for this study. Standard 2D video data from four cameras (Sony RXOII) was recorded concurrently with 3D full-body kinematics from a research grade IMU suit (Xsens Awinda) during 10 min of treadmill walking.

Mediapipe (Google, USA) [2] extracted 2D landmarks from each camera were input to an LSTM neural network to predict 36 lower-body 3D anatomical landmarks from the research-grade IMU suit. 3D joint kinematics were computed from the pelvis, hip, knee, ankle, and foot progression, then scored using the Gait Profile Score (GPS) [3].

Model accuracy and agreement with the IMU suit was assessed using RMSE, ICC, and Bland-Altman Analysis. Effects of height, gait strategy, and mass were evaluated via correlation and R^2; camera position via 1-way ANOVA; and biological sex, pant fit, pant type, and clothing contrast via Student's t-tests or Mann-Whitney U-tests.

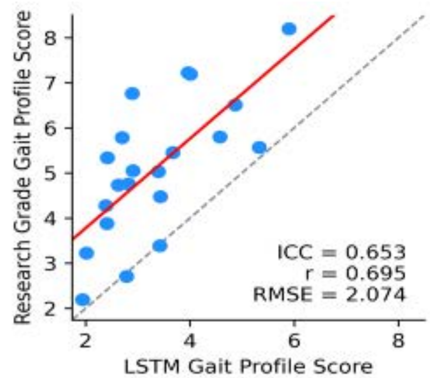

Figure 1: Displays the agreement between GPS scores derived by the LSTM and Xsens.

Results: The front-right camera performed best (RMSE = 2.97 ± 0.63 cm, ICC = 0.93-0.99 ± 0.02-0.5). Group level agreement was good, however notable variation occurred with height, mass, low colour contrast, and loose-fitting pants contributing to error ($p<0.05$). Despite these limitations, GPS showed acceptable agreement between systems (Figure 1; ICC = 0.65, RMSE = 2.07°).

Discussion and Conclusions: These findings demonstrate accurate 3D kinematic modelling from a single standard video, without depth information or calibration. Despite individual-level differences in landmark and joint angle estimation, acceptable GPS agreement suggests downstream clinical utility. Future work will evaluate the algorithm's sensitivity to longitudinal changes in movement energetic efficacy and adaptations to experimental pain.

References:

[1] Scott, B et al. (2025). Int Biomech. 12 (1); p. 35-47. [2] Lugaresi et al. (2019). arXiv. [3] Baker et al. (2009). Gait & Posture., 30 (3), 265-269.

PREDICTIVE MUSCULOSKELETAL SIMULATION OF EXPLOSIVE MOVEMENTS

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[2]Department of Systems Design Engineering, University of Waterloo, Waterloo, ON

Introduction: Musculoskeletal (MSK) models are necessary tools to advance our understanding of human movement, predict new movement patterns, and estimate internal loads that are infeasible to measure in real-world situations. While Hill-type muscle models have been widely used in MSK simulations due to their computational efficiency and ability to capture basic muscle mechanics, they underestimate rapid, dynamic, and explosive movements due to their lack of history-dependent behavior [1]. This discrepancy has been attributed to the protein titin, which has been found to dynamically increase its stiffness during muscle activation and is not represented in Hill-type formulations [2]. While a few titin-based muscle models exist that address these history-dependent effects, such as the viscoelastic active-titin (VEXAT) model [3], none have been implemented in whole-body MSK frameworks.

Aim: The aim of this study is to develop a predictive vertical jump simulation using the VEXAT model and to assess its performance relative to a common Hill formulation during explosive tasks.

Methods: A three-dimensional two-leg MSK model was developed in MapleSim™ (Maplesoft, ON, Canada) comprising rigid segments for the toe, foot, shank, thigh, and trunk, all connected by revolute joints. The model included the primary muscles contributing to ankle, knee, and hip flexion and extension, including the hamstrings, gluteus maximus, iliopsoas, vasti muscles, rectus femoris, soleus, gastrocnemius, and tibialis anterior. Muscles were implemented with anatomically defined origin, via, and insertion points, with muscle length calculated as the Euclidean distance between points. Foot-ground interactions were modeled using a Hunt–Crossley compliant contact formulation. Predictive simulations will be performed in MATLAB™ (MathWorks, MA, USA) using a direct collocation optimal control framework (OptimTraj toolbox). Muscle activation patterns will be optimized to maximize jump height, defined as the peak vertical displacement of the trunk's center of mass, while minimizing muscular effort quantified as the integral of squared muscle activations. Simulations will be performed using both Hill-type and VEXAT muscle models and results will be evaluated against published experimental and simulation data.

Expected Results: After comparison of predicted muscle activations, joint torques, ground reaction forces, and jump height, it is expected that the VEXAT model will provide enhanced alignment with experimental data, due to its ability to capture titin-related force enhancements.

References:
[1] Yeo S-H et al. (2023). Numerical instability of Hill-type muscle models. J R Soc Interface, 20(199).
[2] Nishikawa K. (2020). Titin: A tunable spring in active muscle. Physiology, 35(3); 209–217.
[3] Millard M et al. (2026). A three filament mechanistic model of musculotendon force and impedance. eLife.

GAIT PHENOTYPING IN MULTIPLE SCLEROSIS USING SMART INSOLES

Emilie Kuepper[1], Dr. Matthew P. Mavor[2], Dr. Ryan B. Graham[1-2]
[1]Ottawa-Carleton Institute of Biomedical Engineering, University of Ottawa, Ottawa, ON
[2]School of Human Kinetics, University of Ottawa, Ottawa, ON

Introduction: Walking impairments are common in people with multiple sclerosis (PwMS) [1]. Lesions in the central nervous system can impact various functional systems, resulting in heterogeneous gait patterns that can be difficult to characterize [2]. Identifying gait phenotypes may provide insight into lesion localization and help monitor treatment responses and disease progression within subgroups. Unsupervised clustering algorithms have been used to reveal gait phenotypes in PwMS [3]; however, they use laboratory-based metrics, limiting their use to controlled settings. One solution to track free-living gait is to use instrumented shoe insoles, wearable devices with pressure sensors and an inertial measurement unit (IMU) that can be placed in everyday footwear. This study aimed to identify gait phenotypes using INS data and interpret clusters using spatiotemporal (ST) gait metrics and the Expanded Disability Status Scale (EDSS), a clinical measure of disability in PwMS.

Methods: 123 PwMS (29 male) were recruited from the University of Ottawa (Ottawa, Canada), The Ottawa Hospital (Ottawa, Canada), the Technical University of Dresden (Dresden, Germany), Brigham and Women's Hospital (Boston, USA), and the Royal London Hospital (London, UK). Participants wore instrumented shoe insoles (ReGo, Moticon, Germany; 50 Hz), which streamed data via Bluetooth to a mobile application (Celestra Health Systems, Canada). Participants walked along a straight indoor hallway with turns at each end; the analysis was standardized across all sites by using the first 25 strides. Eighteen features (ST and IMU metrics) were z-score normalized and reduced using principal component analysis (PCA), with each component interpreted based on its loadings. K-means clustering was applied to the PCA-retained components, and clusters were characterized using ST gait metrics and the EDSS.

Results: Three PCA components were retained, explaining 83% of variance. Cluster separation was driven by PC1 (pace/amplitude) and PC2 (variability). K-means yielded four clusters (Figure 1). Cluster 1 had the most preserved gait, while Cluster 4 had the slowest, most asymmetric gait and the highest EDSS. Clusters 2 and 3 had similar EDSS, but people in Cluster 2 had higher ST variability. Further cluster characterization will be presented at the conference.

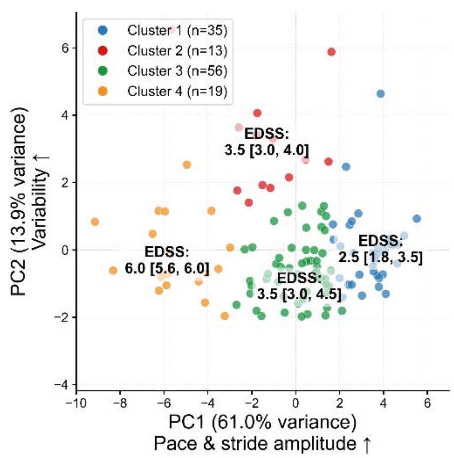

Figure 1: Clusters in PC space with median [IQR] EDSS per cluster.

Discussion and Conclusions: Four gait phenotypes were identified. The clusters captured differences in overall gait impairment and subtle differences in ST variability among those with similar EDSS. These findings serve as a step toward identifying clinically meaningful gait phenotypes in PwMS. Future work will link these phenotypes to longitudinal gait changes and additional clinical endpoints.

References: [1] Coca-Tapia M et al. *Diagnostics*. 2021;11(4). [2] Trentzsch K et al. *Sci. Rep.* 2025;15(1). [3] Filli L et al. *Sci. Rep.* 2018;8(1).

DEVELOPMENT OF AN EXPERIMENTAL FRAMEWORK FOR DESIGNING VIRTUAL KNEE LIGAMENT MODELS

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[1]School of Biomedical Engineering, Western University, London, ON

[2]Department of Mechanical and Materials Engineering, Western University, London, ON

Introduction: Ligaments play an important role in determining post-surgical behaviour of Total Knee Replacement (TKR). Ligament management and prosthesis alignment need to be considered simultaneously, and an optimal surgical plan may vary depending on pre-operative alignment and soft tissue integrity. The ability to accurately simulate the effects of soft tissues around TKR knees with different alignments may be key to optimizing surgical planning algorithms. Advanced joint motion simulators, such as the AMTI VIVO (Advanced Mechanical Technology, Inc., Watertown, MA), can simulate the behaviour of ligaments around physical implants; however, there is currently limited research employing virtual ligaments on these simulators, and even fewer studies that successfully replicate the intact knee condition. Appropriate and representative ligament models have not been universally defined, highlighting the need for further development in this area.

Aim: This work aims to develop experimentally informed virtual representations of the major knee ligaments by defining ligament-specific force displacement relationships derived from cadaveric testing. These models are subsequently used to investigate the combined effects of ligament management and prosthesis alignment to improve surgical planning strategies.

Methods: Cadaveric knee joint mechanics were measured following passive flexion and extension and simulated clinical laxity tests in the internal rotation (8 Nm), valgus/varus ($\pm$4 Nm), and anterior/posterior translation ($\pm$89 N) directions. Kinematics were recorded and re-applied to the joint under displacement control to determine the reaction forces for each major knee ligament. Four sequential testing conditions were considered: (1) all soft tissues intact, followed by resection of (2) the lateral collateral ligament (3) the medial collateral ligament, (4) the posterior cruciate ligament. Note that the joint was anterior cruciate ligament-deficient which was therefore not included. The resulting ligament forces were determined using the principle of superposition. An intact virtual ligament model was developed using insertion sites identified from bony landmarks, with the ligament slack length and stiffness determined and optimized based on computed force length relationships. This model will be run through the same testing protocols to compare the initial forces recorded from the cadaver to the forces computed virtually using mean error and average absolute error. Finally, commercially available prosthesis components will be installed on the AMTI VIVO, and the initial kinematic tests will be repeated, using the virtual ligaments as soft-tissue restraint, to examine the effect of mechanical versus kinematic prosthesis alignment.

Expected Results: It is expected that the optimized virtual ligament model will closely reproduce experimentally measured ligament force patterns, with low root mean square errors and low mean absolute error across all tested loading conditions, indicating close agreement with the intact cadaveric behaviour. Sensitivity to anatomical variability is expected to influence ligament length, force-length behaviour, and peak ligament forces; however, the overall trends and relative force contributions shall remain consistent. These results are expected to demonstrate that the virtual ligament model provides a robust set of predictions despite the expected anatomical uncertainty.

EFFECTS OF RAPID EXTERNAL COMPRESSIVE LOADING ON THE MECHANICAL PROPERTIES OF THE ANNULUS FIBROSUS

Adeline Leddy [1], Sabrina Sinopoli [2], Stephen D. Perry[2], Diane Gregory [1,2]
[1]Department of Health Sciences, Wilfrid Laurier University, Waterloo, ON
[2]Department of Kinesiology and Physical Education, Wilfrid Laurier University, Waterloo, ON

Introduction: Rapid external loading is well known to result in vertebral endplate fracture. While previous research has reported reductions in annular strength following rapid intradiscal pressurization [1,2], it is unclear if similar changes would result following rapid external loading. Therefore, the purpose of this study was therefore to determine whether rapid external impact loading applied to a functional spinal unit (FSU) compromises the integrity of the annulus fibrosus (AF) of the IVD.

Methods: Twenty cervical porcine spines (C3/C4 and C5/C6 levels) were used; 10 underwent rapid external compressive loading via a drop load of 3.25kg from a height of 0.6m, resulting in an average peak force of 5235 N and 10 served as unloaded controls. Four AF samples were dissected from the IVD of each FSU to assess mechanical integrity. Two multilayered samples (one from the anterior region and one from the posterior region of the IVD) underwent a 180° peel test to assess interlamellar adhesion and two bilayer samples (one from the anterior, one from the posterior) underwent a tensile test to assess circumferential annular tension. Vertebral endplate fracture was assessed via morphological analysis. A two-way mixed model ANOVA was conducted to assess the effect of condition (impact versus control) and annular location (anterior versus posterior).

Results: No vertebral endplate fractures were observed following loading. However, when compared with controls, average interlamellar adhesion stiffness was 48% lower in the impact group ($p=0.003$). Interlamellar adhesion strength trended towards significance ($p=0.06$), however a significant interaction between condition and location was observed ($p=0.039$) such that only the posterior interlamellar adhesion strength was negatively affected by the impact while the anterior samples were not. Annular tensile properties did not differ significantly between groups.

Discussion and Conclusions: Despite the fact that the rapid external compression protocol did not produce vertebral endplate fractures, it resulted in significant reductions in interlamellar adhesion properties. Adhesion stiffness was reduced in both the anterior and posterior region of the AF while adhesion strength reduction was primarily isolated to the posterior AF. This suggests that subfailure loading, even without visible bony damage, may still compromise AF integrity, increasing the risk of future disc herniation and degeneration.

References:
[1] Ghelani, R.N., Zwambag, D.P., Gregory, D.E., 2020. J Biomech. 108, 109888.
[2] Snow, C.R., Harvey-Burgess, M., Laird, B., Brown, S.H.M., Gregory, D.E., 2018. Eur Spine J. 27(8), 1767–1774.

Podium Session 2

Thursday May 21 (10:00-11:00AM)

NSC 145

Co-Chairs: Nigel Majoni, Aliza Siebenaller

10:00 AM	10:10 AM	**Etienne Joulin** Western University	Altered Muscle Synergies in Cam Fai
10:10 AM	10:20 AM	**Claudia Smith** University of Guelph	The Design of a Novel, Haptically-Accurate Physical Canine Epidural Simulator
10:20 AM	10:30 AM	**Iwi Eghobamien** McMaster University	Ring Finger Fatigue on Finger Independence
10:30 AM	10:40 AM	**Emilia Logan** Queen's University	Muscle Forces and Joint Loading in Unilateral Transtibial Amputees During Step-Up Task
10:40 AM	10:50 AM	**Johannes Eichwalder** University of Waterloo	Semi-Automated Bone Segmentation
10:50 AM	11:00 AM	**Cinthuja Pathmanathan** University of Ottawa	Interlimb Symmetry Patterns and Sex-Specific Changes Under Running-Related Fatigue Among Male and Female Endurance Runners

ALTERED MUSCLE SYNERGIES IN CAM FAI TO MAINTAIN SPINOPELVIC STABILITY DURING THE SQUAT TASK

Etienne Joulin[1], Mohamad Shatila[1], Trevor Birmingham[1], Ryan Degen[1,2], K.C. Geoffrey Ng[1]
[1]Western University, London, ON, [2]London Health Sciences Centre, London, ON

Introduction: Cam-type femoroacetabular impingement (FAI) is characterized by an enlarged femoral head-neck that slowly damages the surrounding soft tissue, often leading to premature hip osteoarthritis [1]. Whether patients adapt muscle synergies to carry out dynamic flexion-related tasks, where impingement risk is greater, is still unknown [2].

Methods: 15 cam FAI patients awaiting surgery (m:f = 8:7, age = 27 ± 8 years, BMI = 24 ± 5) and 15 controls, matched by age, sex, and BMI (m:f = 8:7, age = 25 ± 8 years, BMI = 24 ± 4), were recruited. Surface electromyography (EMG) electrodes (Trigno Delsys, USA) were positioned to the left and right gluteus maximus (GM), biceps femoris (BF), tensor fasciae latae (TFL), rectus femoris (RF), erector spinae (ES), and rectus abdominus (RA). Participants performed squats and maximum voluntary contractions to normalize data. Variance accounted for (VAF) was calculated to evaluate the synergies' ability to reconstruct the original signals.

Results: While the GM saw greater reconstruction in the FAI group compared to the control group (P = 0.02), the RA saw poorer reconstruction in the FAI group (P = 0.02).

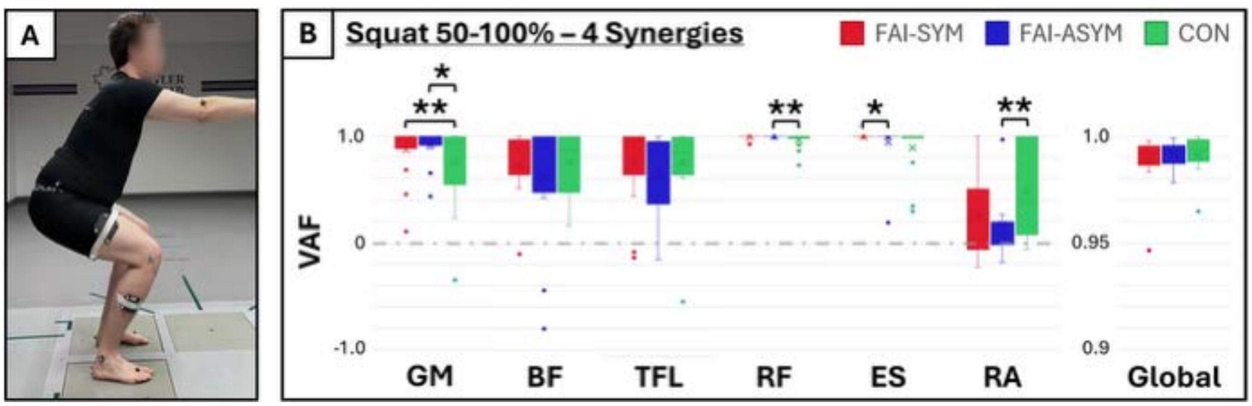

Figure 1. (A) Maximal squat depth during testing. (B) VAF globally and of each muscle for the FAI-symptomatic (FAI-SYM), FAI-asymptomatic (FAI-ASYM), and control group (CON; *$P < 0.05$, **$P < 0.01$)

Discussion and Conclusions: The key finding was that FAI patients showed altered synergistic contributions of their gluteus maximus and rectus abdominus that may indicate compensatory action in the gluteal muscles to offset suboptimal core recruitment and maintain spinopelvic stability. A clearer understanding of compensatory mechanisms can help guide rehabilitation protocols by revealing harmful recruitment patterns prior to hip exacerbation, in turn addressing early symptoms in efforts to personalize non-surgical management.

References:

[1] Beaulé, P., et al. (2018). Unravelling the hip pistol grip/cam deformity: Origins to join degeneration. JOR 36(12): 3125–3135.
[2] Diamond, L., et al. (2017). Coordination of deep hip muscle activity is altered in symptomatic femoroacetabular impingement. JOR 35(7):1494-1504. doi:10.1002/jor.23391

THE DESIGN OF A NOVEL, HAPTICALLY-ACCURATE PHYSICAL CANINE EPIDURAL SIMULATOR

Claudia C. V. S. Smith[1], Carolyn L. Kerr[2], Scott Brandon[1]
[1]College of Engineering, University of Guelph, Guelph, ON
[2]Ontario Veterinary College, University of Guelph, Guelph, ON

Introduction: Medical education requires students to be proficient in certain procedures that require the mastery of psychomotor skills. Anesthesiologists must learn complex procedures including epidural needle insertion, commonly used for long term pain management. Research has shown that it takes approximately 60-90 needle insertions just to achieve basic skills competency (1). The Ontario Veterinary School (OVC) does not currently have a high-fidelity simulator to allow for repeated practice of canine epidural needle insertion. This study presents a methodology for the design of a novel, accurate, physical canine epidural simulator for teaching.

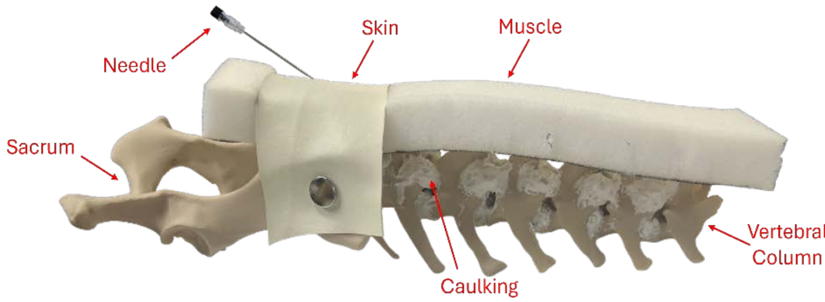

Figure 1: Assembled canine epidural simulator ready for use.

Methods: An L1-S3 canine vertebrae specimen was obtained by the OVC and scanned using an Artec Spider (Javelin Technologies Inc.). The spine was modified with ball and socket joints using SolidWorks (Dassault Systèmes), 3D printed, and assembled. The vertebral joints were filled using flexible caulking (DAP Global Inc.). A multi-layered composite, composed of 2 mm vinyl leather (skin), 24 mm upholstery foam (muscle), and 1 mm 100% polyurethane (ligamentum flavum) was assembled and fit superficial to the L7-S1 epidural space (Figure 1). The composite was validated by comparing force and distance data (Instron) during epidural needle insertion versus data from a previous cadaveric canine needle insertion study.

Results: Needle insertion into the fully assembled composite had comparable peak forces to cadaveric canine needle insertion. Average peak forces for the simulator (cadaver) were a) skin = 4.3N (4.1N), b) muscle = 3.5N (3.9N), and c) ligament = 5.6N (6.2N).

Discussion and Conclusions: All simulator peak forces were within the variability of the cadavers from the previous study. The resulting simulator composite was thinner (27 mm) than ideal, but still within the range from the previous canine study (range 20.4-54.2 mm). Future work will investigate the fidelity of the spine stiffness provided by the caulking; this is important for training clinicians to enlarge the intervertebral space prior to needle insertion. Additionally, future iterations of this simulator could include a full body exterior and an indicator for successful needle location in the epidural space. This research may allow veterinarians to be better trained when treating live patients, therefore reducing errors and improving patient outcomes.

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THE EFFECT OF RING FINGER FATIGUE ON FINGER INDEPENDENCE

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Introduction: Our fingers are capable of an infinite number of complex tasks. However, the fingers do not act independently. Finger interdependence has been attributed to neural and mechanical factors. The degree to which fingers are independent depends on posture of the wrist and fingers, force level, as well as training. This has been examined by many research groups [1] but little is known about the interdependence of the fingers with prolonged or fatiguing tasks. The purpose of this study was to evaluate the effect of prolonged submaximal ring finger flexion and extension exertions on the force produced by the other fingers.

Methods: This study represents a secondary analysis of existing data [2]. Twenty healthy, right-handed participants performed fatiguing isometric ring finger flexion and extension exertions on two separate visits at least 7 days apart. To measure force, each finger was fitted with a ring on the middle phalanx attached to a force transducer (MLP50, Transducer Techniques, CA, USA). Maximum voluntary contractions (MVC) were collected for each finger. Participants maintained a target force of 30% MVC until they were unable to maintain the force (Figure 1). Initially, the force from each finger was plotted against the ring finger on a scatter plot to assess the relationship between fingers over time. Statistical analyses will be used to determine the within-participant and between-participant effects. Finger dependence based on the direction of force production (flexion vs extension) will also be analyzed.

Results & Discussion: Force trends for each finger and condition will be reported. The results are expected to highlight a relationship between finger dependence and variability. Studying the relationship between fatigue and finger independence is crucial for understanding of the mechanical factors affecting finger control in prolonged tasks. Studying this relationship is particularly significant for developing a better understanding of the complex neuromuscular connections between fingers. Novel findings can lead to improved job training and upper limb overuse injury prevention, especially in populations that often do prolonged single-finger force producing tasks.

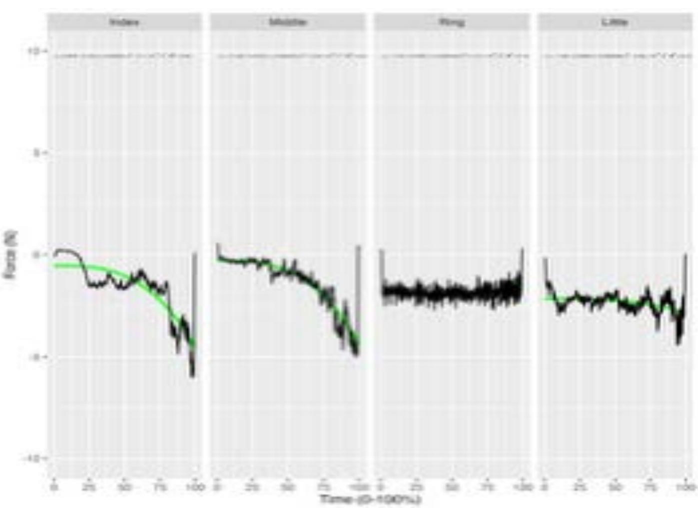

Figure 1: Force produced by digits 2 through 5 during ring finger extension fatigue task (black) and modelled cubic polynomial fits (green).

References:
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MUSCLE FORCES AND JOINT LOADING IN UNILATERAL TRANSTIBIAL AMPUTEES DURING STEP-UP TASK

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Introduction: Unilateral transtibial amputees (UTAs) experience altered biomechanics and functional limitations during daily locomotor tasks [1]. Step-up tasks challenge balance and unilateral strength beyond level walking [2], providing a better view of the neuromuscular adaptations after amputation. A comparison of muscle adaptation in UTAs across intact and amputated may help understand how compensatory strategies are distributed between limbs relative to controls. Therefore, the objective of this study is to assess muscle force adaptations that happens in UTAs after amputation and compare it to controls during step-up activity.

Methods: 11 highly functional UTAs (33.7 ± 1.5 years; 84.5 ± 9.1 kg) and 10 control participants (32.1 ± 4.3 years; 84.5 ± 10.5 kg) performed a step-up. UTAs performed the task twice, with each limb leading, whereas the control subjects used only their right limb. The task was time-normalized from toe-off of the leading limb to before heel strike of the trailing limb. Motion capture and force plate data were collected, and musculoskeletal modeling in OpenSim 4.4 was used to determine joint angles, joint moments, muscle forces, and joint contact forces. Statistical parametric mapping compared control, intact, and amputated limbs using parametric or non-parametric ANOVA with post-hoc tests.

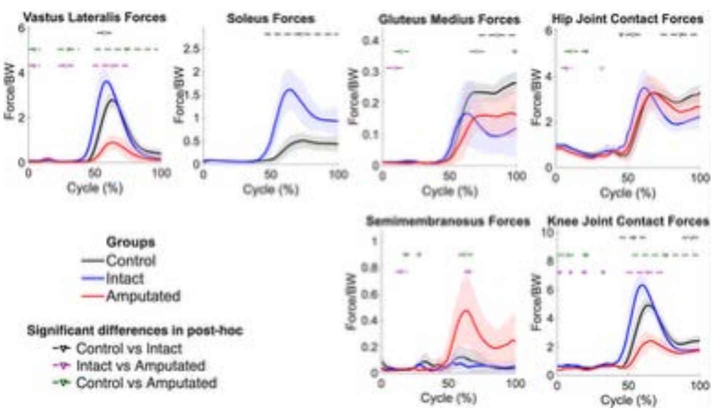

Figure 1. Muscle and joint contact forces for UTAs and the control group (mean ± standard deviation)

Results: The intact limb showed greater plantarflexor and higher vasti forces compared to control (Figure 1). The amputated limb relied more on hip extensors, including semimembranosus, showing higher forces compared to both intact and control limbs. Gluteus medius forces were lower in the intact limb at the end of the task. The muscle forces differences led to the intact limb having higher knee contact forces, but lower hip contact forces compared to control.

Discussion and Conclusions: UTAs exhibit limb-specific compensation strategies. Increased plantarflexor and vasti forces, along with reduced gluteus medius forces, indicate distal compensation strategies in the intact limb, which contribute to the elevated knee joint contact forces, associated with an increased risk of knee osteoarthritis development [3]. In contrast, the amputated limb compensates proximally, relying on hip extensors to compensate for the absent distal musculature. These compensatory strategies highlight the need for prostheses that better replicate distal push-off when the intact limb leads and pull-up when the amputated limb leads, potentially reducing joint loading and improving functional performance. Future work will examine the role of the trailing limb to further clarify the mechanisms underlying these limb-specific compensations.

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DEVELOPMENT OF A PROBABILITY-BASED SEMI-AUTOMATED BONE SEGMENTATION WORKFLOW

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Introduction: Accurate segmentation of cortical and trabecular bone in computed tomography (CT) is essential for microarchitectural assessment and structure functional studies [1]. Manual workflows are labor intensive and operator dependent; automatic segmentations have shown to be error-prone in thin or osteoarthritic cortices and are therefore lack reliability to replace expert guided approaches in challenging morphologies [2], [3]. Existing dual-threshold and semi-automated approaches improve efficiency but exhibit- systematic errors in thin, porous, or highly degenerated cortices [1], [4]. We developed a semi-automated, dual-threshold segmentation workflow that combines calibration density-based banding with an anatomical/morphometric probability assignment for each voxel.

Methods: Ex vivo humeral heads spanning normal to severely osteoarthritic morphologies were scanned using micro-CT. A modular segmentation pipeline was implemented, comprising scanner-specific calibration to mineral density, construction of periosteal and endosteal bands around the cortical shell, and dual-threshold classification within each band. Each voxel was then assigned to cortex, trabeculae, or background using an anatomic and morphometric probability model incorporating local thickness, connectivity, and neighborhood context. The workflow was applied to all specimens to generate 2D cortical and trabecular masks for subsequent comparison with a manual Dragonfly Bui/Kohler reference method.

Results: Semi-automated trabecular morphometry was more self-consistent with the whole-bone masks than the manual trabecular volumes of interest (VOIs). Across specimens, semi-automated bone volume fraction (BV/TV) differed from whole-bone BV/TV by 0.01-0.02 in absolute terms (<10% relative difference), whereas manual trabecular BV/TV showed larger offsets from the same whole-bone reference (≥ 15-30%). Semi-automated trabecular segmentations also showed high spatial correspondence with the manual masks, with Dice coefficients in the successful cases ranging from 0.62 to 0.87 and trabecular distance transform based 95th percentile Hausdorff distance (HD95) on the order of 0.05-0.5 mm, demonstrating that the automated method captures the main trabecular network while remaining closely aligned with the global bone volume implied by the whole bone masks.

Discussion and Conclusions: The developed semi-automated segmentation produced trabecular BV/TV and thickness that were more self-consistent with whole bone morphometry than manual VOIs, suggesting a more biologically coherent representation of global bone structure in complex cortices [1], [2]. This agrees with reports that dual-threshold and deep-learning approaches can match or exceed manual reliability when VOIs and processing are standardized [3], [4]. Overall, the semi-automated method appears preferable as a primary tool, with manual input reserved for resolving ambiguous interfaces.

References: [1] H. R. Buie, et al., Bone, Oct. 2007.
[2] E. C. Herbst, et al., R. Soc. Open Sci., Aug. 2021.
[3] Y. Xu, et al., Bioengineering, Oct. 2024.
[4] N. J. Neeteson, et al., Sci. Rep., Jan. 2023.

Interlimb symmetry patterns and sex-specific changes under running-related fatigue among male and female endurance runners

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Introduction: Clinicians often use isometric strength symmetry indices in deciding return to sports [1]. Interlimb symmetry is affected by fatigue [2], other risk factors [3], and tasks [4]. Further, sex differences in injury prevalence have been reported [5]. However, there is a lack of understanding of sex-specific changes in symmetry indices with fatigue, and on the interchangeability of static and dynamic symmetry indices, such that the role of asymmetry in predicting sex differences in injury rates is poorly understood The study aimed to report sex-specific lower-limb running-related biomechanical asymmetries, the differences between static and functional asymmetry, and the effect of fatigue on these, among endurance runners.

Methods: Twenty-four (14 males) healthy endurance runners (24.33 ± 5.26 years) participated. An incremental running fatiguing protocol where the participant ran to maximum exhaustion, measured on Borg's RPE scale (6-20), was used. Interlimb Symmetry Indices (ISI) were calculated from muscle torque (hip and extensors, knee flexor and extensors), and activity (gluteus medius, gluteus maximus, rectus femoris, biceps femoris, vastus lateralis) and kinematic (pelvis, hip, knee and ankle) outcomes recorded during maximal effort with a dynamometer, and before and after an incremental fatigue protocol on a treadmill.

Results: Only the knee extensors showed a correlation with static and running-related ISI (Spearman's rho=-0.436, p =0.042). A sex-fatigue interaction effect was observed in the ISI of gluteus medius muscle activity in the generation part of the running stance phase (p= 0.008; β=104.008, mean difference and standard error, males: pre-post= 5.039 [19.774], females: pre-post= -98.967 [33.705]).

Discussion and Conclusions: While static ISI should be interpreted with caution in decision-making regarding dynamic tasks, runners would benefit from screening proximal muscles, considering sex-specific anatomical differences, to predict running-induced changes in ISI.

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[2] Gao, Z., et al. (2022).Effects of running fatigue on lower extremity symmetry among amateur runners: From a biomechanical perspective. 13.p.1-12.
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[5] Messier, S.P., et al. (2018).A 2-Year Prospective Cohort Study of Overuse Running Injuries: The Runners and Injury Longitudinal Study (TRAILS). 46 (9).p.1552-3365.

Podium Session 3

Thursday May 21 (11:15AM-12:15PM)

NSC 145
Co-Chairs: Claudia Graham, Ryan Chhiba

11:15 AM	11:25 AM	**Claudia Graham** University of Waterloo	The Effect of Turbans on Biomechanical Effectiveness of Industrial Headwear
11:25 AM	11:35 AM	**Luka Zigomanis** University Health Network	Phase–Amplitude Coupling as a Measure of Corticomuscular Connectivity
11:35 AM	11:45 AM	**Daniel Sheffield** York University	Does QL Asymmetry Impact Vertical Jump Height in Athletes?
11:45 AM	11:55 AM	**Katherine Wiebe** Carleton University	Quantifiable Metrics of Saccadic Eye-Movement Improve with Time in Concussed Subjects
11:55 AM	12:05 PM	**Sepideh Lashkari** Queen's University	Soleus Stretch Reflexes Change with Center of Pressure and Its Velocity During Standing
12:05 PM	12:15 PM	**Nolan Ford** Ontario Tech University	Comparing a Wrist-Support Gaming Mouse to a Traditional Mouse

THE INFLUENCE OF TURBANS ON THE POSITIONING, IMPACT ATTENUATION, AND RETENTION OF INDUSTRIAL HEADWEAR

Claudia M. Graham[1] & Andrew C. Laing[1]
[1] Department of Kinesiology and Health Sciences, University of Waterloo, Waterloo, ON, Canada

Introduction: Head coverings are common amongst several cultures, faiths, and religions. Several occupations require protective headwear (i.e., hard hats) and religious head coverings would interface/interact with this equipment. However, the literature in this domain is limited, focusing on the impact attenuation of religious head coverings independently. The coupling of religious head coverings with protective headwear has not yet been considered [1,2]. Therefore, this study assessed the effect of turbans on hard hat positioning, impact attenuation, and retention.

Methods: Testing generally followed approaches outlines in CSA Z94.1. Head conditions included a bare (B) KIA headform and two Dumalla turban conditions (T1=small and T2=large). Position: The position of the hard hat was determined using motion capture and compared to standard coverage line requirements [3]. Impact: A vertical drop tower was used to impact a representative hard hat at crown (55J), lateral (30J), and anterior (30J) locations. A triaxial accelerometer at the head center of mass collected peak acceleration. Retention: A vertical force was applied to the hard hat's anterior brim with an instrumented hook. Peak force to decouple the hard hat from the headform was recorded.

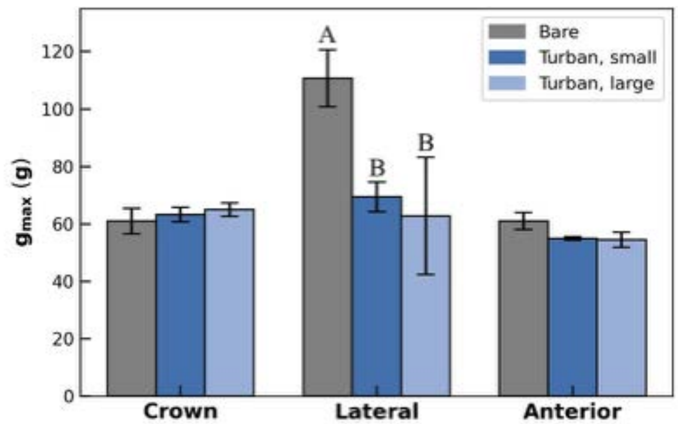

Figure 1: Impact test results. Mean g_{max} for each condition. Capital letters indicate significant differences between conditions.

Results: Position: Hard hat position was shifted superiorly in the turban conditions, and failed coverage line requirements in 16.6% and 33% of trials for T1 and T2, respectively. Impact: T1 (69.5(2.3)g) and T2 (62.8(11.8)g) resulted in significantly lower g_{max} than B (110.8(5.7)g) in lateral impacts ($p<0.001$). Retention: The peak force required to decouple the hard hat from the headform decreased in T1 and T2 compared to B by 32.8% and 39.7%, respectively.

Discussion and Conclusions: In terms of user safety, including a turban underneath a hard hat resulted in increased impact attenuation in lateral impacts. However, it also resulted in uncertainty in the source of the attenuation (hard hat vs turban). Additionally, the turban decreased retention and shifted the position of the hard hat superiorly. The range in outcomes highlight the challenges associated with including a turban underneath a hard hat for both physical test systems and workplace safety.

Acknowledgements: CSA Group; cultural advisor Pavitar Notey

References:
[1] Rowland. (1987). J Occup Accid 9 (1); p. 47-57. [2] Yu X et al. (2024). Ann Biomed Eng 52 (4); p. 946-57. [3] CSA. (2020). Z94.1-15.

BEYOND CORTICOMUSCULAR COHERENCE: PHASE–AMPLITUDE COUPLING AS A MEASURE OF BRAIN–MUSCLE CONNECTIVITY

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Introduction: Neurological motor impairments, such as spinal cord injury (SCI), disrupt communication between the motor cortex and muscles. Reliable biomarkers of corticomuscular connectivity are therefore needed to evaluate motor recovery. Corticomuscular coherence (CMC) quantifies linear coupling between electroencephalography (EEG) and electromyography (EMG). However, CMC is inconsistently observed across individuals, appearing in only 45–65% of healthy participants [1], limiting its usefulness as a biomarker of corticomuscular connectivity. Phase–amplitude coupling (PAC) relates low-frequency phase in one signal to high-frequency amplitude in another, capturing cross-frequency interactions that may reflect corticospinal communication. Here we investigate whether PAC can serve as an alternative biomarker of corticomuscular connectivity during voluntary muscle contraction.

Methods: Biophysical EEG–EMG models incorporating neuronal dynamics were used to simulate signals during sustained muscle contraction, allowing manipulation of corticomuscular connectivity to compare the detectability of CMC and PAC. Both metrics were applied to a previously published EEG–EMG dataset from 28 neurologically intact adults performing sustained plantarflexions [1]. EEG was recorded over the sensorimotor cortex and EMG from the soleus muscle. CMC was calculated between EEG and EMG signals in the β (15–30 Hz) and γ (>30 Hz) bands, and PAC between EEG phase and EMG amplitude.

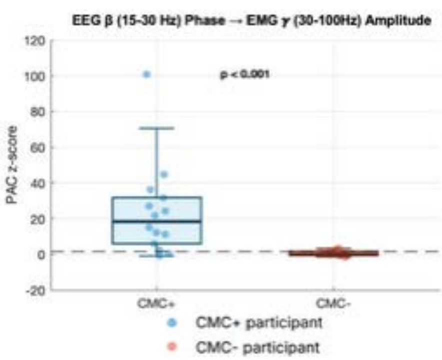

Figure 1: β–γ PAC Segmented by β CMC Responders.

Results: In simulations, beta-band CMC emerged during muscle contraction, consistent with established experimental findings. β–γ PAC also emerged during contraction and disappeared at rest. In experimental data, β CMC was detected in only 14 participants (50%), aligning with the previous paper. In contrast, β–γ PAC was observed in both CMC+ and CMC- participants (Figure 1), indicating that PAC can detect corticomuscular interactions in the absence of coherence.

Discussion and Conclusions: These findings highlight the role of γ EMG in corticospinal drive, demonstrating that PAC can serve as an alternative biomarker of corticomuscular connectivity beyond CMC and providing a robust metric for monitoring recovery during rehabilitation.

References:

[1] M. Zaback et al. (2022). Facilitation and Habituation of Cortical and Subcortical Control of Standing Balance Following Repeated Exposure to a Height-related Postural Threat. Neuroscience 387; 8–25

QUADRATUS LUMBORUM ASYMMETRY AND VERTICAL JUMP HEIGHT IN VARSITY ATHLETES FROM MULTIPLE SPORTS

Daniel W. Sheffield, Sam S. Vasilounis, Dan Desroches, Janessa D.M. Drake
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Introduction: Lumbopelvic muscle asymmetry has been linked to altered trunk mechanics, jumping and landing performance deficits, and increased injury risk. Bilateral cross-sectional area (CSA) asymmetry in the quadratus lumborum (QL) that is greater than 10% has been reported to be associated with higher lower limb injury rates in males. The quadratus lumborum (QL), a key stabilizer of the lumbar spine and pelvis, may develop side-specific differences due to repeated unilateral demands across various sports. Likewise, this research explored whether QL CSA asymmetry influenced single-leg vertical jump performance (jump height).

Methods: Ultrasound measures (GE Logiq E, GE Medical Systems, Milwaukee, WI, USA) of QL were collected from 116 varsity athletes (58 males, 58 females) across five sports: basketball, track and field, hockey, volleyball, and wrestling. Images were processed to quantify bilateral CSA (mm^2), and the larger side was assigned as the dominant side. Single-leg vertical jump height was calculated from flight time captured with a force plate (AMTI OR6-7, Advanced Mechanical Technology Inc., Watertown, MA, USA). Two-way ANOVAs assessed the effects of Sex and QL asymmetry on jump height achieved on each leg.

Results: Across all athletes, there was a dominant QL that was larger than the non-dominant QL. This asymmetry was present in both females (17.7% ±11.3) and males (16.1% ±11.1). Overall, 79 athletes (68.1%) demonstrated >10% asymmetry. All five sports showed significant side-to-side differences in QL CSA ($p<0.001$). Two-way ANOVAs examining the effects of sex and asymmetry on single-leg jump performance revealed a significant main effect of sex for jump height on the larger QL side ($F(1,112)=4.00$, $p=0.048$), with males demonstrating greater jump heights. No significant main effect of asymmetry or sex × asymmetry interaction were observed ($p=0.165$). For jump height on the smaller QL side, no significant main effects or interaction were detected ($p=0.111$).

Discussion and Conclusions: Varsity athletes demonstrated prevalent QL asymmetry, regardless of sex and across all sports tested, suggesting that unilateral adaptations in trunk musculature are a common characteristic of competitive athletic participation. This may reflect common sport-specific unilateral loading patterns, such as repeated cutting, shooting, or skating mechanics. Establishing normative patterns of lumbopelvic muscular asymmetry in varsity athletes provides a valuable reference for clinicians and coaches, as it appears the 10% asymmetry QL value may not be widely predictive. Such benchmarks may help identify atypical asymmetry that may contribute to lumbopelvic dysfunction, performance limitations, or elevated injury risk. Preliminary intramuscular EMG findings (n=5) suggest that functional asymmetries in QL activation may accompany structural differences. More data is needed to determine if neuromuscular changes precede observable declines in performance or the onset of injury that were previously reported with the >10% QL asymmetry.

QUANTIFIABLE METRICS OF SACCADIC EYE-MOVEMENT IMPROVE WITH TIME IN CONCUSSED SUJECTS

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

Introduction: Current concussion assessment tools rely on qualitative and subjective methods. Our objective is to quantify metrics of saccadic eye-movement and observe improvement with time in concussed subjects.

Methods: Twenty concussed subjects performed a saccadic eye-movement task, while being concurrently recorded using a webcam and a commercial eye-tracking tool. We developed analysis software for quantifying and comparing the eye tracking movements. Metrics of interest included the time constant (τ [ms]) of a transition event, and the concurrence of eye position before, during, and after each transition.

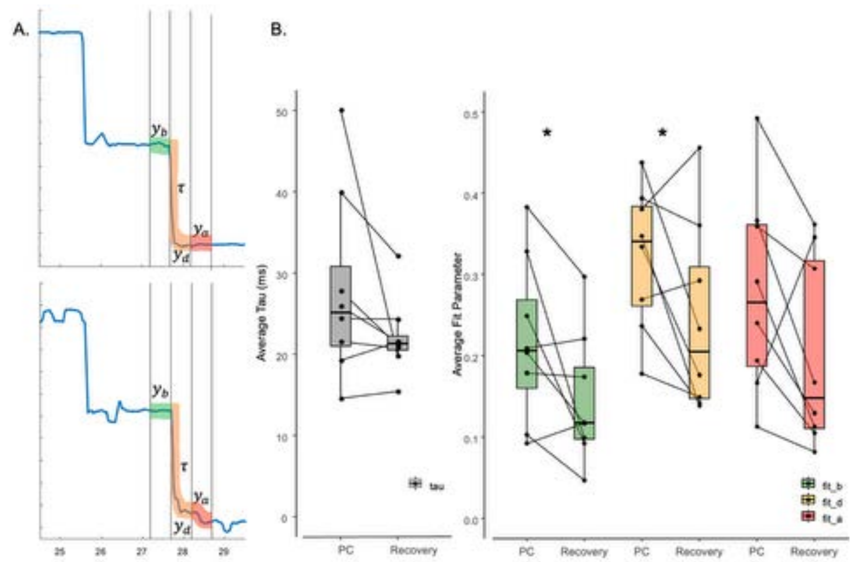

Figure 1A: Comparison of the horizontal displacement of a control (top) and a concussed (bottom) subject's trace during a saccadic eye-movement. 1B: Saccadic exercise performed in concussed subjects where the average tau (ms) and fits (before, during, and after) are shown post-concussion (3 trials) and into recovery (1-4 trials). Concussed subjects were defined as having/described as having experienced a concussion within the last 6 months, with recovery trials taken 1-3 months after initial trials, n=8. * p<0.05

Results: A significant difference in all parameters between the control and concussed subjects, indicated that concussed subjects had slower transition time and difficulty fixating on a target (Figure 1A). These parameters improve with time in concussed subjects, specifically in the before and during phase of a saccadic eye-movement, * $p<0.05$ (Figure 1B).

Discussion and Conclusions: Additional eye-tracking tools may help in the understanding and assessment of concussions. These tools could be utilized for possible clinical or diagnostic use.

SOLEUS STRETCH REFLEXES CHANGE WITH CENTER OF PRESSURE AND ITS VELOCITY DURING STANDING

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Introduction: Maintaining upright standing is a complex sensorimotor task that requires continuous coordination of mechanical and neural mechanisms. Spinal reflexes provide a short-latency response to perturbations and help oppose joint motion in standing. They vary with muscle activation and length in controlled supine experiments, however, their behavior is more complex in functional tasks, such as standing and walking. It remains unclear how soleus spinal reflexes are modulated during standing as the body sways [1]. The objective of this study is to determine how soleus spinal reflexes change with center of pressure (COP) and COP velocity (dCOP).

Methods: Mechanical ankle rotation perturbations were applied to standing healthy participants on a hydraulically driven dual-actuator platform while center of pressure (COP) and lower-limb EMG were recorded. Perturbation trials consisted of pseudorandom position perturbations that were divided into individual pulse perturbations for pulse-by-pulse analysis. For each pulse, the background postural state immediately preceding the perturbation was quantified using COP and dCOP, which reflect sway-related changes in the mechanical state and muscle activation. Soleus reflex responses were evident only for dorsiflexion pulses, identified from EMG activity. Reflex magnitude was quantified as integrated soleus EMG around the response peak, and its relationship with background COP and dCOP was evaluated using pulse-by-pulse binning.

Preliminary Results: Figure 1 shows the integrated soleus EMG as a function of background COP, where each curve shows pulse responses with similar background dCOP for an exemplar participant. The results indicate that the soleus EMG for dorsiflexion pulses varies with background dCOP, and that this relationship differs across background COPs. Overall, reflex magnitude appears to increase with both background COP and background dCOP.

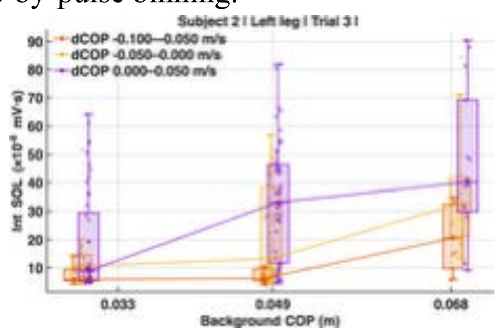

Figure 1: integrated soleus EMG vs COP

Discussion and Conclusions: These preliminary findings suggest that soleus reflex responses during standing are modulated by background COP and background COP velocity. This may reflect the functional role of the reflex in stabilizing posture under different sway conditions. For example, when COP is closer to the ankle and is moving backward, a dorsiflexion perturbation may be more destabilizing; therefore, the reflexes are attenuated. Future analyses will test whether muscle co-contraction and previous pulses explain additional variability in the reflex response.

References:
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ERGONOMIC AND PERFORMANCE IMPACTS OF A WRIST-SUPPORT GAMING MOUSE PROTOTYPE TO A TRADITIONAL GAMING MOUSE

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

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 muscular strain and discomfort [2]. Ergonomic gaming mice are now emerging on the market with designs intended to mitigate injury risks without sacrificing performance. One such example is the prototype SKYLOS™ (North Command) gaming mouse, which includes a padded and adjustable wrist support in its design, but little is known on how use of this mouse affects physical exposures or performance.

Aim: To compare upper-limb muscle activity, joint posture, subjective discomfort, and aiming performance between an industry standard Logitech G502 Lightspeed™ and prototype SKYLOS™ gaming mouse.

Methods: Twenty right-handed collegiate level Esports athletes will participate in this repeated-measures study. Participants will complete an initial baseline assessment, followed by a minimum 7-hour at-home familiarization period. Upon returning to the lab, they will perform a series of 60-second tasks with each mouse in AimLab (State Space Labs, Inc., NY, USA) and 10 minutes of live gameplay in their respective first-person shooter game, administered in a counterbalanced order. Muscle activity from 9 upper limb muscles will be recorded using a Delsys Trigno surface EMG system (Delsys Inc., MA, USA). An Xsens Awinda motion capture system (Xsens Technologies BV, Enschede, Netherlands) will track joint angles at the wrist, elbow, and shoulder. Gaming performance metrics (e.g., accuracy, reaction time) and subjective ratings of discomfort (modified Borg CR10 scale) will also be collected.

Figure 1: Logitech G502 Lightspeed™ *(Left)* and North Command SKYLOS™ *(Right)*

Expected Results: The SKYLOS™ mouse is expected to demonstrate lower wrist muscle activity and more neutral wrist posture than the G502 Lightspeed™, accompanied by elevated shoulder activity. Subjective feedback is anticipated to reflect improved wrist comfort with the SKYLOS™, while aiming performance remains comparable between mice.

References:
[1] Forman, G., & Holmes, M. (2023). Upper-Body Pain in Gamers: An Analysis of Demographics and Gaming Habits on Gaming-Related Pain and Discomfort. *Journal of Electronic Gaming and Esports*, *1*, 1-8.
[2] Dennerlein, J. T., & Johnson, P. W. (2006). Changes in upper extremity biomechanics across different mouse positions in a computer workstation. *Ergonomics*, *49*(14), 1456-14.

Podium Session 4

Thursday May 21 (1:15-2:15PM)

NSC 145

Co-Chairs: Kristen De Melo, Jarrod Smith

1:15 PM	1:25 PM	**Harry Battersby** Western University	Task-Dependent Redistribution of Sagittal Plane Joint Contributions Following ACL Reconstruction
1:25 PM	1:35 PM	**Patrick Crowley** Wilfrid Laurier University	Effect of footwear and Parkinson's on balance during gait termination
1:35 PM	1:45 PM	**Eric Ginzburg** York University	Shoulder Morphology and Mechanics in Athletes
1:45 PM	1:55 PM	**Asal Rashidimalekshah** Toronto Metropolitan University	Prevalence of MSDS Among Baristas and Their Association with Ergonomic Risks Based on TLV for HAL and REBA Evaluations
1:55 PM	2:05 PM	**Tiana Wertelecky** Queen's University	Energy-Incentivized Changes in Gait Symmetry with Exoskeletons
2:05 PM	2:15 PM	**Jessa Davidson** University of Waterloo	Intervertebral Disc Properties Following Simulated Prolonged Sitting

Task-Dependent Redistribution of Sagittal Plane Joint Contributions Following ACL Reconstruction

Harry Battersby[1], Judson Moorhouse[1], Max Smith[1], Derek Pamukoff[1]
[1]Department of Kinesiology/Western University, London, ON

Introduction: Individuals following anterior cruciate ligament reconstruction (ACLR) demonstrate movement asymmetries that increase re-injury risk [1]. They also exhibit hip and ankle dysfunction after ACLR [2,3], possibly due to offloading strategies during movement. During tasks that have a double limb support phase like gait or a drop vertical jump (DVJ), individuals can offload weight to the contralateral limb, whereas single-leg tasks such as hop for distance (SLH) may require within limb compensation strategies. However, it remains unclear how joint contributions are redistributed across the lower limb during these tasks. This study compared sagittal plane joint moment contributions during gait, SLH, DVJ after ACLR.

Methods: 40 individuals with unilateral ACLR participated (19 F, 21 M, Age:20.9±2.9yrs, time since surgery: 26.9±14.1 months). 3-D motion analysis for DVJ and SLH was recorded using 8 cameras (200Hz) and 2 force plates (2000 Hz). Gait biomechanics were collected over 5 minutes on a force-instrumented treadmill at a self-selected speed. Five trials of 10s were collected at the end of each minute after a 5-minute warm-up period. Three trials of DVJ were performed from a 30-cm box placed half the participants' height away onto two force plates, followed by a maximal vertical jump. SLH was performed from a force plate, landing on the same leg. A successful trial was if the landing was held for 3 seconds, with 3 trials recorded. The peak internal hip extension, knee extension and ankle plantar flexion moment were calculated for all tasks. Sagittal plane joint moments were converted to relative joint contribution (%) for the ankle, knee, and hip within each task. A 3(task) × 3(joint) × 2(limb) repeated-measures ANOVA evaluated differences in joint contribution. Bonferroni-adjusted pairwise comparisons examined limb differences within each task ($\alpha = 0.05$). Where significant pairwise limb differences were identified within joints, paired-samples t-tests were performed on limb difference scores (ACLR − contralateral) to compare the magnitude of joint off-loading between tasks.

Results: A significant task × joint × limb interaction was observed ($F_{4,36} = 4.07$, $p = .008$, $\eta^2 = .312$). Relative knee contribution was greater in the contralateral limb than the ACLR limb for DVJ (Δ4.5%, [95% CI: 2.8-6.1%], p<0.01) and SLH (Δ2.8%, [95% CI: 1.5-4.2%], p<0.01). Relative hip contribution was greater in the ACLR limb than the contralateral limb for DVJ (Δ3.9% [95% CI: 2.4-5.5%], p<0.01) and SLH (Δ2.3% [95% CI: 0.6-4.1%], p=0.01). No differences between limbs were observed during gait. The magnitude of knee off-loading was greater during the DVJ compared to SLH (Δ=-1.7% p=0.047), but no differences in the magnitude of hip offloading were observed (Δ=1.6%, p = 0.13).

Discussion and Conclusions: Individuals with ACLR will distribute load away from their knee towards their hip during dynamic tasks, but not during gait. Greater reductions in knee contribution during the DVJ suggest that this task may be more sensitive for detecting redistribution away from the knee within the ACLR limb.

References: [1] Paterno MV et al. (2010) Am J Sports Med (38); p. 1968–1978
[2] Hoch JM et al. (2019) Physical Therapy in Sport (36); p. 55–61
[3] Kline PW et al. (2018) Knee Surg Sports Traumatol Arthrosc (26); p. 1137–1144

DO INSOLE TEXTURE AND MIDSOLE HARDNESS IMPROVE DYNAMIC BALANCE IN INDIVIDUALS WITH PARKINSON'S DISEASE?

Patrick Crowley, Stephen D. Perry
Department of Kinesiology and Physical Education, Wilfrid Laurier University, Waterloo, ON

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 insole texture, and high midsole hardness 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. This study investigated the neuromodulatory effects of insole texture and midsole hardness during a dynamic balance task, hypothesizing that both insole texture and increased hardness midsole would enhance balance by augmenting sensory input from the plantar surface of the foot.

Methods: 13 older adults with PD (4 female; 65.1 (4.41) years), and 8 without (8 female; 67.3 (1.1) years), have been recruited thus far (target sample size: 15 per group). Participants performed a 10-meter walking task wearing standardized footwear (Converse, All-Star) during medication 'on phase'. Participants completed four blocks of ten trials, each representing one condition in a 2 × 2 factorial design of insole texture (present or absent) and midsole hardness (typical to normal footwear or hard). To assess dynamic balance, gait termination (GT) was randomly cued during three trials per block using an auditory buzzer. Participants were instructed to stop suddenly into a side-by-side stance when cued, simulating the need for dynamic postural adjustment. Force plates 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. Surface electromyography of the tibialis anterior, medial gastrocnemius and peroneus longus will be used to assess compensatory muscle activation. Intervention effectiveness will be assessed through GT performance, using COM–COP and COM–BOS relationships and time to stability during gait termination, supplemented by peak and average EMG activity between the GT cue and stability, compared across conditions.

Preliminary Results: To date, data from 11 participants has been collected and analyzed. While no statistical analysis has been performed, preliminary trends suggest that in the PD group, both texture and hard midsoles increased mediolateral and anteroposterior COM–COP maximums on the stance leg following a GT cue. The combination of textured surface and hard midsole produced the greatest COM–COP maximum overall. Additionally, the textured–hard midsole condition appeared most effective in increasing anteroposterior COM–COP minimum.

References:
[1] Parachute. (2021). *Cost of Injury in Canada*. Parachute.
[2] Fasano et al. (2017). *Mov Disord*. *32*(11); p. 1524-1536.
[3] Reina-Bueno et al. (2021). *J Per Med*. *11*(11); p. 1136.

INVESTIGATING SHOULDER MORPHOLOGY AND MECHANICS AMONG COMPETITIVE SWIMMERS AND UNILATERALLY-TRAINED ATHLETES

Eric Ginzburg, Daniel Desroches, Jaclyn N. Chopp-Hurley
Kinesiology and Health Science, York University, Toronto, ON

Introduction: Swimming poses large mechanical loads on the shoulder bilaterally. Repetitive overhead movements, may produce unique morphological and kinematic adaptations about the shoulder [1]. Whether these adaptations differ from those seen in unilaterally-trained athletes (e.g., racquet sport players) and non-athletes, remains understudied; limiting the development of individualized, sport-specific injury prevention and rehabilitation strategies. This study compared subacromial space occupation ratios, supraspinatus tendon thickness, and 3D scapular kinematics across competitive swimmers, unilateral athletes, and non-athletes. We expected disadvantageous mechanics and morphological outcomes for both athlete groups compared to non-athletes.

Methods: Thirty right-hand dominant men (21.5 [2.2] yrs; 25.2 [3.6] kg/m^2) were recruited equally across three groups: competitive swimmers, competitive unilaterally-trained athletes, and non-athletes. Ultrasound images of the dominant and non-dominant shoulders captured the SAS width, and the supraspinatus tendon thickness [2]. Three-dimensional scapulothoracic kinematics were captured across the scapular plane of motion (0-120°) using passive optical motion tracking according to ISB standards [3].

Results: Supraspinatus tendon tissue thickness was significantly higher for swimmers (0.69 [0.05] cm) compared to unilateral athletes (0.60 [0.08] cm) (p=0.033) on their non-dominant side. Consequently, swimmers had a significantly higher occupation ratio on the non-dominant arm (0.62 [0.06]) compared to unilateral athletes (0.57 [0.07]). A significant arm angle effect was present for all three scapular rotations on the dominant side. A group effect was also demonstrated, with swimmers having more posterior tilt (-7.8 [4.1]°) than non-athletes (-10.3 [4.3]°), and retraction (23.4 [4.9]°) than both unilateral (26.8 [5.8])° and non-athletes (27.7 [4.3]°).

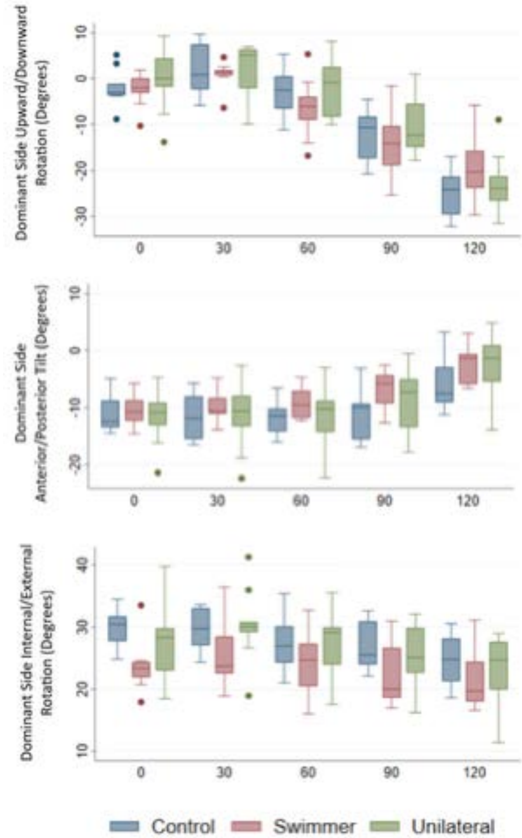

Fig 1. 3D scapulothoracic kinematics by participant group across 5 static elevation angles.

Discussion and Conclusions: Data analysis for this study is ongoing, including the presence of asymmetry in morphological and mechanical outcomes. However, preliminary data analysis suggests that significant morphological and mechanical differences are evident between bilaterally trained athletes, compared to unilaterally trained athletes. This may have important implications for injury prevention and training across different sports.

References:

[1] Blache Y et al. *Eur J Sport Sci,* 2018, 18(5), 659-66. [2] Boulanger et al. *J Orthop Surg Res*, 2023, 18: 986. [3] Wu et al. *J Biomech,* 2005, 38: 981-92.

PREVALENCE OF WORK-RELATED MUSCULOSKELETAL DISORDERS (WMSDS) AMONG BARISTAS

Asal Rashidimalakshah & Mohammad Abdoli-Eramaki
School of Occupational and Public Health, Toronto Metropolitan University, Toronto, ON

Introduction: Work-related musculoskeletal disorders (WMSDs) are a common occupational health issue, resulting in lower quality of life, absenteeism, and loss of productivity [1]. Exposure to repetitive movements, forceful exertions, awkward postures, and prolonged standing can increase the likelihood of developing WMSDs [2]. These risk factors are prevalent in fast-paced retail environments, such as coffee shops, where baristas perform repetitive tasks, including steaming milk, grinding coffee, and warming food. Despite the growth of coffee culture [3-4], the literature on ergonomic hazards in coffee shop environments is scarce. The few existing studies on this population focus on isolated tasks, such as tamping [5], rather than the overall work demands and risk exposure of baristas.

Aim: The primary objective of this study is to determine the prevalence of WMSDs among baristas in the Greater Toronto Area (GTA). Other objectives include identifying tasks with the highest risk scores, body regions where discomfort is experienced, the influence of tenure and time pressure on discomfort, and how discomfort affects sleep, fatigue, and focus.

Methods: 115 participants employed in a large coffee chain participated in the self-reported questionnaire and 15 stores were visited to perform the American Conference for Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) for Hand Activity Level (HAL) and the Rapid Entire Body Assessment (REBA) on five tasks commonly performed by baristas, including hot bar, cold bar, warming, point of sale, and customer support. Descriptive, bivariate, and regression analyses were used to examine associations between risk factors and reported discomfort.

Expected Results: Results reveal that 82% of baristas experience discomfort perceived to be work-related. Furthermore, discomfort experienced affects workers' daily activities, including sleep disturbances, lack of focus, and unusual fatigue. The RULA risk categorization revealed that all the tasks have very high risk, with the point of sale being medium risk. The ACGIH TLV for HAL demonstrated that all the tasks except for point of sale were predominantly above the TLV. Figure 1 demonstrates an overview of the current results. It is expected that the final analysis will reveal a significant association between variables of interest and discomfort. Overall, the current results demonstrate a serious issue within the coffee shop environment and emphasize the need for change.

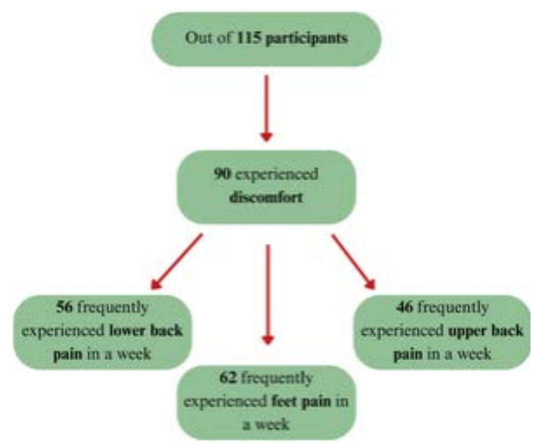

Figure 1: Overview of the prevalence of self-reported WMSD symptoms and frequently affected body regions among participants

References:

[1] Greggi et al (2024) | [2] Nunes & Bush (2012) | [3] Statista (2024, November 12) | [4] Mitchell et al., (2014) | [5] Dainty et al. (2014)

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

Tiana A. Wertelecky[1], Anthony Chen[1], Jessica C. Selinger[1]
[1]School of Kinesiology and Health Studies, Queen's University, Kingston, ON

Introduction: 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 expenditure in real-time [1]. While these parameters are commonly adjusted in naturalistic settings to accommodate varying task demands and terrains [1], gait symmetry remains a near-universal feature of uninjured walking, suggesting it may be less modifiable [2]. Although there is some evidence that persons post-stroke can intentionally (consciously) adapt their asymmetric gait to reduce energy expenditure [3], it remains unclear whether gait symmetry can be implicitly altered in response to modified energetic consequences.

Aim: The aim of my proposed study is to test whether individuals can be incentivized to modify their gait symmetry using robotic lower-limb exoskeletons that manipulate the relationship between gait symmetry and metabolic 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 feedforward, time-based controller that scales peak assistive plantarflexion torque with step-time symmetry, measured in real-time from an instrumented treadmill (Bertec, OH, USA) (**Fig. 1A**). Maximal assistance will be provided when participants walk with an asymmetric gait, 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. The exoskeletons will then be powered in a 12-minute *Pre-Experience* trial to assess whether participants immediately adopt the energetically optimal gait. An *Exploration* trial will then be used to allow participants to self-explore a range of asymmetries and gain experience with the novel cost relationship. A *Cost-Mapping* trial will be then used to assess the relationship between metabolic cost and step-time symmetry across a range of pre-defined gait asymmetries (±6%, ±3%, and 0%; 6-minutes each; randomized order) guided by visual feedback. Following both self-directed and guided experience, participants will complete a 12-minute *Post-Experience* trial, allowing us to assess whether they adapt to an asymmetric gait. Preferred step-time symmetry and metabolic cost will be compared across *Baseline*, *Pre-Experience*, and *Post-Experience* trials.

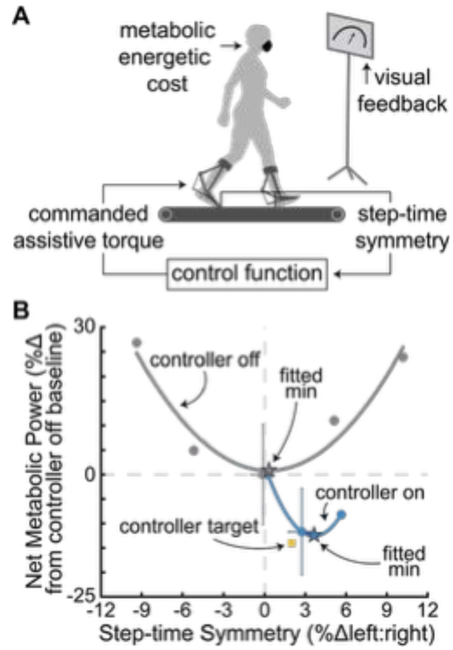

**Figure 1. (A) Participant instrumentation.
(B) Pilot (n=1) energetic landscapes.**

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 (**Fig. 1 B**). If we find that preferred step symmetry can be manipulated using energetic incentives, this paradigm could have significant applications in clinical rehabilitation.

References:
[1] McAllister MJ et al. (2025). J Exp Biol. 228 (Suppl_1); p. JEB248125.
[2] Malone LA et al. (2012). J Neurophysiol. 108 (2); p. 672-683.
[3] Roemmich RT et al. (2019). Neurorehabil Neural Repair. 33 (8); p. 602-613.

AN IN-VITRO INVESTIGATION OF INTERVERTEBRAL DISC MECHANICAL AND STRUCTURAL PROPERTIES FOLLOWING SIMULATED PROLONGED SITTING

Jessa M. Davidson and Jack P. Callaghan
Department of Kinesiology and Health Sciences, University of Waterloo, Waterloo, ON

Introduction: Low back pain responses in sitting may be linked to viscoelastic adaptations in spine tissues, which are mediated by the adopted lumbar spine postures and micromovements [1]. Viscoelastic adaptations that result in changes in intervertebral disc mechanical and structural properties, could predispose tissues to injury or exacerbate existing injuries. The current analysis assessed changes in intervertebral disc mechanical properties, including joint stiffness, and structural properties, including annulus fibrosis collagen and elastin content, following simulated sitting at different postures and micromovement frequencies and amplitudes.

Methods: A mechanical testing system was utilized to apply simulated sitting exposures, derived from *in-vivo* data, to four-two porcine cervical (C34, C56) functional spinal units (FSUs). Following a 15-min 300 N preload and definition of the neutral zone (NZ), FSUs were loaded at 10% of their predicted ultimate compressive tolerance for six hours. FSUs were loaded in static neutral, static flexion (300% NZ), or in flexion with low (25% NZ; 60s) and high (50% NZ; 30s) amplitude and frequency shifting micromovements. NZ testing was then performed again. Posterior-lateral annulus fibrosis specimens were then dissected and frozen for cryo-sectioning. Specimens were serially sectioned at a thickness of 10 μm in the transverse (interlamellar) and frontal (intralamellar) plane, then stained for collagen I and II, as well as elastin.

Results: There were main effects of *time* for the NZ flexion limit, length, and slope, indicating that prolonged static loading increased joint stiffness ($p \leq 0.01$). Moreover, mean changes in the flexion limit were smallest for static neutral (0.5°) and largest for static flexion (-2.7°; $p = 0.03$), with micromovements demonstrating a moderately protective effect (-1.6°). There was no visible damage in collagen I and II and elastin structure (i.e., cleft, fissures, or delamination), indicating that these changes in mechanical properties were likely elastic, rather than plastic.

Discussion and Conclusions: In line with previous *in-vivo* findings [2], the current *in-vitro* analysis indicated that simulated prolonged sitting led to increases in joint stiffness. These changes were likely attributable to time-dependent elastic adaptations in spine tissues (e.g., fluid re-distribution). Results of this study demonstrate that seated micromovements may attenuate these viscoelastic adaptations, potentially mitigating the risk of low back pain.

References:

[1] Dunk, N.M. and Callaghan, J.P. Gender-based differences in postural responses to seated exposures. *Work*. 20 (10): 1101-1110.
[2] Davidson, J.M. and Callaghan, J.P. Are there cumulative changes in lumbar spine passive stiffness throughout a week of prolonged seated work? *J. Appl. Biomech*. 42 (1): 50-59.

Podium Session 5

Friday May 22 (8:30-9:30AM)

NSC 145

Co-Chairs: Harry Battersby, Michael Watterworth

8:30 AM	8:40 AM	**Isabella Shih** Queen's University	Preferred Running Speed: Minimizing Cost and Maintaining Intensity?
8:40 AM	8:50 AM	**Silvia Rio** University of Brescia Brock University	Compartment-Dependent Rate Coding of Deltoid Motor Units Across One and Two Degrees-Of-Freedom Movements
8:50 AM	9:00 AM	**Justin Davidson** University of Waterloo	Beyond Force Plates
9:00 AM	9:10 AM	**Emma Conway** Western University	The Role of Trunk Control in the Development of Knee Overuse Injuries
9:10 AM	9:20 AM	**Sarah Doiron** University of Windsor	Strength Symmetry Predictors Following ACL Reconstruction
9:20 AM	9:30 AM	**Tushar Sharma** University of Guelph	Titles Take Too Much Effort: Location Dependent Effects of Footsole Stimulation on Sense of Effort During Plantar Flexion

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

Isabella Shih[1], Rodger Kram[2], Jessica Selinger[1*]
[1]School of Kinesiology and Health Studies, Queen's University, Kingston, ON, Canada
[2]Department of Integrative Physiology, University of Colorado, Boulder, CO, USA

Introduction: In humans and other animals, locomotor speed preferences tend to align with the speed that minimizes cost of transport (CoT, the *amount* of energy expended per unit distance travelled) [1, 2]. However, maintaining a given exercise intensity (*rate* of energy per unit time) is arguably more physiologically intuitive. A simple, yet untested, way to distinguish between these two objectives is to add load to the body. The speed that minimizes CoT is expected to remain largely unchanged from unloaded to loaded running [3], but exercise intensity naturally increases, allowing us to directly test which better explains PRS. The purpose of this study is to test if human PRS maintains exercise intensity or, instead, minimizes CoT using unloaded and loaded running.

Methods: Twelve participants ran on a treadmill while metabolic expenditure and heart rate were recorded. Across three visits, runners completed a VO_{2max} test, PRS tests under unloaded and loaded (20% bodyweight) conditions, and ran at six speeds ranging from 70% to 120% of their PRS under both conditions. We compared runners' PRS (m/s), exercise intensity at PRS (% VO2max), speed at their minimum net CoT (m/s), and minimum net CoT (J/kg/m) between the unloaded and loaded conditions using paired t-tests (alpha = 0.05).

Results: PRS decreased from unloaded to loaded running (-9.3% ± 5.2%, $p = 3.6*10^{-5}$; **Fig 1**). There was no significant difference in exercise intensity between unloaded and loaded running (60.6% ± 9.0% and 63.9% ± 10.3%, p = 0.092). Unexpectedly, the speed that minimized net CoT decreased from unloaded to loaded running and did so by a magnitude that was consistent with changes in PRS (-10.14% ± 8.56%, p = 0.002).

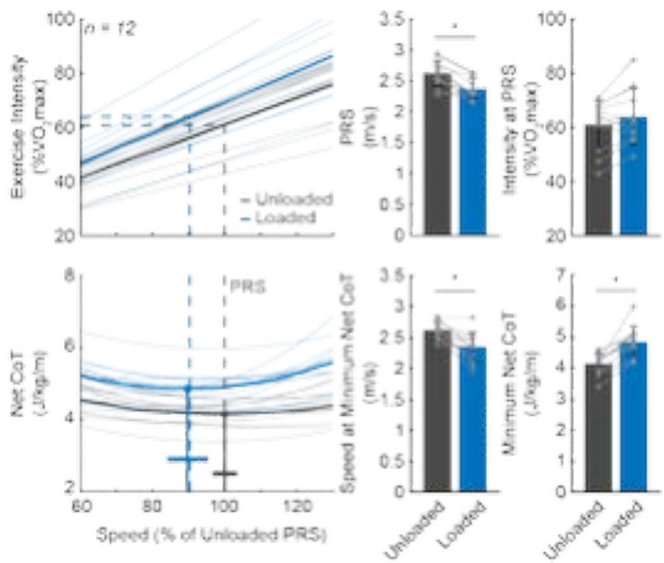

Figure 1: PRS, exercise intensity, and CoT outcomes for unloaded (grey) and loaded (blue) running. Vertical dashed lines represent average PRS, and horizontal dashed lines represent average exercise intensity. Solid vertical lines represent the average speed that minimized CoT and horizontal solid bars represent the 95% CI in that speed. Asterisks represent significant differences.

Discussion: It appears that human PRS may both maintain exercise intensity and minimize CoT, raising important questions about whether these are coupled or coincident objectives. This study may shed light on what fundamental objectives drive human locomotor preferences.

References:

[1] Srinivasan M. & Ruina A. (2006). *Nature*, 439(7072): 72-75.
[2] Selinger J. et al. (2022). *Current Bio*, 32(10): P2309-2315.
[3] Cureton K. & Sparling P. (1980). *MSSE*, 12(4): 288-294.

COMPARTMENT-DEPENDENT RATE CODING OF DELTOID MOTOR UNITS ACROSS ONE AND TWO DEGREES-OF-FREEDOM MOVEMENTS

Silvia Rio[1], Milena A. dos Santos[1], Hélio V. Cabral[2], Elmira Pourreza[1], Caterina Cosentino[1], David A Gabriel[3], J Greig Inglis[1*], Francesco Negro[1*]
[1]Department of Clinical and Experimental Sciences, Università degli Studi di Brescia, Brescia, Italy
[2]School of Physical Education and Sports, Universidade Federal do Rio de Janeiro, RJ, Brazil
[3]Department of Kinesiology, Brock University, Niagara, ON, Canada
[*]Co-Supervisor

Introduction: The shoulder complex dynamically activates across a wide range of motion, with the deltoid playing a primary role in multidirectional movement. Previous research has indicated a non-uniform deltoid activation pattern during shoulder movements [1]. However, whether this regional modulation occurs at the motor unit (MU) level remains unclear. This study investigated MU rate coding during 1 and 2-DoF isometric movements while assessing potential region-specific modulation.

Methods: HD-sEMGs were recorded from the deltoid in 21 participants using two 64-electrode arrays [2]. Participants performed two isometric movements, isolated lateral abduction (1-DoF, Y); combined lateral abduction and medial flexion (2-DoF, YZ), at 5%, 10%, and 20% of a maximum voluntary contraction. The shoulder was positioned at 30° and 65° of abduction. HD-sEMG signals were decomposed into individual MU spike trains and matched across movements. Matched MUs were classified into anterior and lateral regions based on spatial distribution of their MU action potentials [3]. Mean discharge rates (MDR) and coefficient of variation of the inter-spike interval (CoV-ISI) were calculated for each matched MU and compared between 1-DoF vs 2-DoF.

Results: At both shoulder angles, the 2-DoF task increased the MDR of anterior deltoid MUs at 5% (15.5±0.6 vs 13.8±0.6 pps; $p<0.001$), 10% (15.1±0.6 vs 13.7±0.6 pps; $p=0.004$), and 20% MVC (16.4±0.7 vs 14.9±0.7 pps; $p=0.002$). Rate-coding modulation across tasks was not observed in MUs located in the lateral region. Additionally, for both shoulder angles, CoV-ISI of anterior deltoid MUs significantly decreased during the 2-DoF compared to 1-DoF task.

Discussion/Conclusions: Results demonstrate alteration in movement complexity are reflected in rate-coding strategies that compartmentalize neural drive within specific regions of the deltoid to manage multidirectional demands. This supports the specific functional role compartmentalization plays, providing deeper insights into the coordination of complex shoulder movements.

References:
[1] Brown J.M.M et al. (2007). Muscles within muscles: Coordination of 19 muscle segments within three shoulder muscles during isometric motor tasks. Journal of Electromyography and Kinesiology (17); p 57-73.
[2] Inglis J.G. et al. (2025). A novel methodological framework for the assessment of the neural control of the shoulder 3 using high-density surface electromyography. bioRxiv
[3] Negro F. et al. (2016). Multi-channel intramuscular and surface EMG decomposition by convolutive blind source separation. Journal of Neural Engineering (13); 026027

Beyond Force Plates: Evaluating Field-Ready Methods for Low-Back Load Estimation

Justin Davidson[1], Dennis Larson[1], Julia Li[1], Steven Fischer[1]
[1]Kinesiology and Health Sciences, University of Waterloo, Waterloo, ON

Introduction: Accurately estimating cumulative and peak low-back moments is essential for identifying high-risk jobs[1], especially in modern workplaces that are characterized by lower loads and high repetition. While lab environments enable the use of highly accurate force plates to resolve ground reaction forces, this approach is impractical to implement in real-world occupational settings. Hand force estimates are therefore a common alternative; however, accurately measuring hand force magnitudes and direction is challenging and often oversimplified. Additionally, top-down inverse dynamics rely on trunk rigidity assumptions that may introduce error in estimating true spinal loading. Recent innovations in force-estimating insole technology may offer a portable solution to the challenge of capturing ground reaction forces in the workplace[2]; however, their validity in computing low-back moments has not been evaluated. This study aimed to compare force-estimating insoles and hand force-driven inverse dynamics against the force plate-based standard for estimating low-back moments.

Methods: Forty participants (20F, 20M) completed three occupational tasks: floor-to-shoulder lifting, box packaging, and above-shoulder sorting. Thiea3D-derived kinematics were combined with three kinetic approaches: force plates, force-estimating insoles (Loadsol, Novel), and hand force estimates for the purpose of computing peak and cumulative low-back extensor moments in Visual3D. Repeated-measures ANOVAs evaluated differences across tasks and approaches.

Results: Significant interactions between measurement approach and task existed for both peak and cumulative (Figure 1) low-back moments. No significant differences in low-back extensor moments were seen during lifting (when the cumulative moments were highest). Peak and cumulative extensor moments were often overestimated with the field-based approaches, with the exception of above-shoulder sorting.

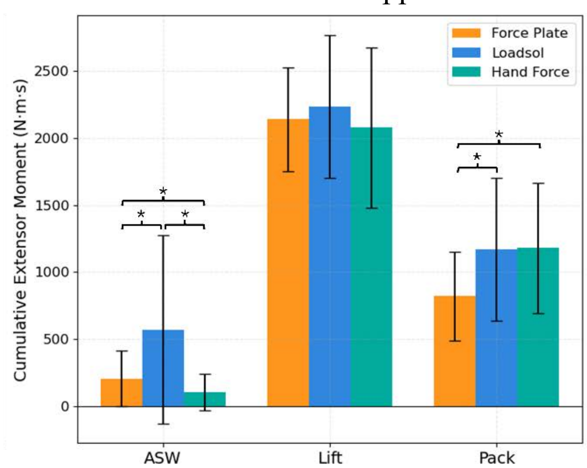

Figure 1: Cumulative low-back moments

Discussion and Conclusions: Overall, few differences were found between low-back extensor moments estimated using hand forces and force-estimating insoles. Considering the practical challenges of estimating hand forces with more complex tasks, where force vector orientation is often not aligned with the gravitational axis, force-estimating insoles may provide a viable alternative for high-resolution, time-series low-back moment estimation. Advancing field-based kinetic measurement accuracy is critical to better understanding, and preventing, occupational low-back injury.

References:
[1] Vieira & Kumar *J. Occup. Rehabil.*, 2004
[2] Davidson et al., *Ergonomics*, 2025

THE ROLE OF TRUNK CONTROL IN THE DEVELOPMENT OF KNEE OVERUSE INJURIES

Emma Conway[1], Shawn M. Beaudette[2], Michael W.R. Holmes[2], Kayla M. Fewster[1]
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Introduction: Previous research has identified many risk factors that contribute to the development of knee overuse injuries (KOIs) [1], but the influence of proximal control on these risk factors remains understudied. In the general population, the prevalence of KOIs is only 0.1% [2]. The prevalence of KOIs is 18% in athletes and rises even higher in athletes who participate in repetitive jumping sports—45% in volleyball players and 32% in basketball players [2-3]. Although these injuries develop gradually, their impact can be significant, leading to training limitations, reduced participation due to pain, and, in some cases, complete withdrawal from sport [3]. Research on acute injuries, such as injury to the anterior cruciate ligament, has highlighted the role of adequate trunk stability in the control of dynamic knee valgus [4]. The overarching goal of this investigation is to advance the understanding of key mechanisms underlying KOIs by integrating load and injury tracking methodologies with laboratory-based assessments of landing mechanics and lumbar spine characteristics. Specifically, this work seeks to explore the role of lumbar spine control as a potential risk factor for the development of KOIs.

Methods: Thirty participants (F =20, M = 10) were recruited from the Western University varsity women's basketball and men's and women's volleyball teams. Participants were asked to visit the laboratory once during preseason training where participants were asked to complete four jumping and landing tasks, during which kinematic and kinetic data were collected via markerless motion capture (Qualysis, Gothenburg, Sweden) and in-ground force plates (AMTI, Watertown, MA). The tasks included a drop vertical jump from a 30cm platform, single-leg drop landings on each limb, and a sport specific jump. Kinematic data were sampled at 60Hz and kinetic data at 1200Hz. Joint kinematics and kinetics were tracked and processed using Theia (Theia Markerless, Kingston, ON). Participants were asked at the beginning of each week of the regular varsity season to identify any knee problems using the Oslo Sport and Trauma Research Centre Overuse Injury Questionnaire and lower body pain using a visual analog scale (VAS). Main outcome variables include peak knee flexion moment and lumbar spine angle during jumping tasks as well as peak VAS, and knee problem severity throughout the varsity season. Based on peak knee problem severity, athletes were separated into groups representing no knee complaints, mild knee complaints, and substantial knee complaints. Pre-season mechanics were then compared across groups.

Expected Results: It is expected that knee problem severity scores will better represent participants' knee problems than VAS scores. We expect that participants who report mild or substantial knee problems throughout the competitive season will display a greater knee moment at peak trunk flexion during pre-season testing than those who reported no knee problems.

References: [1] Waiteman et al., Sports Med. - Open, 8(1): 145, 2022, [2] Nutarelli et al. Orthop. J. Sports Med., 11(6): 23259671231173659, 2023, [3] Lian et al., Am. J. Sports Med., 33(4): 561–567, 2005, [4] Cannon et al., J. Biomech., 116: 110240, 2021.

QUADRICEPS AND HAMSTRINGS STRENGTH SYMMETRY ACHIEVEMENT IN ACL RECONSTRUCTION REHABILITATION: A RETROSPECTIVE ANALYSIS

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Introduction: Anterior cruciate ligament reconstruction (ACLR) requires 9-12 months of rehabilitation to restore functional mobility, sport-specific mechanics, and lower extremity strength. Achieving a ≥ 90% limb symmetry index (LSI) in quadriceps and hamstring strength is an important benchmark for return-to-sport readiness and reduced re-injury risk [1]. Identifying predictors of symmetry attainment may improve rehabilitation strategies and client outcomes.

Methods: A retrospective cohort study was conducted using the Sport Science Rehab and Performance Centre (SSRPC) internal database. Seventy-eight clients (48 F, 30 M; aged 14-65 years) who underwent ACLR within the past five years and initiated rehabilitation at the clinic were included. Graft types included quadriceps (n=34), hamstring (n=24), and patellar tendon (n=20). Surgical cases were classified as isolated ACLR (n=29) or ACLR with additional ligamentous or meniscal repair (n=49). Rehabilitation pathways consisted of one-on-one supervision (n=53) or one-on-one sessions with supervised gym membership (n=25). Seated 60° isometric quadriceps and hamstring strength were measured using VALD™ ForceFrame Technology (VALD Performance Inc., NC, USA), and LSI was calculated. Time to ≥ 90% LSI was categorized by rehabilitation phase (early, mid, late) and analyzed across groups.

Results: Quadriceps strength symmetry was achieved later than hamstring symmetry, with females having greater odds (OR=4.85) of delayed quadriceps recovery ($p<.001$). Hamstring strength symmetry was generally achieved in earlier phases; however, hamstring tendon grafts were associated with delayed recovery ($p=.026$). Surgical complexity and supervision level effects were not significant.

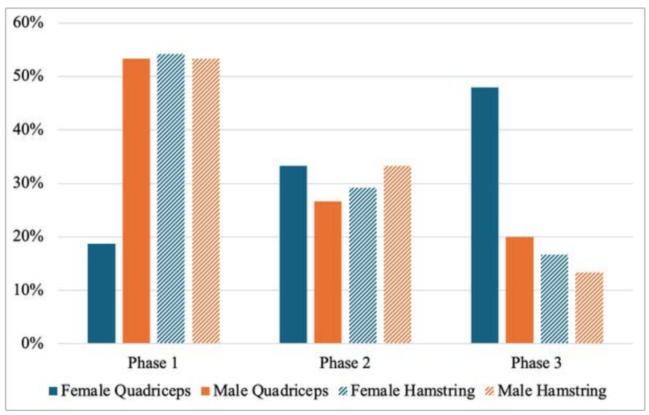

Figure 1. Quadriceps and Hamstring Strength Symmetry Timelines by Sex

Discussion and Conclusions: Quadriceps strength restoration appears to be a significant limiting factor in ACLR rehabilitation, especially in females. Delayed hamstring recovery with hamstring tendon grafts likely reflects donor site morbidity and delayed loading. Results confirmed the effectiveness of the current SSRPC rehabilitation protocol in addressing the needs of the surgical complexity and supervision groups.

Reference:

[1] Kodama, E., Tartibi, S., Brophy, R., Smith, M., Matava, M., & Knapik, D. (2024). Return to sport following ACLR: A scoping review of criteria determining return to sport readiness. Current Reviews in Musculoskeletal Medicine, 18(1), 1-5. https://doi.org/10.1007/s12178-024-09934-7

TITLES TAKE TOO MUCH EFFORT: LOCATION DEPENDENT EFFECTS OF FOOTSOLE STIMULATION ON SENSE OF EFFORT DURING PLANTAR FLEXION

Tushar Sharma[1], Ryan W. Weller[2], Laura C. Marrelli[1], Jayne M. Kalmar[2], Leah R. Bent[1]
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[2]Kinesiology and Physical Education, Wilfrid Laurier University, Waterloo, ON

Introduction: Sense of effort (SoE) relates to how effortful a contraction feels. Increases in SoE are thought to limit physical performance [1]. Thus, finding ways to offset increases in SoE may have functional benefit. Cutaneous stimulation of the foot sole evokes reflexes that modulate both spinal and supraspinal excitability [2], supporting a network to alter SoE. The middle latency component of cutaneous reflexes occurs in a location-dependent manner such that, for plantarflexors, heel stimulation (HL-STIM) excites, while metatarsal stimulation (MT-STIM) inhibits these muscles [3]. Our purpose was to explore the impact of foot sole cutaneous stimulation on SoE during plantarflexion and to explore whether cutaneous modulation of SoE occurs in a location dependent manner.

Methods: While seated, fourteen healthy, young participants (8F;6M) performed constant-effort plantarflexion contractions starting at a 50% of maximal target force held for 8s, after which, visual feedback was removed and the participant was instructed to adjust their force as needed to maintain the same SoE for 45 s. During this phase, participants must drop their force to prevent increasing SoE. This decline was fit to a double exponential decay function where the fast (τ_{fast}) time constant reflects the time course of force decay in the early phase of the contraction, thought to be influenced by rapid changes in central excitability [4], whereas the slow time constant (τ_{slow}) reflects late phase decay associated with slower processes, including the accumulation of muscle metabolites [5]. We also measured percentage of force relative to the initial 50% hold ($\%_{force}$) in 5s epochs (i.e. 0-5s, 5-10s,… 40-45s). Smaller time constants and lower $\%_{force}$ indicated greater SoE. Contractions were performed with no stimulation (NO-STIM), HL-STIM and MT-STIM.

Results: HL-STIM reduced τ_{fast} by 26.1% ($p=0.02$), and $\%_{force}$ in the 0-5s epoch by 2.6% ($p=0.02$) compared to NO-STIM. MT-STIM reduced $\%_{force}$ in the 40-45s epoch by 7.1% ($p=0.05$) compared to NO-STIM. Neither stimulation significantly altered τ_{slow} or $\%_{force}$ in other epochs.

Discussion and Conclusions: Our results suggest that cutaneous stimulation may modulate SoE. Specifically, HL-STIM increases measures of SoE, but only during the start of constant-effort contractions, potentially through changes in central mechanisms. MT-STIM increased measures of SoE during the late phase of constant-effort contractions, but not early. Although HL-STIM and MT-STIM impacted different phases of the constant-effort contractions, both stimulation sites increased effort, and thus a location dependent effect is unclear. Overall, our findings highlight cutaneous stimulation as a promising target for interventions aimed at altering SoE for high-level performance and in everyday tasks.

References: **[1]** Marcora S & Staiano W (2010). Eur J Appl Physiol 109; p. 763-70. **[2]** Gill G et al. (2022). Physiol Rep 10(13); e15240. **[3]** Nakajima T et al. (2006). Exp Brain Res 175; p. 514-25. **[4]** Plaskett C & Cafarelli E (2001). J Appl Physiol 91; p. 1535-44. **[5]** Cain W (1973). J Mot Behav 5(1) p. 33-47.

Podium Session 6

Friday May 22 (9:40-10:40AM)

NSC 145

Co-Chairs: Johannes Eichwalder, Erinn McGrath-Frangakis

9:40 AM	9:50 AM	**Ian Doctor** Brock University	Assessing the Effect of Inter-Athlete Spatiotemporal Coordination on Pairs Rowing Performance Times
9:50 AM	10:00 AM	**Riley Starr** Western University	Quadriceps Strength Does Not Influence the Association Between Joint Loading and Cartilage Thickness 10 Years After ACL Reconstruction
10:00 AM	10:10 AM	**Isabela Fleguel** University of Guelph	Spine Muscle Fatigue Measures
10:10 AM	10:20 AM	**Paige Yoshida** Carleton University	Monitoring Exhale and Lung Volume in Divers Using Electrical Impedance Tomography
10:20 AM	10:30 AM	**Sarah Hallman** University of Waterloo	Gap-Filling Marker Trajectories During Squatting
10:30 AM	10:40 AM	**Gillian Slade** Ontario Tech University	Effect of Overhead Cycle Time on Shoulder Fatigue

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

Ian M. Doctor[1], Daniel S. Brickman[1], Christopher L. Vellucci[1], Aurora Battis[1], Katie A. Bruggeling[2], Shawn M. Beaudette[1]
[1]Department of Kinesiology, Brock University, St. Catharines, ON
[2]Brock University Rowing, St. Catharines, ON

Introduction: Biomechanical analysis to maximize rowing 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].

Aim: To explore the association between inter-athlete coordination outcomes and on-water rowing performance times in pairs rowing.

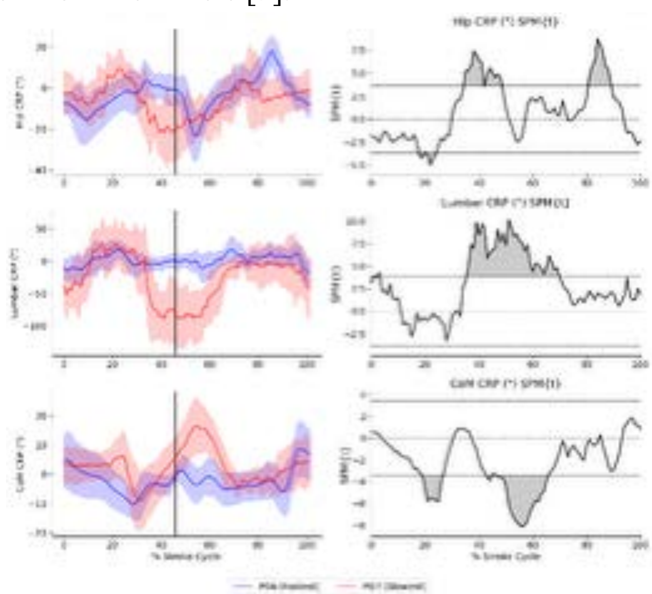

Figure 1: CRP analysis of slowest and fastest pairs (gray shaded shows significant coordination differences)

Methods: 16 competitive rowers participated (6F). Athletes were collected in pairs corresponding to on water time trial (TT) data. Each pair completed a 1-minute indoor rowing tank trial at race pace while eight Miqus cameras (Qualisys AB, SE) captured concurrent video data for the duration of the trial. Post-processing utilized THEIA3D (Theia Markerless Inc., ON, CAN), Visual3D (V3D LLC., USA), and MATLAB (MathWorks Inc., USA) to measure 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 dynamic joint angles for each pair were compared with TT data (normalized to sex and weight class). Multivariate statistical models explored the association between oar, and athlete kinematic outcomes on performance. In addition, a statistical parametric mapping (SPM) approach was used to compare and continuous relative phase (CRP) curves between the slowest and fastest pairs

Results: Multivariate ridge regression yielded significant moderate correlation (R^2=0.57, p<0.01) between oar kinematic variables and performance times. Spatiotemporal body coordination model yielded a significant weak correlation (R^2=0.23, p<0.01) between coordination lag (movement separation) and normalized TT times. SPM analyses noted differences in coordination between slowest and fastest pairs (**Figure 1**).

Discussion: Overall, oar mechanics appear to have a greater effect on water pairs performance than joint coordination, but both areas are significant contributors to pairs rowing performance.

QUADRICEPS STRENGTH DOES NOT INFLUENCE THE ASSOCIATION BETWEEN JOINT LOADING AND CARTILAGE THICKNESS 10 YEARS AFTER ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

Riley Starr[1], Harry Battersby[1], Dianne Bryant[1], Alan Getgood[1], Derek Pamukoff[1],
[1]School of Kinesiology, Faculty of Health Sciences, Western University, London, ON

Introduction: Anterior cruciate ligament reconstruction (ACLR) increases knee osteoarthritis (OA) risk [1]. Quadriceps weakness post-ACLR is linked to aberrant gait biomechanics that affect cartilage morphology [2], and optimal loading is unclear. We examined quadriceps strength's influence on the joint loading and cartilage thickness relationship 10 years post-ACLR.

Methods: Forty-eight subjects 10 years post-ACLR participated (45.8% female, Age=29.6±3.0 years, BMI=27.6±4.9 kg/m^2). Femoral trochlea (FTC) and medial femoral condyle (MC) thickness was imaged via ultrasound. Peak isokinetic (IK) and isometric (IM) knee extensor strength was assessed by dynamometry. Kinetic and kinematic data were collected using 8-camera motion capture and a force instrumented treadmill. A model [3] estimated patellofemoral (PFJF) and medial tibiofemoral (TFJF) joint contact forces. Paired samples t-tests examined between-limb comparisons. Multiple linear regression examined the influence of quadriceps strength on the association between joint contact forces and cartilage thickness within both articulations in the ACLR limb after adjusting for sex, concomitant meniscus injury, and ipsilateral re-injury.

Results: There were no differences in PFJF (p=0.48), TFJF (p=0.67) or IK strength (p=0.99). The ACLR limb had lower IM (p=0.01), and thicker cartilage (FTC: p=0.02, MC: p<0.01) than the contralateral limb. In the ACLR limb, the FTC thickness regression model was significant (R^2=0.42, p<0.01), but was driven by covariates. Male sex (β=0.51, p<0.01) and ipsilateral reinjury (β=0.39, p=0.03) were associated with thicker cartilage. The MC thickness regression model was not significant (R^2=0.20, p=0.14).

	ACLR	**Contralateral**	**p**
PFJF (BW)	0.79±0.29	0.81±0.34	0.48
TFJF (BW)	2.00±0.33	2.02±0.43	0.67
IM (Nm/kg)	2.69±0.69	2.86±0.72	0.01
IK (Nm/kg)	1.79±0.50	1.79±0.46	0.99
FTC (mm)	2.27±0.50	2.13±0.35	0.02
MC (mm)	2.03±0.45	1.79±0.29	<0.01

Table 1: Between-Limb Comparisons

Discussion and Conclusions: No between-limb differences in joint contact forces indicate bilateral gait symmetry restoration. IM between-limb differences suggest persistent quadriceps impairment [4]. Thicker cartilage in the ACLR limb may reflect swelling from the initial injury, signaling incomplete ACLR recovery and further exacerbation by ipsilateral reinjury. The FTC model was significant while the MC model was not, potentially reflecting the direct influence of the quadriceps on the patellofemoral articulation [5]. Sex was a strong predictor of FTC cartilage thickness possibly linked to sex-based differences in strength, gait and cartilage morphology [6].

References: [1] Arhos E et al. (2022). AC&R 74(3); p. 386-91. [2] Hipsley A. et al. (2022). KSSTA. 30(6); p 1949-57. [3] Messier S et al. (2011). OAC 10; p. 272-80. [4] Cobian D et al. (2025). Sports Health. 17(2); p. 365-73. [5] Loudon J (2016). IJSPT. 11(6); p. 820. [6] Black L & Clark A. (2022). J. Orthop. 32; p. 104-8

COMPARISON OF BIOMECHANICAL EVALUATIONS OF SPINE MUSCLE FATIGUE

Isabela Fleguel, Liam MacInnis, Stephen Brown
Human Health Sciences, University of Guelph, Guelph, ON

Introduction: Spine muscle fatigue is often studied in relation to how it affects spine movement, control and loading. Muscle fatigue can be defined as the temporary decline in the ability of a muscle to produce force. The Biering-Sorensen test has been established as a valid method for assessing fatigue in back extensor muscles [1]. It can be challenging to directly measure the force-generating output of muscles, in part because recovery of the force-generating ability happens within minutes. As a result, indirect measures of muscle fatigue such as electromyography (EMG) and subjective ratings of perceived exertion (RPE) are often used. However, their validity in reflecting true spine muscle fatigue still remains unclear. In this study we aim to assess these measures of muscle fatigue and recovery as well as their day-to-day reliability.

Methods: 7 young healthy subjects (4 female, 3 male) performed 3 isometric maximal voluntary contractions (MVC) of the spinal extensor muscles, followed by a fatiguing Biering-Sorenson test, immediately followed by another MVC, with subsequent MVCs 10, 20 and 30 minutes post fatigue trial. The participants were asked to give an RPE following each MVC and the fatigue test. The protocol was repeated seven days later. Surface EMG electrodes were placed bilaterally over the thoracic and lumbar erector spinae muscles. Mean power frequency (MPF) was calculated over the first and last 3 second windows of the fatigue trial. The sample rate was 2048 Hz. Force was measured using a force transducer. The force data were low pass filtered at a cutoff of 3 Hz and the maximum force was determined during the pre and post MVC trials.

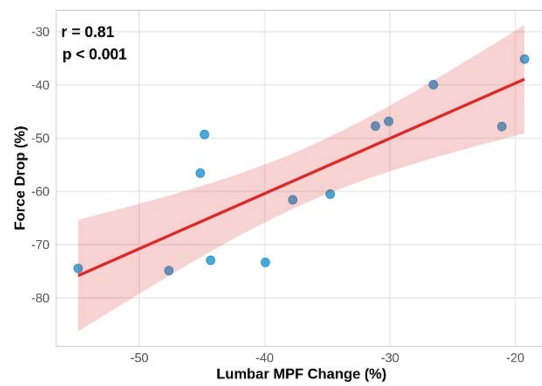

Figure 1: Relationship between force drop % and % change in lumbar mean power frequency (MPF), calculated as post-fatigue MVC relative to pre-fatigue MVC. Both days are included.

Results: Lumbar MPF decline was strongly associated with force loss over the fatigue trial ($r = 0.81$, $p < 0.001$) (Figure 1). The relationship between RPE and force loss was not statistically significant ($p = 0.74$).

Discussion and Conclusions: This study shows that the fatigue-induced reductions in spinal extensor muscle force production are strongly correlated with a decline in lumbar MPF, indicating that MPF may be a useful predictor of fatigue. In contrast, RPE was shown to have no meaningful relationship with objective measures of fatigue, suggesting a larger sample size or improved participant understanding of RPE may be needed to better assess this relationship.

References:

[1] Demoulin C et al. (2016). Is the Sørensen test valid to assess muscle fatigue of the trunk extensor muscles? Journal of Back and Musculoskeletal Rehabilitation 29 (1); p. 31-40.

MONITORING EXHALE AND LUNG VOLUME IN DIVERS USING ELECTRICAL IMPEDANCE TOMOGRAPHY

Paige M. Yoshida[1], Jeff W. Dawson[1] Andreas Fahlman[3], and Andy Adler[2]

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[2]Department of Systems and Computer Engineering, Carleton University, Ottawa, ON.
[3]Global Diving Research SL, Sanlucar de Barrameda, Spain

Introduction: Lung volume can be reduced either through increased pressure during a breath-hold dive, or by exhaling. While both processes result in reduction of lung volume, only the exhale decreases the amount of lung gas. In this study, we wanted to compare these two mechanisms to assess whether they produce similar regional changes in lung air distribution. We hypothesize that regional air movement within the lungs is different during these mechanisms. We used Electrical Impedance Tomography (EIT), modified for underwater use [1] to image lung air distribution.

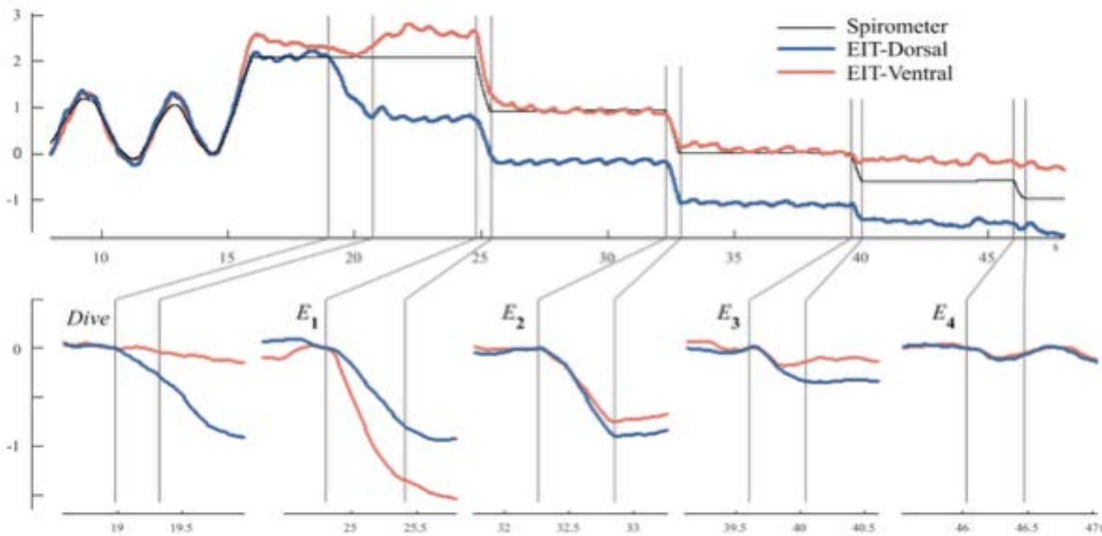

Figure 1: Spirometer, regional EIT signals, and event sequence (top) for an experiment. A dive (surface to 1m depth) was followed by four exhales at depth (E_1 ... E_4). Bottom: expanded time axis for each event

Methods: Ongoing research consisted of 3D EIT electrode belts (as per [1]) placed circumferentially onto participants' (N=5) chests. Participants breathed through a snorkel attached to a spirometer. Starting at the surface, participants were pushed to 1m depth (*Dive*) and then exhaled four times (E_1 ... E_4) at depth (figure 1). EIT images were reconstructed with dorsal and ventral lung regions analyzed. The distribution of flow between the dorsal and ventral ROIs was calculated. Each participant was tested in prone and supine postures.

Results: Clear difference in dorsal-to-ventral flow was observed between the dive and exhales. These differences often reversed between the two postures. Large variations between subjects are seen.

Discussion and Conclusions: Results show that EIT can be used reliably to obtain real-time data of human participants underwater. This opens the opportunity for future studies to further the understanding of diving related lung injuries and mechanics.

Reference: [1] Adler et al. (2025) Physiol Meas, 46:03NT01

GAP-FILLING MARKER TRAJECTORIES DURING SQUATTING

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Introduction: Cubic spline interpolation, while easy to implement and commonly used for filling missing marker trajectories, is accurate only up to 10 frames [1], yet gaps often exceed this duration. Therefore, this secondary analysis compared spline interpolation with two newer gap-filling methods across different gap durations during squat movements. We hypothesized that spline interpolation would produce higher error than the other two methods at each gap length.

Methods: Lower extremity and pelvis motions were recorded at 50 Hz for 50 healthy young adults [2] during three flatfoot squat trials using an eighteen-camera Optotrak Certus system (Northern Digital Inc., Waterloo, Canada). Gaps (0.5s, 1s, 2s, 5s) were manually created for a subset of 11 participants with no marker gaps for 1 trial in MATLAB (MathWorks, Natick, USA) at randomized frames and markers for the right lower extremity and pelvis marker trajectories (one foot, two shank/thigh, three pelvis markers) to simulate occlusion. Cubic spline interpolation was applied via the MATLAB "interp1" function, with 5 frames before and after each gap serving as knots [1]. Principal Component Analysis (PCA) [3] and Kalman Smoothing [4] gap-filling methods were implemented using published procedures and codes. Gap-filling accuracy was evaluated by calculating the maximum Euclidean distance (d_{max}) and root mean square error (RMSE) between reconstructed and original marker positions. Average d_{max} and RMSE across all markers for each gap length and method were input to Aligned Rank Transform Analyses of Variance, with a Holm-Bonferroni correction applied to pre-planned comparisons.

Results: A significant main effect of gap-fill method was found for d_{max} ($p<0.01$) and RMSE ($p<0.01$). Pairwise contrasts for d_{max} (Table 1) and RMSE (Table 2) revealed that spline and Kalman methods differed significantly from PCA ($p<0.05$), but not from each other, except at 0.5s, where all methods significantly differed ($p<0.05$).

Table 1: Max Euclidean Distance (mm), Mean (SD)

		Cubic Spline	PCA	Kalman
Gap Length	0.5s	[a]8.8 (9.6)	[b]1.1 (0.6)	[c]54.2 (74.6)
	1s	[a]34.6 (67.8)	[b]2.3 (3.2)	[a]116.6 (201.7)
	2s	[a]95.1 (116.4)	[b]2.6 (1.6)	[a]162.0 (250.2)
	5s	[a]259.6 (143.0)	[b]6.0 (4.7)	[a]217.5 (216.8)

Table 2: Root Mean Square Error (mm), Mean (SD)

		Cubic Spline	PCA	Kalman
Gap Length	0.5s	[a]3.0 (3.3)	[b]0.4 (0.2)	[c]18.6 (24.4)
	1s	[a]9.7 (17.1)	[b]0.7 (0.7)	[a]32.9 (46.5)
	2s	[a]29.3 (30.5)	[b]0.7 (0.4)	[a]41.5 (52.6)
	5s	[a]111.4 (54.3)	[b]1.5 (0.9)	[a]82.2 (115.9)

Means sharing the same superscript letters are not significantly different (Holm, p>0.05).

Discussion and Conclusions: Opposing our hypothesis, Spline and Kalman exceeded PCA in error, with Kalman's high mean reflecting high variability. Notably, the small subset of clean marker trajectories underscores the need for accurate gap-filling methods in motion capture. While spline interpolation remains the most common approach, these results suggest a shift towards PCA would be advantageous.

References:

[1] Howarth & Callaghan. (2010). Quantitative assessment of the accuracy for three interpolation techniques in kinematic analysis of human movement. 13(6); p. 847-855.
[2] Laudanski. (2022). Development of a wearable sensor-based framework for the classification and quantification of high knee flexion exposures in childcare [Doctoral dissertation]. UW Space.
[3] Gløersen & Federolf. (2016). Predicting missing marker trajectories in human motion data using marker intercorrelations. 11(3).
[4] Burke & Lasenby. (2016). Estimating missing marker positions using low dimensional Kalman smoothing. 49(9), p. 1854-1858.

CYCLE TIME INFLUENCES SHOULDER FATIGUE DURING OVERHEAD WORK

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Faculty of Health Sciences (Kinesiology), Ontario Tech University, Oshawa, ON

Introduction: Overhead work can lead to chronic shoulder pain or work-related musculoskeletal disorders (WMSDs), with key risk factors including awkward postures, repetitive actions, and joint compression - all common during overhead work[1]. While eliminating overhead work is ideal, this is often impractical in many industrial processes. A more feasible solution is to limit overhead duration. Some automotive companies restrict overhead work to 33% or 50% of a total work cycle; however, these guidelines consider only the total time spent overhead, not its distribution. For example, a 50% overhead limit could involve 5s above / 5s below vs. 30s above / 30s below. Previous research shows fatigue responses vary with cycle time[2], but no consensus exists on the least fatiguing cycle. As such, the purpose of this study is to evaluate shoulder fatigue responses across four different cycles time conditions with an equivalent duty cycle.

Methods: Ten participants (5F, 5M) aged 18-65 were recruited to date. Participants cyclically raised and lowered a weighted cylindrical tube to a set height with their elbow flexed to 90° until stopping criteria were met. Baseline maximum upwards push strength was measured, and the weight of the tube was set to 15% of strength using lead shot. Four different cycle-time conditions (5s, 10s, 15s, & 30s) were completed in a counterbalanced order on separate days, all at a 50% duty cycle (Figure 1).

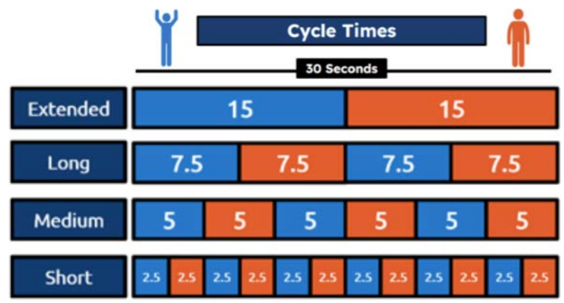


Figure 1: Cycle times investigated.
light blue = overhead, orange = below head

Participants rated their perceived discomfort (RPD) on a scale from 0-10 every 2 minutes. Once the fatiguing task concluded, one final strength exertion was measured. Lastly, participants completed a NASA-TLX, which assessed perceived task demands on a scale from 0 to 100.

Results: The medium cycle time had the longest endurance (51.8 ± 39.1 min), while the short cycle time had the shortest (16 ± 20.2 min). RPD development was slowest for the medium cycle time and fastest under the short cycle-time. Post-protocol strength declines were largest after the extended cycle time (24%), with the smallest decline for the medium and short cycle times (both 17%). The short cycle time led to the highest median NASA-TLX ratings across mental demand (67.5), physical demand (85), temporal demand (90), effort (86), and frustration (60).

Discussion & Conclusions: The short cycle time resulted in shorter endurance times than any of the other conditions. Combined with consistent NASA-TLX and RPD measures, this suggests rapid "up-down" movements are less favourable for prolonged overhead work. A larger sample size may help clarify differences among the remaining cycle times, particularly whether the 15-second condition is too long, given that it led to the largest median post-protocol strength declines.

References:
[1] Barthelme, J. et al. (2021). *BMC Musculoskeletal Disorders*, *22*(1), 624.
[2] Dickerson, C. R., et al. (2015). *Journal of Biomechanics*, *48*(11), 2911–2918.

Podium Session 7

Friday May 22 (10:50-11:50AM)

NSC 145

Co-Chairs: Daniel Cousins, Claudia Smith

10:50 AM	11:00 AM	**Aidan Armitage** University of Waterloo	Investigating the Influence of Upper Extremity Kinematics on Dual Target Fastball Command in Elite Level Baseball Pitchers
11:00 AM	11:10 AM	**Avery Marshall** Lakehead University	Nature of Unilateral Force Attenuation and Production in Elite Youth Dancers
11:10 AM	11:20 AM	**Desmond Brent-Hurst** HAS-Motion	Assessing Characteristics of Representative Signal Methods
11:20 AM	11:30 AM	**Cameron Lang** Brock University	Office Ergonomics in Augmented Reality
11:30 AM	11:40 AM	**Laura Vancer** Western University	Understanding the Effects of Malrotation on the Lateral Elbow Radiograph to Improve Fracture Detection
11:40 AM	11:50 AM	**Aryan Sadghian** Western University	Validity of a Smartphone Motion Capture Rep Counter

Investigating the Influence of Upper Extremity Kinematics on Dual Target Fastball Command in Elite Level Baseball Pitchers

Aidan S. Armitage[1], Clark R. Dickerson[1]
[1]Kinesiology and Health Sciences/Faculty of Health, University of Waterloo, Waterloo, ON

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 neglect to assess command, the ability to manipulate location of the ball within 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 multi target command in fastballs.

Methods: Participants will perform individual warm-ups prior to collection. Each set will consist of 15 pitches, randomized to either the left or right-side target. Kinematic data is collected using 8 Optitrack Cameras (Optitrack Inc., Corvallis, Oregon) and is processed using Theia3D, Visual3D and Matlab. Kinematics calculated will include thoracopelvic, thoracohumeral and elbow joint angles (Figure), along with pelvis, torso, upper arm and forearm segment angular velocities and release point defined as wrist centre of gravity. Kinematic snapshots will include select joint angles at discrete events of foot-plant, maximum external rotation or ball release. Statistical analysis will include Statistical Parameter Mapping to compare time-series kinematic data. Command will be tracked via high-speed video, and a Matlab image identification script will be used to identify distance from intended target using the an image of the ball impact on a calibrated target.

Expected Results: Among participants, the top and bottom 20% in command will be analyzed as high command (HC) and low command (LC). The HC group is anticipated to have more consistent mechanics, while. the LC group is expected to show more variation, especially during discrete events of maximum external rotation and ball release.

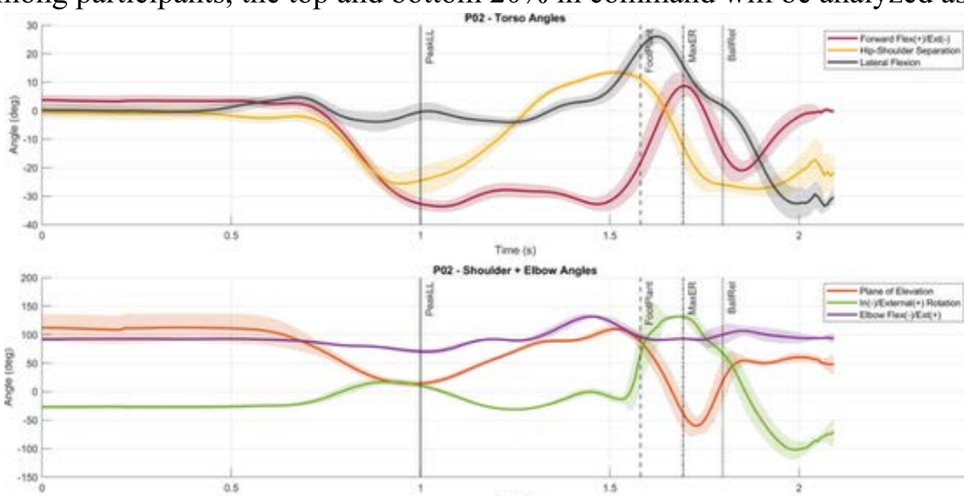


Figure 1. Sample pitch kinematic trajectories, including discrete event timing

References:

[1] Wilk, K et al. (2011). *The American journal of sports medicine,* 39(2); p. 329-335.
[2] Scarborough, D.M. et al. (2021). *Journal of Sports Science and Medicine,* 20(1); p. 94-100.
[3] Fleisig, G. et al. (2009). *Sports biomechanics*, 8(1), 10–21.
[4] Escamilla, R. F. et al. (2017). *The American journal of sports medicine*, 45(14); p. 3358-3367

NATURE OF UNILATERAL FORCE ATTENUATION AND PRODUCTION IN ELITE YOUTH DANCERS

Avery Marshall[1], Eryk Przysucha[1], Carlos Zerpa[1]
[1] School of Kinesiology, Lakehead University, Thunder Bay, ON

Introduction: In ballet, jazz, tap, hip-hop or contemporary dance, “leaping” and “landing” represent critical elements of artistry. The issue of “landing” is often synonymous with force “force attenuation”, while the “take-offs” are related to force production, in vertical or horizontal planes of motion. In the domain of dance, majority of the research involved older, more advanced performers. Also, it only focused on vertical landings and jumps, although vertical and horizontal actions are biomechanically different. Also, the issue of inter-limb asymmetry has not been examined at all despite the fact that overwhelming amount of literature across many sports support the fact that asymmetry indices above 10-15% are highly correlated to possibility of injuries. Therefore, the purpose of this research was to examine the nature of unilateral force attenuation and production across different task constraints, and the prevalence of the asymmetries associated with these constructs, among youth elite dancers.

Methods: Ten adolescent competitive female dancers were recruited. The forces attenuation indices were derived from Vertical Peak Ground Reaction Force (VPGRF adjusted for weight), Time to VPGRF, and Loading Rate, from depth and scatter jumps. Force production measures were obtained via Peak Propulsive Force and Reactive Strength from depth jumps. Also, asymmetry index was derived for all the measures, across all three tasks which were performed on the AMTI force platform (Advanced Mechanical Technology, Inc, MA, US).

Results: The results showed statistically significant differences across depth and skater jumps for all three measures of force attenuation ($p < .01$ - 05), with depth jumps exhibiting stiffer landings across both limbs (see Figure 1). The results emerging from the drop jumps revealed statistically significant differences in concentric Peak Propulsive Force between the two limbs ($p < .03$), as well as in explosiveness as inferred from Reactive Strenhgt Index ($p < .05$). In terms of asymmetries the most pronounced imbalances across the constructs and tasks examined, emerged in horizontal force attenuation, with indexes substantially exceeding 15-20% mark.

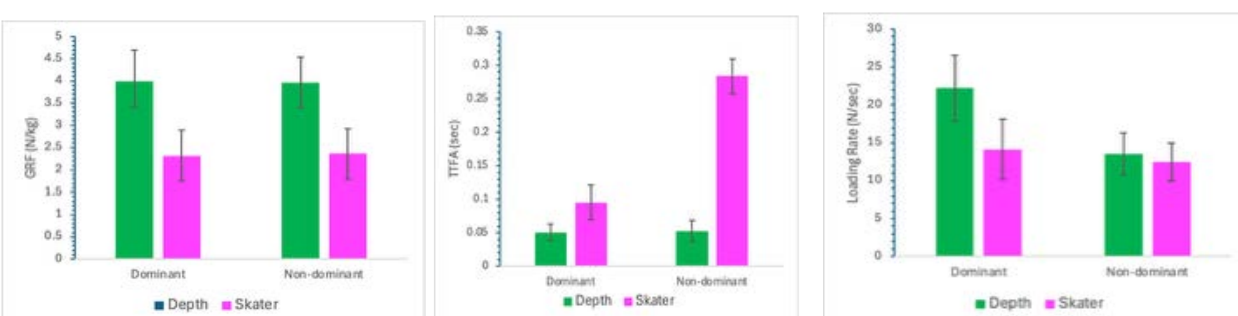


Figure 1. Differences between dominant and non-dominant limbs, across vertical (depth) and horizontal (skaters) tasks, in Peak GRF, Time to Peak GRF and Loading Rate.

ASSESSING CHARACTERISTICS OF REPRESENTATIVE SIGNAL METHODS

Desmond Brent-Hurst[1,2], Michael Robles[1,3], Amy Coyle[1], Sydney Garrah[1] , Richard Moulton[1]
[1]HAS-Motion, Kingston, ON
[2]Department of Mechanical and Materials Engineering, Queen's University, Kingston, ON
[3]Department of Electrical and Computer Engineering, Queen's University, Kingston, ON

Introduction: Biomechanical data is typically summarized using representative signals (RS) like the mean for group analysis. Here we compare eight methods of finding RS, evaluating their sensitivity and robustness by varying input.

Methods: We extracted hip, knee and ankle angles, and ankle flex./ext. angular velocity and acceleration for 34 (24 M) healthy participants from a public data set [1] using Visual3D and Sift (HAS-Motion, Canada). We computed RS with real signal methods (Euclidean medoid [2], PCA medoid [3], vector correlation [4], DTW medoid [5]) and synthetic signal methods (mean, median, shapeDBA [5], softDBA [5]). We evaluated robustness via bootstrapping, randomly removing 10% of traces for 25 iterations, and calculating the dispersion of the resulting RS. We evaluated sensitivity by excluding the top or bottom 1/3 of signals based on the sum of y-values and comparing RS.

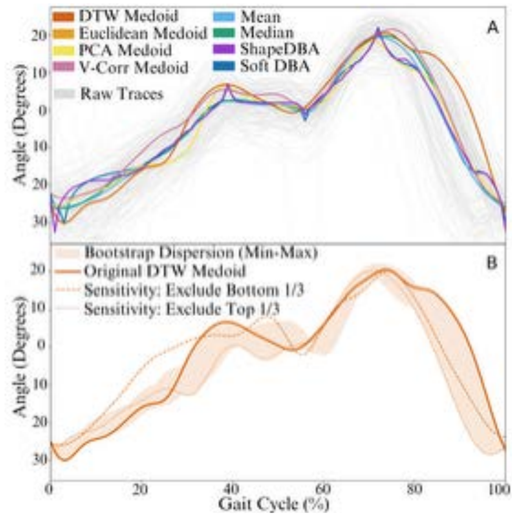


Figure 1: A) Ankle flex./ext. RS for 8 methods. B) Sensitivity and robustness of DTW medoid.

Results: Each method found different RS (Figure 1A). Methods producing real signals were more sensitive and less robust than methods producing synthetic signals. Figure 1B shows that DTW Medoid has a large bootstrapping dispersion and a clear distinction between exclusion scenarios.

Discussion and Conclusions: While measures of sensitivity/robustness clearly demonstrate advantages of synthetic methods, the resulting RS are not a real signal whose properties can be explored and are sometimes radically different (shapeDBA and softDBA). Given this, method selection should consider whether a real signal is needed when finding RS.

References:

[1] Bond, Colin. (2025). SanfordStrideProject. GitHub, https://github.com/SanfordEAS/Sanford_Stride_Project_Public. OSF, https://osf.io/ebntq

[2] Z. Hossain et al. (2015). "Comparison of Euclidean Distance Function and Manhattan Distance Function Using K-Mediods"; *Int. J. Comput. Sci. Inf. Secur.* (13); p. 61-71

[3] J. Wang et al. "Functional data Analysis"; *Annu. Rev.*, 2015.

[4] R. Shadmehr et al. (1994). "Adaptive Representation of Dynamics during Learning of a Motor Task"; *J. Neurosci.* (5); p. 3208-3224

[5] A. Ismail-Fawaz et al. (2023). "ShapeDBA: Generating effective time series prototypes using SHAPEDTW Barycenter averaging"; *Adv. Anal. Learn. Temporal Data* (8); p. 127-142

COMPARING TWO AUGMENTED REALITY SYSTEMS ON MUSCLE ACTIVITY AND POSTURE DURING COMPUTER TASKS AT SIT AND STAND WORKSTATIONS

Cameron Lang[1], Garrick Forman[1], Jack Callaghan[2], Jessa Davidson[2], Michael Holmes[1]
[1]Department of Kinesiology, Brock University, St. Catharines, ON
[2]Kinesiology and Applied Health Sciences, University of Waterloo, Waterloo, ON

Introduction: Virtual Reality (VR) and Augmented Reality (AR) technologies are rapidly evolving. Traditionally used for gaming and entertainment, these tools have potential to revolutionize the modern office, demonstrating improved productivity, and enhanced collaboration [1]. Advances in resolution and computing power have allowed traditional computer work to completed in AR [2]. Prolonged use of head-mounted displays increases neck and shoulder discomfort, but current literature suggests advancement in headsets counteract these ratings [3].

Methods: 20 adults (10 M, 10 F; 18-30 years) were recruited. Muscle activity was measured using surface electromyography (sEMG) bilaterally on the upper extremity. Kinematics were measured using motion capture, with markers placed bilaterally on the upper limbs, head and thorax. Triaxial accelerometers were placed along the spine (C7, T12, L1) to measure spine rotation and angle. Comparison of two headsets (Meta Quest 3 (MQ) & Apple Vision Pro (AVP)) was completed during simulated office work in both sit and stand conditions. Two 60-minute sessions were completed. Alternating 5-minute blocks of two tasks was performed in AR: 1) typing and 2) text editing using a physical keyboard.

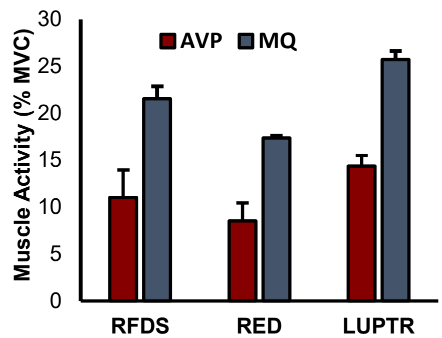


Figure 1: 50th percentile APDF muscle activity for flexor digitorum superficialis (FDS), extensor digitorum (ED) and upper trapezius (UPTR) across headsets.

Results: Significant differences across device existed for the FDS (AVP: 11.0±2.9 %MVC; MQ: 21.5±1.3 %MVC), ED (AVP: 8.5±1.9 %MVC; MQ: 17.3±0.3 %MVC), and UPTR (AVP: 14.3±1.1 %MVC; MQ: 25.7±0.9 %MVC), with the MQ yielding greater muscle activity compared to the AVP. A decrease in muscle activity occurred for the typing task while standing vs. sitting in the ED (Sit: 14.0±5.9 %MVC; Stand: 11.9±6.1 %MVC) and UPTR (Sit: 24.3±5.5 %MVC; Stand: 15.8±7.3 %MVC). MQ demonstrated greater neck extension compared to AVP (MQ: 19.0±2.4°; AVP: 17.9±1.2°). No significant changes in discomfort/sickness across device and condition*task.

Discussion and Conclusions: Our findings are in line with previous literature, demonstrating a decrease in upper limb muscle activity during typing tasks while sitting vs. standing [4]. Increased neck extension while using the MQ may be a result of lower visibility of external devices (i.e. keyboard) and reduced field of vision, which may affect overall performance.

References:

[1] Riches S et al. (2023). Virtual Reality and Immersive Tech. J of MH. 33(2); p. 253-273.
[2] Pavantto L et al. (2023) Virtual Monitors vs. Physcial Monitors. Front in VR. 04:4:1215820.
[3] Kim et al. (2023) Impact of Discomfort on VR Immersion. *VRST 2023,*1–2.
[4] Cui A et al. (2020) Sex effects of sit vs. stand in Upper Body MA. App. Ergo, 82, 102957.

UNDERSTANDING THE EFFECTS OF MALROTATION ON THE LATERAL ELBOW RADIOGRAPH TO IMPROVE FRACTURE DETECTION

Laura Vancer[1,2], Max Campbell[2,3], Clara Malak[1], Greg Garvin[4], Emily Lalone[1,2,3]

[1] School of Biomedical Engineering, Western University, [2] Roth McFarlane Hand and Upper Limb Centre, [3] School of Mechanical and Materials Engineering, Western University, [4] Schulich School of Medicine and Dentistry

Background: Conventional radiography is the most common imaging modality used worldwide, in part due to its unique ability to assist healthcare workers in diagnosing, screening, and monitoring for a wide range of injuries and conditions. The diagnostic utility of a radiograph, however, is highly dependent on proper anatomical positioning. The positioning of the elbow joint during lateral radiographs is particularly sensitive to malrotation due to the difficulty of aligning both the long and short axes. This challenge is highlighted through a missed fracture rate of up to 10% in patients who have previously undergone radiography [1]. The current practice of aligning the condyles through manual palpation is difficult to achieve due to unique patient anatomy. The primary objective of this study is to evaluate how elbow malrotation from a neutral lateral position influences the proposed radiographic landmarks.

Methods: This study builds on previous work conducted by our lab that analyzed the effects of malrotation on proposed radiographic landmarks of the wrist [2]. Twelve fresh-frozen cadaveric specimens (n=12) were manipulated from a neutral lateral elbow position, where the incident x-ray beam intersects the condyles perpendicularly. A total of eight angular deviations were performed along the two axes at the elbow: the short axis, aligned with the forearm, and the long axis, aligned with the humerus. Radiographs were captured at the neutral lateral elbow position, during the elevation of the forearm and humerus at 10°, 20°, and 30°, and during the depression of the forearm at 10° and 20°. Positioning was performed by a medical radiation technologist with greater than 10 years of experience. Proposed radiographic landmarks, including condylar positioning and supracondylar ridge, will be analyzed through measurements of condylar overlap, deviation of condylar margins along both axes, and relative posterior position of the supracondylar ridge within the humerus.

Results: Analysis of radiographs demonstrates a significant decrease in condyle overlap during just 10-degrees of short-axis elevation and depression from the neutral position (Figure 1). A similar effect was also observed during 10-degrees of long-axis elevation. Additionally, significant differences were observed between the anterior and posterior condylar margins with just 10-degrees of elevation of the forearm.

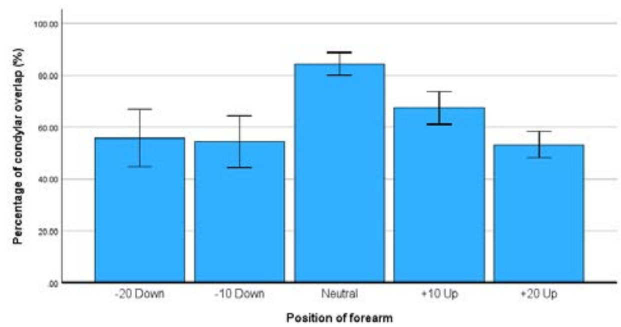


Figure 1. The effect of elevation and depression of the forearm from a neutral lateral position on the mean measured condylar overlap.

Conclusion: Although radiography is commonly performed to detect elbow injuries, inaccurate positioning can result in missed fractures and secondary complications. Understanding the radiographic changes that occur during malrotation of the elbow can provide technologists with the knowledge and skills to identify a good quality lateral elbow radiograph, reducing the need for repeat imaging and enhancing fracture detection.

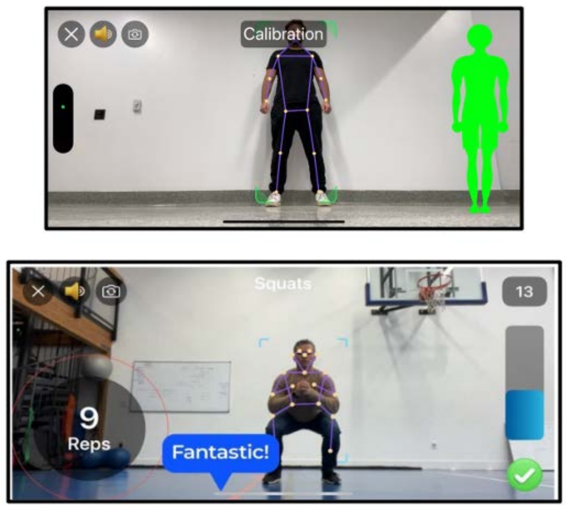
[1] Lennon RI, Riyat MS, Hilliam R, Anathkrishnan G, Alderson G. Can a normal range of elbow movement predict a normal elbow x ray? Emerg Med J EMJ. 2007 Feb;24(2):86–8.
[2] Campbell M, Schurmans G, Suh N, Garvin G, Lalone E. The sensitivity of the scapholunate interval and bony landmarks to wrist rotation on posteroanterior radiographs. HAND. 2024 May 30;20(6):958–65. doi:10.1177/15589447241255705

CRITERION VALIDITY OF A SMARTPHONE-BASED MOTION CAPTURE TOOL FOR REAL TIME EXERCISE REPETITION

Aryan Sadghian[1] & Marc Mitchell[1],
[1]School of Kinesiology, Western University, London, ON

Introduction: Canadians commonly fall short of resistance training (RT) guidelines, and self-monitoring can support behaviour change; however, many RT tracking tools show limited accuracy during complex movements. Smartphone-based markerless motion capture may provide a scalable solution, but its pragmatic criterion validity under realistic conditions (e.g., clothing occlusion; varied user groups) remains under-tested.

Methods: In this cross-sectional criterion validation study, 26 adults (13 students aged 18–25; 13 faculty/staff aged 35–65) completed one set of 10 repetitions of squats, sit-ups, push-ups/knee push-ups, and high knees under two clothing conditions (short-sleeved athletic attire; long-sleeve loose attire). Each set was recorded for manual scoring by two independent video raters using external parameters (criterion = mean of two raters), while the motion capture tool provided live repetition counts during performance (Figure 1). Agreement was summarized using signed mean bias (tool − manual) and the proportion of sets within ±1 and ±2 reps. Equivalence of mean counts was tested using paired two one-sided tests (TOST) with ±1 rep bounds (α = .05; 90% CI) [1].



Results: Inter-rater reliability was strong across 206 analyzable sets (ICC[2,2] = 0.90, 95% CI 0.87–0.92; ICC[2,1] = 0.82, 95% CI 0.77–0.86), with 94.7% exact agreement and 98.5%/99.5% agreement within ±1/±2 reps. Pooled tool–criterion bias was +0.024 reps; 90.3% and 96.6% of sets were within ±1 and ±2 reps, respectively, and pooled TOST supported equivalence (mean difference = 0.024; 90% CI −0.127 to 0.176; p<0.001). Exercise-specific equivalence was supported for all movements; accuracy varied by exercise, with high knees showing the lowest ±1 agreement (73.1%) but high ±2 agreement (96.2%).

Discussion and Conclusions: This smartphone-based markerless motion capture tool produced repetition counts statistically equivalent to human video counting within a pragmatic ±1 rep margin, supporting its potential for scalable RT self-monitoring and future behaviour-change interventions. Exercise type drove the largest variability in set-level error, highlighting high knees as a priority target for algorithm refinement.

References:

[1] Schuirmann DJ. (1987). A comparison of the two one-sided tests procedure and the power approach for assessing equivalence. J Pharmacokinet Biopharm, 15; 657–680.

Poster Session 1

Wednesday May 20 (7:45PM – 8:45PM)

Poster #	Name	Affiliation	Poster Title
1	**Megan Hutter**	Western University	Longitudinal Three-Dimensional Ultrasound Synovial Blood Flow Volume Assessment in Thumb Osteoarthritis
2	**Nigel Majoni**	University Health Network	Stepping Strategy for Lateral Balance Perturbations Predice Successful and Unsuccessful Reactions in Healthy Older Adults and People with Chronic Stroke
3	**Cailin Blair**	Wilfrid Laurier University	The Influence of History of Concussion and Fatigue on Gait Initiation
4	**Rosa Mirshahi**	York University	Lower Limb Outcomes in Adults with and without Shoulder Pain
5	**Serena Cardoso**	Wilfrid Laurier University	Use of Virtual Reality During Slip Perturbations
6	**Olivia Szczepanek**	University of Waterloo	Investigating Effectiveness of Landmarking Techniques in Young and Older Females of Different Body Compositions
7	**Jacob Schweyer**	University of Guelph	Location Dependent Peroneus Longus Cutaneous Reflexes with Load
8	**Ella Callaghan**	University of Waterloo	Influence of Hair Types and Styles on Industrial Protective Headwear
9	**Ian Doctor**	Brock University	Effect of Artificial Limb-Length Asymmetry on Lumbar Paraspinal Muscle Activation in Functional Movement Tasks
10	**Jeffrey Visbal**	Western University	Force and Image Collection of the Wrist Joint of Football Player's When in the Prone Blocking Position
11	**Jason Aibi**	Brock University	The Effect of Perturbation Training on Dynamic Knee Stability in Copers and Non-Copers Following ACL Injury: a Critically Appraised Topic
12	**Bhavna Birdi**	Wilfrid Laurier University	Combining Nucleus Pulposus Hydrogel with Annular Closure
13	**Allison Penner**	Wilfrid Laurier University	Orthotics in Diabetic Neuropathy
14	**Alexandra Blandford**	University of Waterloo	Evaluating Predictive Model Generalization for Machine Learning-Based Markerless Upper-Limb Kinematics Estimation in Industrial Work
15	**Morleigh Mckenna**	Carleton University	Concussion Impairs Balance: Insights From Static Posturography and EMG

16	**Andras Dobai**	Carleton University	Hookers and Rollers in Armwrestling: An Anthropometric, Dynamometric and Kinematic Analysis
17	**Isabelle Battersby**	Western University	Investigating Load Management in Jump Sport Athletes
18	**Kasia Puzio**	University of Waterloo	High-Speed Ultrasound for Impact Biomechanics
19	**Dylan Mun**	Waterloo	The Effects of Compressive Load on Functional Spinal Joint Failure in Cumulative Exposure Paradigms
20	**Tiffany Hsu**	Brock University	Measuring Friction in Hockey Goalie Pads
21	**Kirsten Nowell**	Ontario Tech University	Scoping Review of Physical Exposures and Outcomes During Manual Massage Therapy
22	**Jonathan Eskinazi**	Wilfrid Laurier University	The Effect of Spinal Flexion of Disc Mechanics
23	**Aida Chubbs**	Western University	Reverse Total Shoulder Arthroplasty Wear Testing
24	**Olivia Laviolette**	University of Guelph	Exploring the Effects of Combining HIIT Exercise and Task Specific Training on Cognitive Motor Dual-Task Performance
25	**Abby Hughes**	Western University	Influence of Physical Activity History on Lumbar Spine Properties in Young Adults
26	**Evelyn Sokolowski**	University of Guelph	Design of a High-Fidelity 3d Printed Canine Tibia Fracture Fixation Model
27	**Jared-Isaac Friedel**	University of Waterloo	Niosh Calculated Using Computer Vision
28	**Kyle Sage**	Wilfrid Laurier University	Balance Consideration for Work Boots
29	**Rachel Low**	University of Guelph	Menopause and Spinal Degeneration
30	**Noelle Donatelli**	McMaster University	Effects of Load, Posture, Occlusion on Ct in Females
31	**Abeer Malik**	University of Waterloo	Does Coordination Explain Task Performance Time in Select Firefighting Tasks
32	**Jared Hughes**	University of Guelph	Cutaneous Reflexes in the Abductor Hallucis While Seated with Load
33	**Emma Ratke**	Brock University	Quantifying Changes to Paraspinal Muscle Pennation Angle in Response to Alterations in Lumbar Posture and Muscle Activation
34	**Charlotte Green**	Trent University	The Influence of Hand Posture on Upper Arm Muscle Activity During Isometric Wrist Contractions
35	**Amber Van Nes**	University of Guelph	The Effect of Foot Progression Angle on Magnitude and Location of Tibiofemoral Joint Contact forces During Running

36	**Andrew Kan**	Queen's University	Gait Biomechanics and T2 MRI of Tibiofemoral Cartilage 3 Years After ACL Reconstruction
37	**Adam Rusin**	Waterloo	Force Direction Effects on Lumbar Segmental Stiffness
38	**Hayley Janes**	Ontario Tech University	Validation of Theia3d for Upper Extremity Motions
39	**Benjamin Kozlowski**	University Health Network	Torque-Matched Motor Point Stimulation Therapy Enhances Corticospinal Excitability
40	**Anastasia Sullivan**	Wilfrid Laurier University	Spine Extension in Dancers
41	**Valentina Massone**	Brock University	Robotic Assessments of Hand Function
42	**Hua-Bin Lin**	University of Waterloo	Individual Muscle Contributions to Lower Limb Feasible Force Sets
43	**Karina Wilson**	Wilfrid Laurier University	Spinal Twist and Its Effect on the Annulus Fibrosus
44	**Levi Morrissy**	Trent University	The Influence of Sustained Maximal Isometric Wrist Flexion and Extension on Antagonist Maximal Force and Muscle Activity
45	**Teodora Maluckov**	University of Waterloo	Salmon Calcitonin Effect on Bone Remodeling
46	**Sylvia Masse**	University of Waterloo	Hip Muscle Coordination on 3d Hip Dynamics During Squat Tasks
47	**Aaron Austin**	Western University	Force and Kinematic Analysis of Fatigue in Collegiate Baseball Players in a Simulated Game Environment
48	**Jared Seick**	Brock University	The Effect of Eccentric Muscle Damage on the Topographical Activation Patterns of the Biceps Brachii Muscle
49	**Zoe Holliday**	Western University	Evaluation of Labral Behaviour Following Cam Over-Resection and Labral Reconstruction
50	**Trinity Pambis**	University of Waterloo	Does Jerk Explain Discomfort During Stair Chair Conveyance
51	**Ashley Vanderhaeghe**	University of Guelph	Topical Menthol and Camphor Alter Ankle Proprioception
52	**Olivia Yang**	University of Waterloo	Muscle-Bone Interactions in Glenohumeral Oa
53	**Emily Marino**	University of Guelph	Caution Under Visual Complexity: Reduced Speed and Safety Margins Used in Virtual Navigation

LONGITUDINAL THREE-DIMENSIONAL ULTRASOUND SYNOVIAL BLOOD FLOW VOLUME ASSESSMENT IN THUMB OSTEOARTHRITIS

Megan Hutter[1,2], Clara Duquette-Evans[1,2], Randa Mudathir[2], Assaf Kadar[3,4], Aaron Fenster[1,2], Emily Lalone[3,5]

[1]School of Biomedical Engineering, Western University, London, ON
[2]Robarts Research Institute, Western University, London, ON
[3]Roth | McFarlane Hand and Upper Limb Centre, St. Joseph's Health Care, London, ON
[4]Schulich School of Medicine and Dentistry, Western University, London, ON
[5]Department of Mechanical and Materials Engineering, Western University, London, ON

Introduction: The first carpometacarpal joint (CMC1) is a common site of hand osteoarthritis (OA). The role of synovial inflammation in OA is recognized and contributes to progression. Blood vessel growth and blood flow changes are associated with inflammation. However, there is limited understanding of the role of synovial vascularization and joint blood flow changes in OA and its progression. Ultrasound (US) imaging enables soft tissue visualization and blood flow detection with Doppler technologies. Current musculoskeletal US assessment denotes active joint inflammation by the presence of Doppler signal [1]. This 2D US assessment is operator-dependent and limited to visualizing the 3D anatomy and vasculature in 2D. 3D US overcomes these limitations and provides comprehensive 3D visualization and quantification. Previous work in the lab has examined 3D US synovial blood flow measures but has not investigated how the measures change over time and their longitudinal relationship with function and pain.

Aim: To assess changes in 3D US synovial Doppler measures in CMC1 OA patients over 1 year and compare to functional and pain measures.

Methods: Nineteen CMC1 OA patients were imaged at 3 timepoints: at baseline, 6-months, and 1-year. 3D US images were acquired using a 3D US device with Doppler imaging capabilities. The 3D US device linearly translated a semi-submerged 14L5 linear transducer with a Canon Aplio i800 US machine (Canon Medical Systems Corporation, Otawara, Tochigi, Japan). 3D US B-mode and Doppler images were acquired, using Power Doppler (PD) and superb microvascular imaging (SMI). The synovial tissue volume was manually segmented in the 3D US images. PD and SMI coloured voxels were automatically counted within the segmentations. Pinch grip force, patient rated wrist evaluation (PRWE), and visual analog scale of pain pressing the fifth digit were completed at each imaging session.

Expected Results: Preliminary baseline results demonstrated average 3D US PD and SMI synovial blood flow volumes of 4.71 ± 7.72 mm^3 and 1.97 ± 2.96 mm^3, respectively. Anticipated results include 3D US PD and SMI synovial blood flow measures at 6-months and 1-year. Comparisons of 3D US Doppler measures will be assessed with functional and pain measures.

References:

[1] Takase K et al. (2012). Simultaneous evaluation of long-lasting knee synovitis in patients undergoing arthroplasty by power Doppler ultrasonography and contrast-enhanced MRI in comparison with histopathology. Clin Exp Rheumatol 30(1);p. 85-92.

STEPPING STRATEGY FOR LATERAL BALANCE PERTURBATIONS PREDICE SUCCESSFUL AND UNSUCCESFUL REACTIONS IN HEALTHY OLDER ADULTS AND PEOPLE WITH CHRONIC STROKE

Nigel Majoni,[1,2] Maria Merith Claras,[1] Elizabeth. L Inness,[1,2] David Jagroop,[1] Cynthia Danells,[1] Avril Mansfield[1,2]
[1]KITE, University Health Network, Toronto, ON
[2]University of Toronto, Toronto, ON

Introduction: Step reactions to recover balance after lateral perturbations require either stepping with the loaded leg or navigating the stance leg when stepping with the unloaded leg. This is challenging for individuals with post-stroke hemiparesis, who may have challenges with both bearing weight on and executing steps with the paretic limb. The objective of this study was to determine optimal stepping strategies during lateral perturbations in people with stroke and healthy older adults.

Methods: Responses to perturbations during baseline sessions of two ongoing clinical trials were analyzed. Successful balance recovery was executing only 1 step, and an unsuccessful response was taking ≥2 steps to recover balance after a perturbation. We used logistic regression with generalized estimating equations, with stepping strategies, and magnitude as independent variables and outcome (successful or unsuccessful response) as the dependent variable to determine the relationship between step strategy and outcome. Analyses were completed separately for both groups, and separately by direction for stroke participants.

Results: Preliminary analysis included 8 people with stroke and 20 healthy older adults; data from a larger sample will be presented at the conference. The crossover step had more unsuccessful outcomes compared to the side-step sequence for older adults (odds ratio (OR)=0.238 [95% confidence interval (CI): 0.123–0.459], $p<0.001$) and people with stroke falling toward the less affected side (OR=0.159 [95% CI: 0.041–0.617], $p=0.008$). In the current analysis, there were no significant associations between step strategy and successful outcome when people with stroke fell toward the more affected side.

Discussion and conclusions: The side-step strategy seemed to be the most effective response for regaining balance following lateral perturbations. Crossover steps may increase the risk of limb collisions, or result in an unstable final position, necessitating extra steps to avoid a fall after a loss of balance. These results suggest that reactive balance training programs should aim to train side-step sequence reactions following lateral perturbations.

UNDERSTANDING THE IMPACT OF CONCUSSION HISTORY AND FATIGUE ON ANTICIPATORY POSTURAL ADJUSTMENTS

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Introduction: Gait initiation is the transition from standing to walking and requires precise coordination to generate forward momentum while maintaining balance. A key component of this process is anticipatory postural adjustments (APAs), which are feedforward mechanisms involving shifts in centre of pressure (COP) and body weight prior to stepping. These adjustments allow for controlled movement of the centre of mass (COM) and are essential for stable gait initiation. In individuals with a history of concussion, impairments in balance and motor control may persist even after medical clearance to return to activity. Acute concussion has been shown to delay APA onset and reduce APA magnitude[1]. While these deficits may not be apparent during steady-state walking, they may become evident during transitional tasks such as gait initiation. Additionally, fatigue has been shown to further challenge neuromuscular control and may exacerbate underlying deficits. Understanding these effects may help identify subtle impairments that persist beyond medical clearance to sport and may not be otherwise detectable.

Aim: To determine how APAs during gait initiation differ between individuals with a history of concussion and healthy controls under non-fatigued and fatigued conditions.

Methods: Participants will include physically active team sport athletes aged 18-30 years, including individuals with a history of concussion and healthy controls. The concussion history group will have sustained >1 concussions within the past 2 years but are medically cleared to return to sport. Participants will attend two testing sessions, at least one week apart. Participants will perform 20 gait initiation trials while stepping forward from a standardized starting position. Trials will include a self-paced (normal) and fast gait initiation condition. Gait initiation will be cued via self-paced initiation and externally cued trials with a visual (light) or auditory (buzzer) signal. The fatigued condition will involve treadmill walking while wearing a weighted vest (~15% of body weight) until reaching 80% of their predicted maximum heart rate. Gait initiation trials will be performed immediately afterwards. Ground reaction forces will be collected using force plates to calculate COP displacement and identify APA characteristics. Key outcome measures will include APA onset timing, magnitude, and duration, as well as COP and COM displacement and velocity.

Expected Results: It is expected that individuals with a history of concussion will demonstrate altered APAs during gait initiation, particularly under fatigued conditions. Specifically, they may exhibit delayed APA onset and changes in COP displacement, reflecting impaired motor planning and balance control. Fatigue is anticipated to further exacerbate these differences, highlighting the importance of assessing dynamic tasks when evaluating post-concussion motor function.

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LOWER LIMB STRENGTH, FUNCTION, AND MOBILITY PERFORMANCE IN OLDER ADULTS WITH AND WITHOUT SHOULDER PAIN

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Introduction: Knee and shoulder pain are among the most common musculoskeletal complaints in primary care [1], with knee osteoarthritis and rotator cuff pathology being the primary diagnoses in older adults [2,3]. Both conditions are associated with reduced physical function and limitations during daily activities, consequently leading to decreased independence [4,5]. Many studies have shown that multi-joint pain can further increase disability [6]. We are interested to learn whether musculoskeletal pain in one joint leads to functional limitations in another, and whether adults commonly exhibit co-existing conditions. This study evaluated differences in lower-limb strength, self-reported function, and mobility performance in older adults with and without shoulder pain.

Methods: Nine older adults have been recruited for this study to date, with an anticipated final sample of 40 (n=20 with shoulder pain, n=20 without shoulder pain). Participants were grouped into shoulder pain or no shoulder pain groups based on clinical tests for subacromial impingement syndrome [7]. Maximal isometric knee flexor and extensor strength of the right knee was measured using an isokinetic dynamometer (Biodex Medical Systems Inc., Shirley, NY, USA). A battery of mobility performance tests was also performed. These included the 6-minute walk test, 40-m fast-paced walk test, Timed Up-and-Go, 30-second chair stand test, and stair climb test. Lastly, lower limb self-reported function, self-efficacy, and depressive symptoms were assessed using validated questionnaires.

Results: Our preliminary analyses include 6 participants with no shoulder pain (68.3 [6.9] yrs), and 3 participants with shoulder pain (69.0 [4.6] yrs). 2/3 participants with shoulder pain also had positive clinical criteria for symptomatic knee osteoarthritis [8]. Thus, while no statistical differences were demonstrated between pain and no pain groups due to low sample size, preliminary results are trending towards higher knee extensor strength, and better chair stand performance in the no pain group (Table 1). Further, those with shoulder pain had lower self-reported outcomes for most functional measures, compared to the no pain group.

Table 1. Strength and mobility performance outcomes for those with and without shoulder

	Shoulder Pain (n=3)	No Shoulder Pain (n=6)
Strength		
Knee Flexor (Nm/kg)	1.0 (0.5)	1.0 (0.3)
Knee Extensor (Nm/kg)	1.6 (0.7)	2.1 (1.1)
Mobility Performance		
30-second Chair Stand (n)	13.0 (2.6)	17.8 (7.3)
Timed up-and-go (s)	7.6 (0.5)	7.2 (1.9)
40m walk (s)	22.5 (5.2)	22.4 (3.5)
6-minute walk (m)	539.6 (41.3)	528.7 (69.6)
Stair ascent and descent (s)	16.9 (4.0)	15.6 (2.4)

Discussion and Conclusions: These preliminary results demonstrate trends towards co-existing conditions, with those with shoulder pain exhibiting lower function and self-efficacy, and reduced strength and mobility performance, compared to those with no shoulder pain. Data collection is ongoing.

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EXAMINING SLIP RESPONSES IN INDIVIDUALS WITH INACCURATE VISION USING VIRTUAL REALITY

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Introduction: Slip and falls are a major source of both injuries and fatalities at home, work, and during leisure activities [1]. Falls are often a result of inadequate balance recovery responses after an individual experiences a loss of stability, which occurs when the center of mass moves outside of the base of support [2]. The visual system is important for slip prevention and balance recovery, with two strategies related to visual control of locomotion: avoidance and accommodation [3]. Virtual reality can be used to manipulate the accuracy of the visual information an individual receives to examine their balance recovery responses following an unexpected slip perturbation.

Aim: Examine the effects of inaccurate visual information, through the use of virtual reality, on a person's balance recovery responses following an unexpected slip perturbation.

Methods: Kinematic data will be collected using the Optotrak Certus 3D motion capture system with a 12-marker setup (Northern Digital, Ontario, Canada). Surface EMG data from the stance/trailing leg will be collected using the Noraxon Ultium EMG system (Noraxon, Arizona, USA). Force plates embedded in the floor will be used to determine foot contacts, centre of pressure and vertical ground reaction forces. The protocol has participants walk forward, about 10m, at a comfortable pace while looking at a marker on the wall ahead of them. There will be two trial blocks, one under normal visual conditions and the other using the VR environment. The VR environment is a simple grid with no other objects or markers around. There will be one slip perturbation per every 10 trials, there will always be at least five normal trials before a slip to ensure participants adopt a normal gait pattern.

Expected Result: It is expected that the balance recovery responses during conditions with inaccurate visual information will have reduced efficacy and result in increased muscle activation latency as well as increased muscle activation magnitude.

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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 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 resolve 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, potentially resulting from inadequate training information on proper injection technique. There are various options of landmarking deltoid intramuscular (IM) injection sites across Canada, however no consensus exists for which is best. Further, beyond landmarking techniques, female sex, small deltoid muscle bulk, and thin body build[4] increase risk of SIRVA, but little research explores the intersection of landmark placements and personal risk factors.

Aim: Compare effectiveness of 5 different landmarking deltoid IM injections (2 fingers below the acromion, 3 fingers below the acromion, the triangular method, 4 cm below the acromion and the Australian technique) 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 3D optoelectronic motion tracking system (Qualisys 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), and their torso using 4 additional markers (suprasternal notch, xiphoid process, C7, and T8). The 5 different landmarking techniques will be marked with a wash-able marker, containing a 3D cluster on the cap, by several pharmacy trainees. This marker will be used to approximate needle orientation and skin location relative to the upper arm markers. Following each landmarking deltoid IM injection, a small piece of reflective tape will be placed over the mark and a longitudinal panoramic ultrasound image will be taken, using a real-time B-mode ultrasound imaging device (GE LOGIQ E10) with a multi-frequency linear array transducer (ML6-15 MHz). 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. Further, the construction of the local coordinate system of the upper arm will follow ISB standards (Wu et al., 2005).

The ultrasound images and 3D motion capture data will be used to determine effectiveness by measuring success as a binary (yes or no) of whether the needle would insert into the deltoid muscle, and its linear distance from the deltoid target (centre of thickest deltoid section).

Expected Results: Older females with less muscle volume will be associated with lower success rates and accuracy across the different landmark placement methods.

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EXPLORING THE LOCATION DEPENDENCY OF CUTANEOUS REFLEXES IN THE PERONEUS LONGUS IN STANDING, WITH OR WITHOUT LOAD

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Introduction: Acute inversion ankle sprains are one of the most common musculoskeletal injuries, which often have a high recurrence rate, and chronic outcomes [1]. The peroneus longus (PL) muscle, whose main function is to evert the ankle, plays a key role in prevention of inversion ankle sprain [2]. Improved activation of peroneus longus plays a critical role in reducing inversion related movements, and subsequent ankle sprains. Previous literature has shown that cutaneous stimulation to the foot sole modulates peroneus longus muscle activity, producing location-dependent responses [3]. However, it is unclear how this location dependence is influenced by different tasks; sitting versus standing, or across different loads. [3].

Aim: To determine how cutaneous stimulation across different regions of the foot sole can modulate peroneus longus muscle activation across different tasks, and load magnitude.

Methods: Six (4M, 2F ; 22.8 ± 3.4) participants performed 20% of maximal isometric eversions of the peroneus longus under four loading conditions; seated, which corresponds to 0% body weight (BW) load, double leg stance (50% BW), single leg stance (100% BW) and standing with a weighted vest (125% BW). In each condition, cutaneous stimuli were applied at a 5/10 intensity (moderate and non-noxious sensation) to three distinct foot sole locations, the medial metatarsal (1MT), the lateral metatarsal (5MT), and heel (HL). Surface electromyography (EMG) was recorded from the PL muscle. All four task conditions were completed at each foot sole stimulation location before moving onto a new stimulation site. To quantify reflexes, we spike trigger averaged PL EMG to the cutaneous stimulation and assessed reflexes in the medium latency window (70 ms – 120 ms) following stimulation. Significant reflexes were determined if they occurred within the cutaneous reflex window and exceeded the mean ± 3 SD of the background EMG activity prior to stimulus onset for a duration of ≥8 ms [3].

Preliminary Results: Stimulation to the 1MT site produced inhibitory responses across all loading conditions (n = 5), 5MT site produced initial inhibition in sitting to excitation upon standing (n = 4), while HL produced variable responses, showing both excitation (n = 3) and inhibition (n = 5). We conducted a linear mixed effects model on absolute reflex ratios to examine the effects of load magnitude and site on reflex amplitude. No significant interaction ($p = 0.838$) or main effect of load/posture ($p = 0.828$) were seen, however a significant effect of site was found ($p = 0.009$), showcasing that reflex amplitude was affected by stimulation location. Post-hoc analysis revealed significant differences at the 1MT site when compared to 5MT ($p = 0.024$) and HL ($p = 0.024$). No difference was seen between 5MT and HL ($p = 1.000$).

Significance: These findings highlight the site-specific nature of cutaneous reflexes in modulation of PL muscle activity. Given the critical role of PL for prevention of inversion ankle sprain, targeted sensory interventions such as cutaneous stimulation may offer an approach to optimizing peroneal muscle responses in populations at risk of inversion ankle sprain.

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INFLUENCE OF HAIR TYPES AND STYLES ON THE BIOMECHANICAL EFFECTIVENESS OF INDUSTRIAL PROTECTIVE HEADWEAR

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Introduction: Hair conditions, specifically those worn with more tightly coiled hair, have the potential to negatively impact the fit of protective headwear [1]. Additionally, the literature shows that frictional differences of hair differ greatly from those of a Hybrid III head form [2]. However, current literature quantifying the behaviors of industrial protective headwear lack biofidelic models that can serve as a representation of the variability of hair anthropometrics across users. This study aimed to quantify the interaction of offset and deformability of hair conditions on industrial headwear efficacy, quantifying impact attenuation and passive retention performance.

Methods: Retention of the helmet on the head form and impact attenuation were measured across thirteen hair conditions, including two hair-types, eleven styling conditions, and three tests per condition. Prior to testing, each condition's stiffness and offsets were measured. For passive retention, a dynamic upward force was applied at both the anterior and posterior brim of the headwear. For impact testing, impacts were applied to the crown (C) (55 J), anterior (A) (30 J) and left lateral (L) (30 J) aspects of the headwear [3]. Outcome variables included the max resultant acceleration (g_{max}) and head injury criterion (HIC) for the impact testing and the force required to cause helmet decoupling (retention testing).

Results: The addition of a hair condition increased the impact attenuating properties of the system but decreased the retention of the headwear. At every impact location, the bare condition (C: 60.6 (4.5)g; A: 67.3 (1.5)g; L: 125.7 (6.3)g) resulted in greater g_{max} than the curly condition (C: 51.5 (1.6)g; A: 61.2 (3.7)g; L: 111.5 (14.1)g). However, the curly condition yielded a retention decreased by 33%, as compared to the bare condition. The simulated curly condition showed improved retention and impact attenuation as compared to the straight condition. In both conditions, the addition of a skull cap over the hair increased both the retention and the impact attenuating properties of the head form.

Discussion and Conclusions: It is relevant to note that although the addition of hair conditions led to an improvement in impact attenuation, it also resulted in lower retention performance. These factors must both be considered as they are each relevant when quantifying the efficacy of protective headwear. Additionally, it must be considered that although stiffness and offsets were quantified within the relevant conditions, the compressive force of the retention system around the circumference of the head would have affected both these measures in the lateral area. This indicated that the measured offset values may not accurately represent the lateral impact condition with the addition of protective headwear. Finally, future work will explore how hair conditions influence the repeatability of these physical test outcomes.

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EFFECT OF ARTIFICIAL LIMB-LENGTH ASYMMETRY ON LUMBAR PARASPINAL MUSCLE ACTIVATION IN FUNCTIONAL MOVEMENT TASKS

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Introduction: Limb length discrepancy (LLD) is characterized by the difference in physical length or proportion of the legs, often resulting in musculoskeletal disorders including hip and knee osteoarthritis [1], significant gait and balance difficulties [2], and non-specific lower back pain (LBP). The link between LLD and LBP is debated with some studies reporting significant relationships between LLD and LBP [3], and others have found limited to no relationship [4]. Gait and standing have historically been a focal point for LLD impact research, as ease of mobility is a central question for those with LLD and its possible relationship with LBP and lumbar loading [5].

Aim: To investigate the effect of artificially induced LLD on lumbar muscle activation and predicted lumbar loads during functional movement tasks.

Figure 1: BoB modeling software example

Methods: 40 participants (20F) will complete a series of functional movements used in previous research [6] including a standing balance test, deep squat, sit to stand transitions, farmers carry, and lift from floor. Each participant will complete the battery in three randomly ordered and counterbalanced artificially induced LLD conditions plus one control trial. Each movement will be completed three times per condition while full body XSens motion capture (Movella, USA) and bilateral lumbar and abdominal surface electromyography (sEMG) (Noraxon, USA) will be captured. Kinematic and EMG data will be analyzed in Biomechanics of Bodies (BoB) (Figure 1) to compute predicted lumbar joint compressive loads. Subjective measures of participant's relative discomfort will be also recorded.

Expected Results: We expect sEMG to reveal increased abdominal and lumbar muscle co-activation proportional with mediolateral pelvic tilt due to the artificially induced LLD. We expect subjective feedback from participants for tasks like the deep squat, loaded carry, and lift from floor to be more difficult to execute movement coordination as the heel lift increases. Paired with the increased muscle co-activation we expect to observe an increased lumbar joint com-pressive load in conditions with larger LLDs.

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FORCE AND IMAGE COLLECTION OF THE WRIST JOINT OF FOOTBALL PLAYER'S WHEN IN THE PRONE BLOCKING POSITION

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Introduction: Hand and wrist injuries represent a significant but overlooked problem in American football, where repeated high-impact contact and blocking motions place athletes at risk of injury. While previous studies have investigated rates of injury, there is little research directly assessing tendon morphology and function in American football players across the different player positions [1]. The purpose of this study is to examine whether tendon morphology and signs of inflammation differ between positions, and whether these factors correlate with functional outcomes and exposure to mechanical loading.

Methods: 17 varsity athletes from a university football team were recruited for a preliminary study. 40 additional participants were recruited (30 athletes, 10 healthy). Athlete participants were grouped by position (wide receivers, defensive backs, linebackers, running backs, offensive linemen, and defensive linemen). Ultrasound imaging was conducted using a standard 2D Ultrasound Wrist Imaging System. Extensor compartments 1, 2, 4, 5, and 6 were imaged, with tendons assessed for thickness, cross-sectional area, vascularity via power doppler, and tenosynovial thickening. Functional tests included grip strength, pinch grip, dexterity, and wrist range of motion. In addition, the magnitude of force and force distribution will be mapped using custom tactile sensors.

Expected Results: Across the preliminary study, 65% of the participants displayed tenosynovial thickening in compartment one, while 77% showed thickening in compartment six. WRs exhibited high grip strength but the lowest mobility across flexion, extension, radial deviation, and ulnar deviation, suggesting a trade-off between tendon hypertrophy and mobility. It is expected to find more presence of injury within the athlete cohort. Additionally, results are expected to show the magnitude of force and specific location on the palm of the hand in Newtons.

Conclusions: These findings indicate that repetitive mechanical loading from the 3-point stance in football players may correlate to tendon morphological changes and mild inflammation. This research may help inform the future development of screening tools that could support earlier detection of tendon changes.

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THE EFFECT OF PERTURBATION TRAINING ON DYNAMIC KNEE STABILITY IN COPERS AND NON-COPERS FOLLOWING ACL INJURY: A CRITICALLY APPRAISED TOPIC

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Introduction: Anterior Cruciate Ligament (ACL) injury causes disability through knee destabilization. In physically active patients who suffer an ACL tear, a reconstruction surgery is performed to help regain stability, avoid secondary injuries, and to return patients to their pre-injury lifestyles.[1] Another option is to cope with ACL deficiency (copers) by modifying lifestyle activities, or by undergoing systemic rehabilitation to address impairments, and determine readiness to return to sport.[3] Regardless of treatment option, rehabilitation following ACL injury is crucial to ensuring patients successfully return to their pre-injury lifestyles, and the Functional Hop Tests, a battery of hops to measure dynamic knee stability,[2] are often used to determine return to activity. Perturbation Training, an alternate or adjunct to standard rehabilitation, is a type of balance training that involves manual or mechanical externally applied perturbations to a support surface or to a patient to enhance postural stability.[2] Examining the effect of perturbation training on dynamic knee stability may provide improved outcomes in the ACLR and coper population.

Methods: This research used a Critically Appraised Topic format. Three articles were identified based on our inclusion/exclusion criteria. Our inclusion criteria involved: studies that included patients who have undergone ACL-reconstruction (ACLR), studies that included patients who have not undergone ACLR (copers), English language studies, and randomized controlled trials. Our exclusion criteria included: studies that used perturbation training pre-op, studies that don't include perturbation training and standard rehabilitation, and studies that don't measure Functional Hop Tests. Critical appraisal was performed using the PEDro scale.

Results: Two studies found no differences between groups in Functional Hop Test results in patients that underwent ACLR. One study found no differences between groups for pre-intervention and post-intervention Functional Hop Test scores in patients who were considered copers, however, differences were observed in a six-month follow up session where the perturbation group performed significantly better on the single hop and triple hop for distance tests and a trend was observed in the standard group where the crossover hop test scores decreased from post-intervention to follow up, while the perturbation group maintained performance.

Discussion and Conclusions: The effect of perturbation training on dynamic knee stability appears to be limited in patients who are undergoing rehabilitation following ACL injury. However, perturbation training does not appear to have a negative effect on dynamic knee stabilization and could be used as an adjunct to standard rehabilitation.

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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: As a leading cause of disability worldwide, low back pain is most attributed to intervertebral disc degeneration (IVDD)[1]. Research on nucleus replacement strategies alone is insufficient without concurrent annular repair, as failure to restore annular integrity compromises disc containment and mechanical stability[2]. Currently, there is no established method for repairing annular defects to reduce the re-herniation rate and limit the progression of IVDD[3].

Aim: This study aims to evaluate whether a dual approach combining nucleus pulposus hydrogel injection with annular closure better preserves disc height under physiologic combined loading compared to hydrogel injection alone, while reducing the risk of re-herniation.

Methods: Six-month-old porcine cervical spines will be obtained from a standard source, stored at −20 °C, and thawed at room temperature for 12 hours prior to testing. Two functional spinal units (C3/4 and C5/6) will be dissected from each spine and randomly assigned to four groups: (1) control, (2) injury only, (3) injury + hydrogel injection, and (4) injury + hydrogel injection with annular closure. Groups 2–4 will undergo a standardized annular injury consisting of a 3.5 mm posterior annular puncture followed by three passes with a pituitary rongeur through the same tract to replicate mild degeneration[4]. Polyvinyl alcohol (PVA)-based hydrogel, enhanced with glycerol-mediated hydrogen bonding will be used for nucleus augmentation, while genipin-crosslinked fibrin (FibGen) will be used for annular closure. Specimens will be subjected to 1200 N axial compression with simultaneous cyclic flexion–extension at 0.5 Hz for 3000 cycles. Disc height will be measured pre- and post-loading using actuator displacement from the mechanical testing system (Model Criterion 43, MTS, Eden Prairie, MN, USA), and nucleus pulposus migration will be assessed visually. Following testing, annular tensile properties will be evaluated using the BioTester™ 5000 system (CellScale, Waterloo, ON, Canada).

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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THE EFFECTS OF TEXTURED FOOT ORTHOSES ON BALANCE DURING GAIT PERTURBATION IN DIABETIC PERIPHERAL NEUROPATHY

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Introduction: Diabetic peripheral neuropathy (DPN) is a common complication of diabetes characterized by progressive sensory loss in the plantar surface of the foot [1]. This sensory impairment is associated with reduced balance control and an increased risk of falls, which occur in approximately 39% of adults with diabetes over the age of 65 [2]. Reduced plantar sensory input limits the ability to detect foot-ground interactions, leading to altered plantar pressure distribution, delayed neuromuscular responses, and impaired balance during gait [3, 4]. Interventions such as textured insoles and foot orthoses have been proposed to improve balance through distinct mechanisms, including sensory augmentation and mechanical support; however, their combined effects during gait perturbation in DPN remain unclear.

Aim: This study aims to investigate the effects of textured insoles, foot orthoses, and their combination on balance during gait perturbations in individuals with DPN.

Methods: Twenty adults aged 30-50 years with diabetes and reduced plantar sensation will be recruited from local clinics. Participants will complete walking trials along a 10 m walkway with embedded perturbation plates producing medial-lateral tilts. Four conditions will be tested in a block-randomized design: control (standard insole), textured insole, foot orthosis, and combined condition. Kinematic, kinetic, electromyography, and plantar pressure data will be collected. Primary outcome measures include medial-lateral center of pressure displacement, center of mass-center of pressure separation, muscle onset latency, and peak plantar pressure. Data will be analyzed using repeated-measures ANOVA with condition as a within-subject factor.

Expected Results: It is hypothesized that both sensory augmentation and mechanical support will improve balance during perturbed gait, with the combined condition producing the greatest improvements in balance and neuromuscular control.

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EVALUATING PREDICTIVE MODEL GENERALIZATION FOR MACHINE LEARNING-BASED MARKERLESS UPPER-LIMB KINEMATICS ESTIMATION IN INDUSTRIAL WORK

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Introduction: Marker-based motion capture systems provide highly accurate measurements of human kinematics but are limited by their reliance on controlled laboratory environments and specialized equipment, restricting their use in industrial settings. Markerless approaches using convolutional neural networks, such as DeepLabCut, offer a scalable alternative by estimating movement from standard video data (1). However, the accuracy and generalizability of these approaches for complex upper-limb tasks remain unclear, particularly in applied environments (2). The primary aim of this study is to compare marker-based motion capture (Qualisys) with a machine-learning-based markerless method across controlled and industrial tasks. Specifically, this study evaluates whether a generalized model trained on standardized movements can more accurately predict kinematics for unseen industrial tasks than a task-specific model.

Methods: Twenty-four 18- to 65-year-old participants (12f / 12m) will be observed. Exclusion criteria will include a history of upper extremity or torso disorders or pain within the past year. Upper-body kinematic data for 9 markers and 3 marker clusters on the upper limbs and torso will be captured using a Miqus M5 optoelectronic system (Qualisys AB, Gothenburg, Sweden) and processed using DeepLabCut (Mathis Lab, EPFL, Geneva, Switzerland) to estimate joint centers and reconstruct three-dimensional kinematics. Participants will perform principal shoulder movements and a simulated overhead industrial task. Separate DLC models will be developed, including a generalized model trained on principal shoulder movements and a task-specific model trained on the simulated overhead industrial task. Model performance will be evaluated against motion capture data using Mean Absolute Error (MAE) and Root Mean Squared Error (RMSE). Statistical Parametric Mapping (SPM) will assess time-series differences, and Monte Carlo bootstrapping will be used to evaluate variability and generalization across participants.

Expected Results: This study will examine the accuracy and generalizability of machine-learning-based markerless motion capture relative to a marker-based reference. It is expected that DeepLabCut models will demonstrate strong agreement with Qualisys data during controlled, planar movements, while larger errors will occur during multi-planar and overhead industrial tasks. The task-specific model is expected to outperform the generalized model under complex industrial conditions, where task-specific training more effectively captures movement variability. However, the generalized model is expected to maintain acceptable accuracy, supporting its potential for cross-task application. Findings will highlight the trade-offs between model specificity and generalization, informing the development of scalable, markerless motion-capture pipelines for industrial biomechanics and real-world ergonomic assessment.

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CONCUSSION IMPAIRS BALANCE: INSIGHTS FROM STATIC POSTUROGRAPHY AND EMG

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Introduction: A concussion disrupts sensorimotor systems involved in postural control, resulting in symptoms such as vertigo and imbalance. Balance testing in concussion evaluation commonly uses the Balance Error Scoring System (BESS), in which static tasks are performed, and errors are counted to estimate impairment. However, such clinician-scored measures are limited by subjectivity and may not be sensitive to subtle impairments. We sought to more accurately quantify BESS performance using objective measures of static posturography and concurrent muscle activity to capture concussion-related balance impairments.

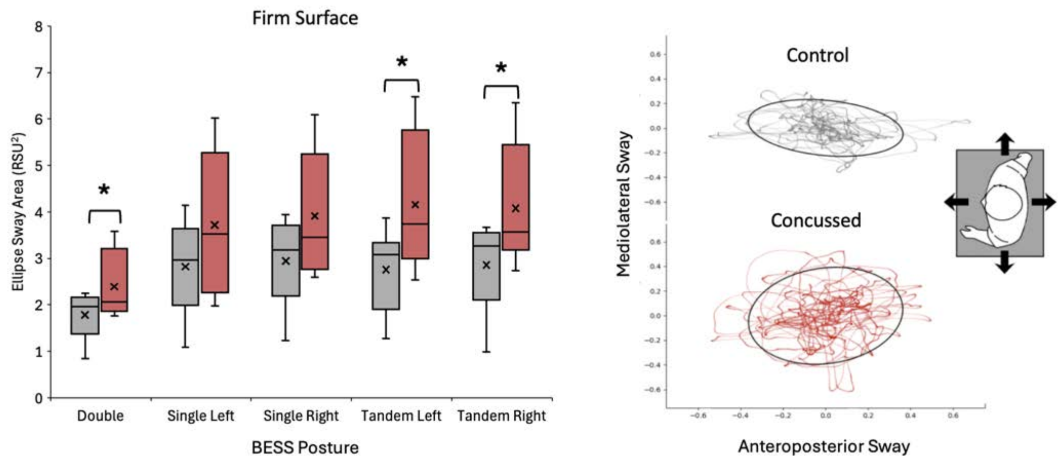

Figure 1: Normalized ellipse sway area (95% CI) for control (grey) vs concussed (red) across BESS firm surface postures (*p<0.05). Example CoP trajectories of a control and a concussed participant (double-leg posture on a firm surface); black ellipse shows 95% sway area.

Methods: Eight participants with self-reported concussions within the past 6 months and six control participants with no history of head injury or related afflictions were tested. Postural stability was measured using BESS balance tasks on both firm and foam surfaces, by measuring the centre of pressure with a force plate (Bertec FP4060-05 PT Bertec Corp, Columbus, OH, USA). Concurrent muscle activity of the tibialis anterior (TA) and medial gastrocnemius (MG) was recorded bilaterally (Delsys Trigno Avanti wireless surface EMG sensors, Delsys Inc., Natick, MA, USA).

Results: A repeated-measures ANOVA revealed a trend toward a group vs. posture interaction for ellipse sway area only on firm surface ($F = 2.46$, $p = 0.058$). Follow-up one-tailed independent-samples t-tests indicated significantly greater sway in the concussion group compared with controls during the double-leg and tandem stances on a firm surface (Figure 1). iEMG activity of the TA and MG appeared similar between groups. BESS error scores were not significantly different between groups.

Discussion and Conclusions: Measures of postural sway revealed differences in postural control not captured by traditional BESS scoring. The use of objective measures in balance assessments could improve sensitivity and support automated analysis.

HOOKERS AND ROLLERS IN ARMWRESTLING: AN ANTHROPOMETRIC, DYNAMOMETRIC AND KINEMATIC ANALYSIS

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Introduction

Armwrestling is a sport casually enjoyed by many people; however, it is also an organized sport with multiple international organizations registering tens of thousands of members worldwide (https://www.waf-armwrestling.com/). Despite this popularity, the biomechanics and physiology of armwrestling are underexplored. A lack of scientific investigation has led to training and recovery strategies based on tradition and anecdotes, often leading to opposing methodologies. Armwrestlers employ many styles including the “toproll” and the “hook” or “side pressure” to gain advantage on the table. There is a need for quantifying the biomechanics of armwrestling to build evidence-based strategies that maximize performance while preventing injury.

Aim

The aim of the proposed study is to quantify the anthropometric differences among armwrestlers and test for correlations with the level of success in the sport and the preferred style. Correlation will also be tested between anthropometry and torque production ability in relevant basic joint movements, as well as the kinematics of real armwrestling moves.

Methods

Basic demographic, experience and injury data will be collected via questionnaire. Anthropometric data will be collected using traditional tools including soft measuring tapes, calipers and a goniometer. Dynamometric data will be collected using a HUMAC NORM™ isokinetic dynamometer (Computer Sports Medicine, Inc., MA, USA). Marker-based motion capture will be used to collect kinematic data via OptiTrack™ cameras and Motive™ software (NaturalPoint Inc, OR, USA). Kinematic data will be analyzed using an existing musculoskeletal model of the upper exetremity [1] in OpenSim [2].

Expected Results

We expect to observe significant differences in certain anthropometric measures compared to the general population and between armwrestlers of different levels of success in the sport. We also expect certain torque and range-of-motion metrics to closely correlate with the anthropometric data, as well as the style and level of success or experience of the athletes. Finally, we predict significant kinematic differences between armwrestling moves and we expect these differences to be greater in athletes specializing in certain styles.

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INVESTIGATING LOAD MANAGEMENT IN JUMP SPORT ATHLETES

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Introduction: Load management is widely used to reduce injury risk in sport, yet most approaches emphasize activity volume rather than joint-specific mechanical loading. Jump-sport athletes repeatedly experience high spinal compressive forces that may contribute to low back pain (LBP) development. This study developed and evaluated a biomechanical informed spinal load metric and examined its association with LBP relative to traditional internal and external workload measures.

Methods: A total of 29 varsity athletes (10 women's volleyball players, 10 men's volleyball players, and 9 women's basketball players) were observed across a three-week competitive period. External load was quantified using jump counts and running time, while internal load was calculated from session rating of perceived exertion and minutes played [1,2,3]. Lumbar spine loading was estimated by multiplying the frequency of sport-specific moves by the corresponding peak compressive force [4]. Pain was assessed using a 100-millimeter visual analog scale and dichotomized to indicate LBP. A logistic regression was utilized to evaluate lumbar spine loading and LBP development with a between-participant comparison used for mean peak lumbar spine compression across weeks while a within-participant comparison used to evaluate week-to-week deviations from each participant's mean lumbar spine peak compression. A generalized linear mixed model analysis was used for traditional workload measures.

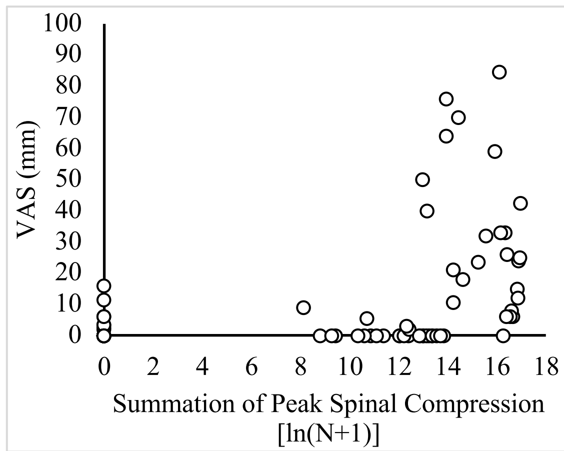

Figure 1: Mean Spinal Compression vs. VAS Scores for LBP Pain.

Results: The logistic regression revealed that between-participant average cumulative peak spinal compressive forces were significantly associated with LBP (β = -0.224, p = 0.037; OR = 0.80, 95% CI: 0.65-0.99). Whereas week-to-week deviations in spinal loading (β = 0.151, p = 0.147; OR = 0.86, 95% CI: 0.70 – 1.06), jump count (β = -0.014, p = 0.397), time spent running (β = 0.016, p = 0.479), and ITL (p = 0.227: OR = 1.001, 95% CI: 0.999 – 1.002) were not.

Discussion and Conclusions: These findings indicate magnitude based joint-specific load estimates explain LBP better than volume-based measures. Incorporating biomechanical informed load monitoring may improve athlete health management.

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VALIDATION OF HIGH-SPEED DYNAMIC ULTRASOUND FOR SOFT TISSUE IMPACT BIOMECHANICS

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Introduction: Falls are the leading cause of injury among older adults, including 95% of hip fractures [1,2]. While trochanteric soft tissue can attenuate up to 70% of impact energy in a lateral fall, its dynamic deformation during the impact event remains poorly characterized due to the temporal limitations of clinical imaging [3]. Traditional ultrasound systems sampling at low pulse repetition frequencies (prf) are insufficient for high-speed impact events due to limited images captured during the impact event and/or motion blur associated with rapid tissue deformation [4].

Aim: The aim of this study is to develop and validate a novel ultra-fast dynamic ultrasound imaging protocol for measuring deformation of surrogate soft tissues in the lateral pelvis during simulated sideways falls on the hip.

Methods: In phase 1, a tissue-mimicking ballistic gel phantom (300 kPa elastic modulus) will be subjected to compressive loading trials using a custom linear actuator system. Trials will be conducted across three impact velocities (0.5, 1.0, and 1.3 m/s). Ultrasound data will be acquired using a Verasonics Vantage NXT 64LE research system with a 6 MHz linear array transducer. Trials will be captured at 10,000 prf and compared across 6 different prfs distributed from 15-10,000 Hz. Gross deformation will be analyzed using ProAnalyst software and compared against a gold-standard Optotrak motion capture sampled at 3000 Hz (Optotrak Certus®, Northern Digital, Waterloo, ON, Canada). In phase 2, similar approaches will be employed to characterize system performance in porcine tissues selected to match the soft tissue distribution (superficial adipose, underlying muscle) observed in the human hip region.

Figure 1: Experimental apparatus used for controlled mechanical loading, consisting of a linear actuator, specimen platform, and an ultrasound probe positioned below the specimen to measure subsurface deformation during loading.

Expected Results: It is anticipated that gross deformation measurements will demonstrate strong agreement with the gold-standard motion capture and actuator data, with Pearson's correlation coefficient of $r \geq 0.9$ and a Root Mean Square Error (RMSE) $\leq 5\%$. It is expected that higher sampling frequencies will be necessary to accurately capture peak deformation during high-speed impacts.

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The Effects of Compressive Load Order on Functional Spinal Joint Failure in Cumulative Exposure Paradigms

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Introduction: Injury to the musculoskeletal system is commonly assessed using models that assume damage accumulates in a linear manner [1]. However, the cumulative load that biological tissues can tolerate is complicated by loading history [2]. Previous injury models have largely ignored loading sequence implying that the order of exposure to high and low loads poses no difference in injury risk. On the contrary, a more recent theoretical model has demonstrated clear order effects with respect to different magnitudes of loading [3]. Although, how these order effects influence the potential for spinal injury is still unknown.

Aim: The aim of this study is to assess whether the order of high- and low-magnitude loading influences spinal joint failure when the cumulative exposure dose is equal.

Methods: Twenty-four fresh-frozen porcine cervical functional spinal units (C34) will be tested in a material testing system. Following a 15-min 300 N preload, cyclic compressive loading via a 1 Hz haversine waveform will be applied in a neutral posture at one of two loading sequences: Low/High or High/Low loading orders. High loading will consist of an exposure at 60% of maximum compression, and Low loading at 30% [4]. Cumulative dose (force-time integral) between the Low and High load will be equalized by varying the number of repetitions. Following both loading sequences, specimens will be cyclically loaded at 60% compressive load until failure or until 10800 cycles are tolerated. Macroscopic dissection and injury characterization will then be performed. T-tests ($\alpha = 0.05$) will be used to evaluate differences in cumulative load tolerated at failure between loading orders.

Expected Results: Based on results from the model [3], it is hypothesized that functional spinal units in the Low/High group will reach failure as slow accumulation of smaller structural insults would make the joint more susceptible to subsequent high loading. Additionally, it is predicted that the functional spinal units subjected to the High/Low sequence may not reach failure, possibly due to a plateau in damage accumulation after the high loading.

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CONTRIBUTION OF LEG PAD MATERIALS TO SLIDING MECHANICS IN ICE HOCKEY GOALTENDERS

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Introduction: The athlete-equipment interaction in gliding and sliding sports has been recognized as a fundamental component of performance success [1-4]. In ice hockey, goaltenders frequently rely on sliding movements along the medial surface of their leg pads during critical moments of gameplay. In response to the performance demands, manufacturers have introduced design modifications such as channeled knee blocks to disperse ice shavings and add-on plastic covers to reduce friction between the leg pads and the ice surface. However, there is currently limited scientific evidence to support the effectiveness of these modifications in reducing friction. Moreover, it remains unclear whether a threshold exists for the minimum coefficient of friction, below which further reductions may compromise control and stability.

Aim: To compare the kinematic and kinetic profiles of hockey goaltender sliding on three different leg pad materials, namely i) high friction, ii) medium friction, and iii) low friction, on ice. A secondary objective is to determine whether there is a minimum threshold of friction, below which further reductions may compromise control and stability.

Methods: Eight male and eight female (N = 16) hockey goaltenders will be recruited. Participants will wear their own goaltending equipment while executing three different sliding techniques, namely i) power slide, ii) butterfly slide, and iii) butterfly into a power slide, with three different materials adhered to the medial surface of the pads. Kinematic data will be collected using an inertial measurement unit (IMU) motion capture system (Xsens Awinda, Movella Inc., CA, USA), consisting of 17 sensors secured, sampling at 60 Hz. Kinetic data will be collected using a wireless pressure insole and pressure pad (X4 Foot and Gait Measurement System, XSENSOR® Technology Corporation, AB, Canada), sampling at 120 Hz to measure pressure within the skates and at the knee block. Outcome measures include joint angles (deg) and velocities (deg/s) of the ankle, knee, hip and trunk continuous relative phase (CRP), tibial shock (m/s^2), mean and peak force (N), impulse (Ns), and CoP path length (mm). Descriptive statistics ($M \pm SD$) will be calculated for each material. Repeated measures ANOVA will be used to identify significant differences in the kinematic and kinetic variables across different materials, and principal component analysis will evaluate variations in time-series data.

Expected Results: It is expected that pad material will significantly influence kinematic and kinetic profiles during sliding movements. Lower-friction materials are anticipated to reduce peak force during push-off, reflecting enhanced sliding efficiency; however, they may also increase tibial shock during deceleration, as well as upper body movement and out of sync torso CRP, indicating reduced stability and control.

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A SCOPING REVIEW OF PHYSICAL DEMANDS AND MUSCULOSKELTAL OUTCOMES IN MASSAGE THERAPY

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Introduction: Massage therapists are exposed to substantial physical demands during clinical practice, including sustained poor postures, repetitive movements, and application of high forces. These exposures have been associated with a high prevalence of work-related musculoskeletal disorders (WMSDs), with approximately 85-90% of therapists reporting pain or injury over the course of their careers [1]. Previous research has also identified the upper extremities and low back as the most affected regions, likely due to repetitive loading and sustained manual force application [2]. Despite this, the existing literature examining physical exposures and ergonomics interventions in massage therapy remains fragmented. A scoping review is warranted to systematically map the literature and inform future laboratory and/or field-based research.

Aim: To map the existing literature on occupational physical demands and ergonomic risk factors in manual massage therapy practice and their relationship to adverse musculoskeletal outcomes.

Methods: This scoping review will be conducted in accordance with PRIMA-ScR guidelines. A comprehensive search strategy, developed by a health services librarian and peer-reviewed according to the PRESS guideline, will be implemented across multiple databases (MEDLINE, EMBASE, CINAHL, Web of Science, Scopus) and grey literature sources (ProQuest Dissertations). Studies will be included if they examine practicing massage therapists and report occupational physical demands (e.g., posture, force, repetition, duration) and/or related musculoskeletal outcomes. Title/abstract and full-text screening will each be completed independently by two reviewers using a standardized platform, with disagreements resolved through discussion or a third reviewer. Data will be charted on study characteristics, exposures, measurement methods, and study outcomes. Findings will be descriptively synthesized to map the current evidence.

Expected Results: This review is expected to identify and organize evidence on physical exposures in massage therapy, with a long-term goal of understanding potential research gaps and opportunities for ergonomic interventions. The research team aims to use these findings to design an experimental study that addresses the most pressing needs and explores interventions that have the highest likelihood for adoption (e.g. recommendations for setting table height based on body region and treatment modalities).

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BENDING THE LIMITS: DOSE-RESPONSE EFFECTS OF SPINAL FLEXION ON INTERVERTEBRAL DISC MECHANICS

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Introduction: Lower back pain is often linked to the mechanical environment of intervertebral discs [1,2]. The disc's outer ring, the annulus fibrosus (AF), is a multilamellar structure that relies on interlamellar adhesion to maintain structural integrity under load [1-3]. When adhesive properties are compromised, small delaminations occur and accumulate to increase risk of disc injury and herniation [2-4]. Spinal flexion under compression is a particularly damaging scenario, as it shifts compressive load to the anterior region of the disc, increasing tensile and shear strain posteriorly [5,6]. Recent work has demonstrated that combined flexion and compression weakens the AF compared to neutral posture [6]. Further research is required for a dose-response map of how increasing flexion angle can alter AF interlamellar adhesion.

Aim: The primary aim of this study is to quantify the mechanical effect of varying magnitudes of flexion on the AF. This will be accomplished by comparing mechanical properties obtained from two complementary AF mechanical tests: peel testing and bilayer testing.

Methods: Ex vivo porcine C3/C4 cervical functional spinal units will be thawed according to laboratory procedures and preconditioned with 300 N compression for 15 minutes after which the flexion range of motion (ROM) will be determined. Specimens will then be randomly assigned to one of four static flexion conditions (0%, 25%, 50%, and 75% specimen-specific ROM) combined with 1200N axial compression for 1 hour. Posterior AF samples will then be extracted and mechanically analyzed using interlamellar peel testing and bilayer testing under standardized protocols.

Expected Results: It is hypothesized that greater magnitude of flexion will produce progressive reductions in posterior interlamellar adhesion, demonstrated by both complementary AF tests.

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VALIDATION OF SIMULATOR KINEMATICS FOR REVERSE TOTAL SHOULDER ARTHROPLASTY WEAR TESTING

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Introduction: Reverse total shoulder arthroplasty (RTSA) is used to treat degenerative and traumatic glenohumeral pathologies, including osteoarthritis, massive rotator cuff tears, and failed anatomic total shoulder arthroplasty [1]. In 2017, 62,705 RTSAs were performed in the USA with a revision rate of 27%, with the primary reason for revision being dislocation or instability at 30% [1]. While polyethylene (PE) wear is an underreported cause of implant failure, 57% of patients show evidence of PE wear despite citing instability as their primary complaint [2]. PE wear causes an inflammatory response, which leads to osteolysis, and can result in instability and failure [2]. While standardized tests for pre-clinical evaluation of prosthesis wear exist for knees, hips, and conventional shoulder replacements, a similar standard for RTSA has only recently been developed. To our knowledge, no published studies have implemented a VIVO joint motion simulator (AMTI, MA, US) for this proposed RTSA standard. The aim of this work is to validate an experimental setup to use a VIVO simulator for RTSA wear testing.

Methods: Custom fixtures were designed to mount, align, and articulate the prosthesis components with the VIVO. The achieved motion was validated by comparing the machine-measured rotations with a tolerance envelope of ±5% of the maximum prescribed rotation in each axis and a ±1% phase shift. The accuracy of the force was similarly evaluated with respect to the maximum prescribed force. Additionally, a lubrication fluid enclosure was designed and its effect on the joint reaction force characterized. The reaction forces in the enclosure were quantified by running the wear test motion in displacement control without the glenosphere mounted, to eliminate joint contact force.

Results & Discussion: The motion prescribed by the standard was achieved, with rotations about the X, Y and Z axes all found to be within the tolerance window. The lubrication enclosure reaction forces were negligible compared to the applied load, at 0.18%, 0.15%, and 0.36% of the applied load in the X, Y, and Z directions, respectively. The test setup is shown to be valid for articular wear testing of RTSA, and will be proceeded by long-term wear tests of different bearing materials.

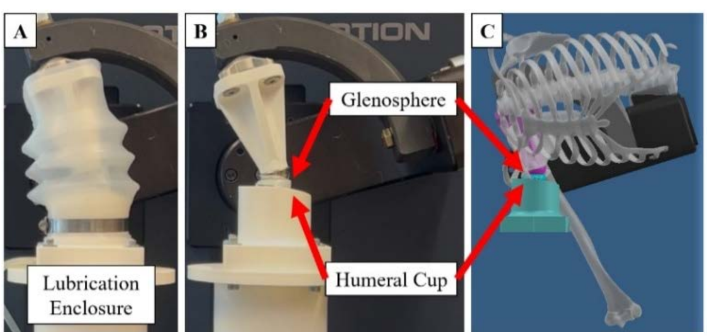

Figure 1: A) Lubrication enclosure. B) Fixtures mounted to VIVO. C) CAD rendering with superimposed anatomy.

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EXPLORING THE EFFECTS OF COMBINING HIIT EXERCISE AND TASK SPECIFIC TRAINING ON COGNITIVE MOTOR DUAL-TASK PERFORMANCE

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Introduction: Cognitive-motor dual tasking (CMDT) is the simultaneous execution of a movement and mental task, which impairs our ability to execute these tasks due to limited cognitive resources [1]. Decreases in gait speed and increases in variability (i.e., step length) occur with dual-tasking, increasing the risk of falls [1]. Dual-task (DT) practice is effective in improving CMDT performance by enhancing our ability to process both inputs simultaneously [5]. Exercise triggers the release of catecholamines (i.e., dopamine) and neuroplastic factors (i.e., BDNF) which support executive functioning [2]. Combining exercise and motor task practice has been shown to be effective for improving balance 24 hrs post training [4] while upper-limb motor performance improvements have been shown 24 hours and 7 days post-training [3]. Few studies have investigated the effects of exercise on locomotor task practice under DT conditions and if timing of exercise, pre or post practice, results in greater improvements.

Aim: The current study aims to determine whether combining exercise and dual-task practice influences CMDT performance in young adults aged 18 to 30 years when HIIT is performed before or after task practice. Findings from this study could guide practitioners in structuring rehabilitation sessions to aid in the learning of complex locomotor tasks.

Methods: *Day 1.* A biking ramp protocol to determine peak power output (PPO) (Velotron, USA). *Day 2.* Gait will be analyzed using a 3D motion capture system (OptiTrack, Corvallis, USA), tracking 32 retroreflective markers placed on anatomical landmarks (e.g. trunk, feet, pelvis). Participants will be required to step over an obstacle while performing an auditory Stroop (AS) task. The AS test will require participants to identify the pitch of a prerecorded word (e.g. words "high" and "low" spoken in low or high pitch). Participants will be assigned to one of three groups: non-exercising group, pre-exercise group (exercise before DT practice) and post-exercise group (exercise after DT practice). Exercise groups will complete a HIIT protocol: 10 x 1 minute biking at 70% PPO, interspersed by 10 x 1 minute of recovery biking (50 W). DT practice will consist of concurrent obstacle crossing and auditory Stroop training (32 trials). Re-testing will be scheduled 24 hours (*Day 3*) and 7 days following (*Day 4*). Visual3D software will be used to analyze gait parameters, including obstacle clearance, step length/width and gait velocity. Cognitive task performance will be captured using accuracy and reaction time.

Expected results: It is expected that gait parameters will improve in the exercise groups compared to the control group. As well, the post-exercise group will have the greatest gait performance improvements, compared to the pre-exercise group. Demonstrated through decreased variability in gait velocity, reduced step length/width and obstacle clearance.

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INFLUENCE OF PHYSICAL ACTIVITY HISTORY ON LUMBAR SPINE PROPERTIES IN YOUNG ADULTS

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Introduction: Low back pain (LBP) is highly prevalent in young adults with 60%-80% of adults experiencing LBP at some point in their lifetime[1]. Increased physical activity and high sporting activity are associated with a decline in LBP measures, with no association observed between type of sporting activity[2]. Further, research shows that high levels of physical activity and VO_2 max in childhood seem to protect against adolescent back pain; however, these studies do not measure into adulthood[3]. Lumbar spine passive stiffness has direct implications with spinal injury risk, with inactive individuals having significantly lower stiffness compared to active adults[4,5]. The spinal range where passive tissues avoid excessive strain causing injury is referred to as the Neutral Zone (NZ), which is a sensitive biomechanical measure of passive tissue injury; the application of this measure to participants addresses a gap in the literature[4,6]. The purpose of this study is to analyze how participation of sporting activities during childhood affects lumbar spine properties such as spinal stiffness in adulthood.

Methods: Forty young healthy adults will be recruited (20 male, 20 female). Participants will complete a questionnaire gathering information about physical activity habits and sporting activities throughout childhood (ages 6–12)[7]. Participants will then complete a five-minute static standing trial to assess upright standing posture and lumbopelvic sway characteristics. NZ properties will be quantified using a frictionless flexion-extension passive jig consisting of a stationary lower body cradle and a dynamic upper body cradle. The upper body cradle is attached to a controller maintained at a constant angular velocity of 0.5°/sec, with a torque transducer mounted in line with the motor to continuously record applied moments. Throughout all trials, a ten-camera passive motion capture system will be used to track participants' lumbar spine kinematics and lumbar spine angle (Qualisys AB, Göteborg, Sweden). Reflective markers placed on anatomical landmarks will be used to calculate lumbar spine motion during passive flexion-extension testing and upright standing. Moment-angle curves will then be generated to quantify NZ length, passive stiffness, along with lumbar spine posture during upright standing[5].

Expected Results: It is anticipated that physical activity during childhood will alter lumbar spine properties such as spinal stiffness into adulthood. Participants with higher levels of physical activity during childhood and expected to demonstrate greater spinal stiffness while those with lower levels of physical activity during childhood are expected to demonstrate less spinal stiffness[5]

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DESIGN OF A HIGH-FIDELITY 3D PRINTED CANINE TIBIA FRACTURE FIXATION MODEL

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Introduction: Biomechanical testing of orthopaedic fixation implants relies on cadaveric specimens, which are limited by anatomical variability, accessibility, and cost. Synthetic models compromise either anatomical accuracy or mechanical properties [1,2]. Three-dimensional (3D) printing offers an alternative to develop bone models which achieve both anatomical and mechanical fidelity [3]. However, its ability to replicate bone properties has not been fully explored.

Aim: The aim of this study is to design and validate a 3D printed canine tibia model that is both anatomically accurate and exhibits similar mechanical properties to cadaveric bone under clinical loading conditions. Acceptable equivalence thresholds will be defined based on biological variability and prior studies.

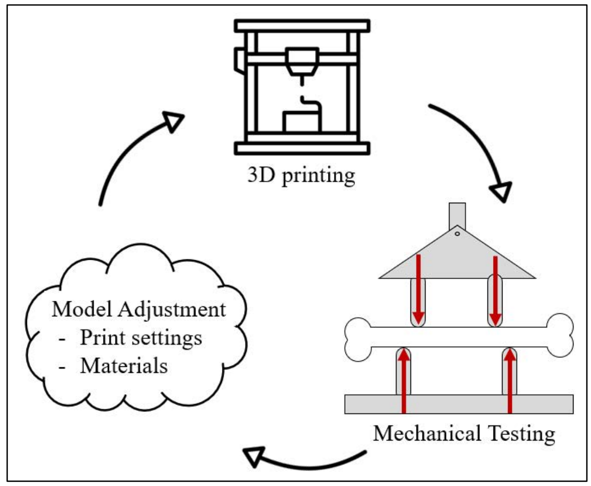

Figure 1: Workflow chart of the study.

Methods: Canine tibia models will be reconstructed from computed tomography data of cadaveric specimens. Models will be fabricated using fused deposition modeling, a fast and accessible 3D printing method, with materials selected to approximate bone properties. A 4-point bending test will be performed on both the cadaveric specimens and printed models using an Instron® machine (Instron Corp., Norwood, MA, USA). Key parameters such as wall thickness, density, infill geometry and material selection will vary between model iterations (Figure 1). Outcome measures will include ultimate strength, failure load, and stiffness.

Expected Results: The optimized model is expected to demonstrate consistent performance and produce mechanical properties comparable to cadaveric specimens. A validated 3D printed canine tibia model could support implant evaluation, surgical technique optimization, and comparative studies. The combination of mechanical and anatomical fidelity will allow for greater research applications where both factors are necessary to consider. Future work could focus on optimization, evaluating fractured models and assessing compatibility with fixation devices.

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A COMPARATIVE ANALYSIS OF NIOSH LIFTING INDEX CALCULATED USING MULTI-CAMERA MOTION CAPTURE AND SINGLE-CAMERA COMPUTER VISION-BASED POSE ESTIMATION

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Introduction: The NIOSH Revised Lifting Equation (RNLE) is a common ergonomic assessment tool that calculates the Recommended Weight Limit (RWL) of a task from manual measurements by ergonomists but can be time-consuming and have low reliability between assessors [1]. Inseer Vision (Inseer Inc., Iowa City, Iowa, USA) accelerates RNLE analysis and improves inter-assessor reliability by using single-camera computer vision-based pose estimation. However, it is not known how accurately it estimates the RWL or the RNLE required inputs. Therefore, the objective of this research was to determine how similarly Inseer Vision calculates RWL and RNLE inputs when compared to a research-grade multi-camera markerless motion capture method.

Aims: To quantify the biases and limits of agreement in RWL and RNLE inputs between the single- and multi-camera method.

Methods: Thirty-nine participants performed three sets of a vertical transfer task (from floor to shoulder height) and a palletizing task. The tasks were recorded with an eight-camera system oriented around the participant. Theia3D was used to measure segment and joint positions over time as the multi-camera method for capturing RWL and RNLE inputs for each crate transfer. Video data from the sagittal camera view were processed through Inseer Vision to produce RWL and RNLE inputs for each crate transfer. A Bland-Altman analysis illustrated the differences between methods for RWL and RNLE inputs for the sagittal camera view.

Results/Discussion: The sagittal camera did not produce significantly different values for RWL or horizontal distance between methods for the vertical transfer task. The RWL calculated by Inseer Vision was within 1 kg of the multi-camera method (Table 1) and limits of agreement were similar to those seen in manual execution of the RNLE [1]. Similarities between methods indicate that Inseer Vision would be effective at quickly screening occupational tasks, provided the video is taken perpendicular to the primary plane of motion.

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Table 1. Differences in recommended weight limit and RNLE inputs between Inseer Vision from left camera view and multi-camera system across two occupational tasks.

Task	Recommended Weight Limit (kg)	Horizontal Location (cm)	Vertical Location (cm)	Asymmetry Angle (°)
Vertical Transfer	-0.03 (±0.25)	0.32 (±4.32)	-5.83 (±5.26)	12.60 (±10.18)
Palletizing	0.26 (±0.59)	-3.16 (±5.98)	-8.39 (±10.24)	4.60 (±8.95)

EFFECTS OF FOOT ORTHOTICS ON BALANCE, GAIT MECHANICS, AND TRIP RECOVERY IN OCCUPATIONAL SAFETY FOOTWEAR

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Introduction: Safety footwear is required within occupational workspaces; however, this footwear can impede balance leading to an increased risk of falling. Within the workplace, 67% of falls are due to overground walking, leading to hospitalizations and workplace injury[1]. The design of safety footwear is a potential cause for falling. Key design features of safety footwear include high shafts, soft midsoles, and an increased heaviness compared to everyday footwear[2]. Shaft height can limit ankle dorsiflexion for toe clearance, while soft midsoles have shown to impede balance through changes in the centre of mass (COM) and base of support (BOS) relationship[3]. Boot weight further increases risk by decreasing toe clearance of obstacles[2]. Foot orthotics may provide a practical solution to the balance issues imposed by safety footwear. Specifically, orthoses may improve dynamic balance control during obstacle navigation through mechanical support and sensory information. However, the effects of orthotics in safety footwear during a trip perturbation have not been investigated.

Aim: Investigate whether foot orthotics improve dynamic balance and trip-recovery performance in safety boots by counteracting the biomechanical constraints imposed by boot design

Methods: Recruitment of 30 adults aged 18-50 who wear safety footwear ~35 hours per week and are currently or have been employed in an industrial workspace for at least 6 months. Participants will walk along a 10m platform where an obstacle requiring elevating over will appear at random, producing a trip perturbation. This will be done using standardized safety footwear with a standard insole and orthotic condition. Kinetic, kinematic, and electromyography data will be collected. Primary outcome measures include COM-BOS relationship, minimum toe clearance, ankle sagittal range of motion, and muscle amplitude. Data will be analyzed using a 2x2 repeated measures ANOVA.

Expected Results: We hypothesize that the foot orthotic condition will improve dynamic balance and trip recovery during the perturbation event.

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THE EFFECTS OF CHEMICALLY INDUCED MENOPAUSE ON LUMBAR SPINE MECHANICS AND INTERVERTEBRAL DISC STRUCTURE

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Introduction: Menopause is associated with declining estrogen levels which can contribute to intervertebral disc (IVD) degeneration, altered spinal mechanics, and low back pain [1]. Estrogen is thought to help maintain IVD structure, but its effects on lumbar spine biomechanics are not yet fully understood [2]. The VCD mouse model provides a useful way to study menopause related changes because it mimics gradual ovarian failure while preserving ovaries in place. In this study, we examined whether VCD-induced ovarian failure and estradiol supplementation affect lumbar spine biomechanics and IVD degeneration [3]. We hypothesized that IVDs would be more degenerated in the VCD group compared to control and VCD + estradiol supplementation (VCD + E2) groups, and that neutral zone (NZ) stiffness would be lower and NZ length would be higher in the VCD group compared to the control and VCD + E2 groups.

Methods: Experiments were conducted on three groups of mice: control (CON, n=16), VCD (n= 9), and VCD with estradiol supplementation (VCD + E2, n=10). In the VCD + E2 group estradiol supplementation began at the onset of ovarian failure, and mice in the VCD and VCD + E2 groups were sacrificed 8 weeks after the onset of ovarian failure. Lumbar spines (L2-L5) were removed, stored frozen and tested in cyclic axial compression and tension to determine neutral zone length and stiffness. Histology was used to visualize and score degenerative changes on the L3/L4 IVD.

Results: NZ stiffness differed amongst groups ($p < 0.03$), with the VCD + E2 group statistically greater than control ($p = 0.011$) and trending toward being greater than VCD ($p = 0.054$). NZ length did not differ significantly among groups ($p > 0.05$). Histological analysis showed significant differences among groups ($p = 0.045$). Specifically, the VCD group had significantly higher IVD degeneration scores (i.e. were more degenerated) than VCD + E2.

Discussion and Conclusions: Chemically induced ovarian failure leads to accelerated IVD degeneration. Estradiol supplementation may protect IVD structural integrity, as degeneration scores were lower than in the VCD group. However, estradiol supplementation resulted in lumbar spines that were stiffer than the control group. Further study is needed to understand the mechanism of this result.

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EFFECTS OF DYNAMIC LOAD, WRIST POSTURE, AND VENOUS OCCLUSION ON CARPAL TUNNEL CONTENTS IN FEMALES

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Introduction: Carpal tunnel syndrome (CTS) is the most common peripheral neuropathy, characterized by median nerve compression within the carpal tunnel. Altered motion between the flexor digitorum superficialis (FDS) tendon and subsynovial connective tissue (SSCT) has been implicated in the development and progression of CTS [1]. Mechanical loading, venous congestion, wrist posture, and aging have each been shown to influence relative tendon-SSCT motion, yet their combined effects are unclear [2,3]. The shear strain index (SSI) quantifies relative tendon-SSCT motion as the percentage difference between tendon and SSCT excursion, where higher SSI values indicate greater relative motion.

Aim: To determine the effects of external load, partial venous occlusion, and wrist posture on tendon and SSCT mechanics in adult women.

Methods: Women aged 17-80 years performed a series of 12 isolated middle-finger flexion-extension cycles at 0.75 Hz while colour Doppler ultrasound captured FDS tendon and SSCT motion (GE Vivid Q, 12L-RS). A 2×2×2 repeated measures design was used. Eight randomized conditions, each repeated twice, used two levels of force (0 N, 2 N), two wrist postures (neutral, 20° flexion), with and without brachial venous occlusion using a blood pressure cuff (none, 80% sub-diastolic blood pressure). Tissue (FDS and SSCT) velocity and displacement were quantified using the EchoPAC (GE HealthCare) software using frame-by-frame tracking. Hand use, physical activity, and hormonal status are recorded as exploratory covariates.

Results: Preliminary analysis using 13 of 40 participants (36.8 ± 14.8 years) are presented. The baseline condition of no load, no occlusion, and a neutral wrist posture had a mean SSI of 26.2% ± 5.4%. Venous occlusion produced a slightly larger SSI (46.7% ± 10.3% compared to no occlusion (45.6% ± 16.8%), across all load and posture combinations. Load increased SSI (49.2% ± 13.0%) compared to no load (43.0% ± 14.1%). Also, wrist flexion increased SSI (50.2% ± 11.7%) compared to neutral (42.0% ± 14.6%) across all conditions.

Discussion/Conclusion: Sub-diastolic occlusion, finger load, and wrist flexion each increased SSI, suggesting that relative motion between the tendon and SSCT increases with each factor compared to individual baselines. These factors are commonly encountered in occupational settings, where sustained or repetitive hand use combined with awkward wrist postures may compound tissue dysfunction over time, potentially contributing to the development of CTS. The observed increase in SSI with venous occlusion further suggests that circulatory changes within the carpal tunnel may impair the SSCT's ability to accommodate tendon movement.

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KINEMATIC COORDINATION AS A PREDICTOR OF FIREFIGHTER TASK PERFORMANCE

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Introduction: The Candidate Physical Ability Test (CPAT), developed by the International Association of Fire Fighters (IAFF), is a standardized assessment used to determine whether candidates can complete simulated Firefighting tasks within a fixed time frame. Performance on the CPAT is assumed to be dependent on physical capacity (e.g., strength and aerobic fitness). However, technical skill is also important for select tasks and can be observed as the coordination of body segments during CPAT task performance. This can be quantified using coordination-based kinematic measures such as coordinative variability. The construct of coordinative variability reflects the ability to adapt movement strategies to task demands and fatigue, which may be important to successfully complete the CPAT in time.

Aim: To determine whether coordination patterns and their variability can explain differences in CPAT performance, while controlling for physical fitness

Methods: Participants will complete the CPAT while full-body kinematics are recorded using wearable inertial measurement units (IMUs) (Xsens Awinda, Movella, Enschede, Netherlands). Intersegmental coordination will be quantified using vector coding to assess coordination patterns and coordinative variability across repetitions and tasks. Outcome measures will include CPAT completion time, physical fitness metrics, and task-specific performance metrics. Participants will be grouped based on initial CPAT performance (pass vs fail), and their coordination metrics will be compared to determine whether individuals who successfully complete the CPAT elicit different levels of coordinative variability. Regression analyses will be used to evaluate whether coordinative variability explains CPAT performance, including the likelihood of passing and task completion time, while accounting for differences in physical fitness.

Expected Results: It is expected that individuals who successfully complete the CPAT will elicit smaller changes in coordinative variability over the course of each task within the CPAT, compared to those who failed. Specifically, pass groups are expected to maintain more consistent coordination patterns with smaller differences in the standard deviation of the coupling angle, whereas fail groups are expected to exhibit larger increases in this measure.

EXPLORING CUTANEOUS REFLEXES IN THE ABDUCTOR HALLUCIS WHILE SEATED WITH LOAD

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Introduction: The abductor hallucis (AH) is an intrinsic foot muscle important for supporting the medial longitudinal arch [1]. Cutaneous stimulation has been shown to elicit location-dependent reflexes in lower leg muscles [2]. Our prior work shows that location-dependent reflexes in the AH do not occur in a seated posture but do occur with increasing postural context (i.e. standing) [3,4]. Standing increases postural context but also load on the foot sole. It is unclear whether it is load or postural context that drives the location dependence in the AH.

Aim: Our purpose was to determine how increasing load on the foot in a seated position affects the location dependence of AH reflexes.

Methods: Participants (n=5) were seated with a load of 0%, 50%, 100%, and 125% of bodyweight applied to their right knee. Electromyography (EMG) was measured from their AH, triceps surae, and tibialis anterior. Their right foot was strapped to a custom device, stabilizing the foot to allow isometric abduction of the big toe, while cutaneous stimulation was delivered to one of three regions of the foot: the heel, lateral metatarsal, or big toe. AH contractions were performed at 20% of EMG max; stimulation was delivered at a 5/10 (non-noxious, moderate) intensity. Site order was randomized, and load conditions were randomized within each site.

Preliminary Results: AH reflexes from stimulation of the big toe (n=5) remained inhibitory, regardless of load condition. AH reflexes from stimulation of the lateral metatarsal (n=3) were initially inhibitory but transitioned to excitatory with increased load. AH reflexes from stimulation of the heel (n=1) were excitatory for 0%, 50%, and 100%, but inhibitory for 125%. Our preliminary results show, by changing load alone, without changing postural demand, that reflexes generated from the big toe and lateral metatarsal mimic those found in standing. While the heel did follow the trends seen in standing, significant artifact in the EMG prevented us from being able to analyze heel data from all participants. More participants are required to establish a consistent pattern. Early results suggest sitting with load mimics the results found in standing, without increased postural context, which may indicate that cutaneous AH reflex generation is load dependent. This finding may provide insight into rehabilitation strategies to increase AH activity in populations with poor arch strength.

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Quantifying Changes to Paraspinal Muscle Pennation Angle in Response to Alterations in Lumbar Posture and Muscle Activation

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Introduction: The paraspinals play an important role in generating posterior shear and compressive forces to stabilize the spinal column during a range of postures and demands [1]. During spinal flexion [2] and differing muscle activations [3], there is a reorientation of paraspinal muscle fibers along the compressive axis of the spine. It is presently unknown how these two factors interact to alter paraspinal muscle pennation angle (MPA) across a diverse range of postures. The purpose of this study was to explore the combined roles of changes in lumbar posture and paraspinal muscle activation to the architecture of the paraspinal musculature.

Methods: At present, eight participants (2 M, 6 F) have completed the study (mean ± SD: age 23.86 ± 4.58, mass 72.14 ± 17.68, and height 170.71 ± 11.02). Participants completed various static postures and dynamic flexion extension movements. Static postures include standing, sitting, and prone lying, and slouched standing and sitting. Dynamic movements included flexion-extension tasks, with and without added mass to the torso (5lb, 10lb). During all tasks, lumbar kinematics (100 Hz, 6x Vicon Vero 2.2), paraspinal muscle activation (2000 Hz, Noraxon Ultium), and m-mode ultrasound images (30 Hz, Clarius L15HD3) were captured concurrently. The ultrasound probe was affixed to the torso (Usono ProbeFix) superficial to the L1 facet joint. MPAs were manually recorded by calculating the relative angle between the inferior aspect of the dermis and underlying muscle fibers.

Results: Preliminary data from the static postures suggest that MPAs are significantly affected by lumbar posture ($F = 3.44$; $p = 0.020$). Prone lying (9.01 ± 2.95 deg) postures had larger MPAs than slouched sitting (5.08 ± 1.27 deg; $p = 0.011$), with a trend towards statistically significant differences with respect to slouched standing (6.04 ± 1.99 deg; $p = 0.085$).

Discussion and Conclusions: The current results corroborate those from previous reports [1-3], suggesting that changes in lumbar flexion-extension posture results in a reduction in paraspinal MPA. This represents a reduced capacity for the paraspinals to generate posterior shear force in high flexion postures, which may contribute to disk pathology. Additional analyses will aim to explore the interacting relationship between lumbar posture and muscle activation on MPA during dynamic tasks.

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THE INFLUENCE OF HAND POSTURE ON UPPER ARM MUSCLE ACTIVITY DURING ISOMETRIC WRIST CONTRACTIONS

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Introduction: Upper arm muscle activity is strongly influenced by isometric wrist contractions [1]. These activity levels can exceed 30% of maximal activity, which may be sufficient to increase the risk of developing musculoskeletal disorders in workplaces with frequent and/or intense wrist actions. However, these findings come from studies that have examined isometric wrist contractions performed with an open hand, which may not translate to tasks that require gripping. Indeed, research has shown that a closed hand causes a reorganization of shoulder muscle activity when compared to an open hand [2]. It is presently unclear if hand posture similarly influences muscle activity of the upper arm.

Aim: The purpose of this study is to examine how isometric wrist contractions influence upper arm muscle activity, both with an open and a closed (gripped) hand posture.

Methods: Muscle activity was collected from the biceps and triceps brachii. Participants were 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 performed isometric wrist flexion, extension, and radial/ulnar deviation at 50% of maximal wrist extension force. Conditions were repeated with the hand either open or loosely gripping a wooden dowel.

Preliminary Findings: In agreement with previous research [1], biceps brachii muscle activity appears to be greatest when force is exerted upwards and to the left (Figure 1) while triceps brachii muscle activity is greatest when exerting force downwards. In general, hand posture (open vs closed) seems to have no influence on either biceps brachii (Figure 1) or triceps brachii muscle activity across wrist actions and exertion directions.

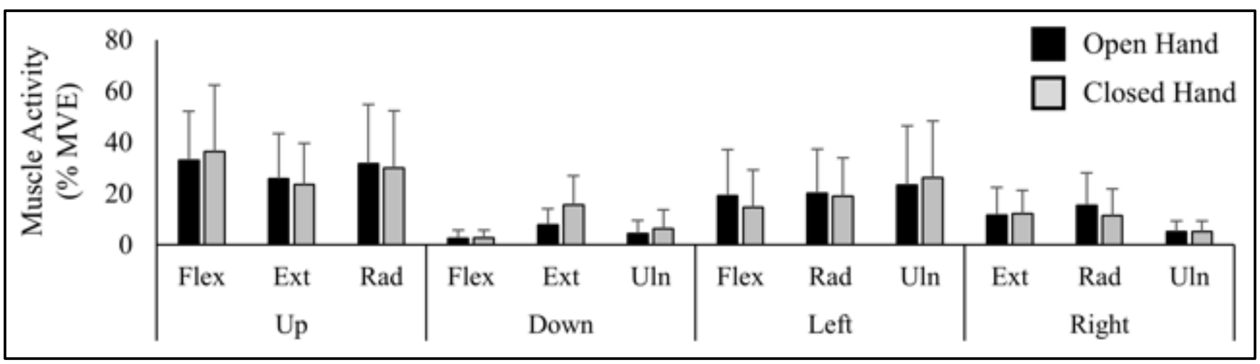

Figure 1: Group means ± SD (n = 16) for biceps brachii muscle activity during isometric wrist actions in four directions. Muscle activity is expressed as a percentage of maximal voluntary excitation (MVE). Black bars correspond to wrist contractions performed with an open hand; grey are with the hand gripping a dowel.

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THE EFFECT OF FOOT PROGRESSION ANGLE ON MAGNITUDE AND LOCATION OF TIBIOFEMORAL JOINT CONTACT FORCES DURING RUNNING

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Introduction: Approximately 30% of individuals over the age of 60 develop knee osteoarthritis (KOA), with prior knee injury, such as an Anterior cruciate ligament (ACL) tear, being a major risk factor [1, 2]. Modifying foot progression angle (FPA) has been proposed as a strategy to alter tibiofemoral (TF) joint contact loading; however, most studies have focused on walking and examined changes in load magnitude rather than spatial loading patterns [3,4]. Therefore, the purpose of this study was to investigate how FPA influences both the magnitude and distribution of TF joint loading during running. It was hypothesized that toe-in (TI) running would shift TF joint loading medially, and toe-out (TO) would shift loading laterally relative to baseline (BL).

Methods: 11 healthy runners completed three running conditions: BL, TI, and TO, with FPA self-modified by approximately ±10° relative to their natural running pattern. Motion capture and ground reaction force data were collected. OpensimJAM used static optimization and a 12-DOF elastic foundation knee model to estimate medial and lateral TF joint contact pressures and forces. Only 1 participant's data has been analyzed to date.

Results: TI produced the largest changes in loading relative to BL. Peak total TF contact force increased by 6% (3.8 vs 3.6 BW). At this instant, medial force decreased by 19 % (2.2 vs 2.8 BW), while lateral force increased by 88% (1.7 vs 0. 9 BW). These shifts were also evident in the pressure maps. TO running showed a similar trend to TI but with a smaller change, primarily in the lateral compartment (+15% vs BL).

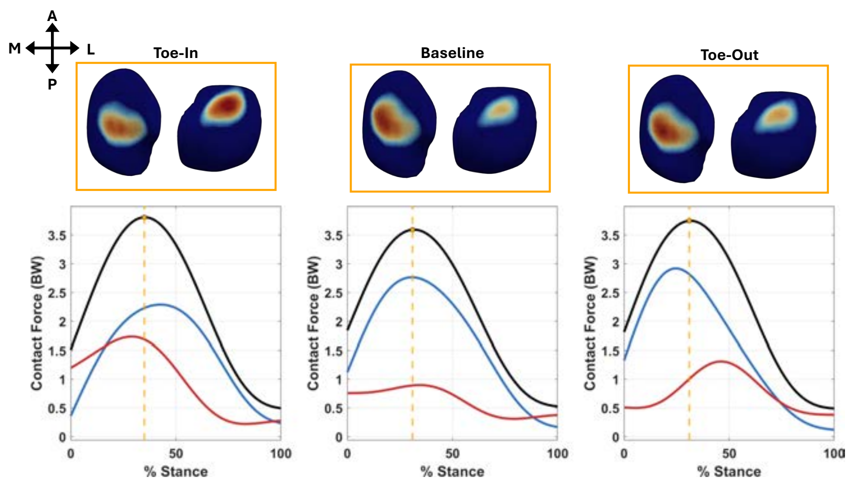

Figure 1: TF joint loading during TI, BL, and TO running. Top panels show pressure maps illustrating medial (M) and lateral (L) loading distribution. Bottom panels show TF contact forces across stance, normalized to body weight (BW), with total (black), medial (blue), and lateral (red) forces. The dashed line indicates the instant of peak total TF contact force.

Discussion and Conclusions: These preliminary findings suggest that modifying FPA during running can alter TF load distribution In this participant, TI produced the largest redistribution of load, while TO running showed smaller shifts. Further analysis across the full cohort is needed to determine whether these trends are consistent across participants.

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GAIT BIOMECHANICS AND T2 MRI OF TIBIOFEMORAL CARTILAGE 3 YEARS AFTER ACL RECONSTRUCTION

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Introduction: Anterior cruciate ligament (ACL) tears are treated through ACL reconstruction (ACLR) [1]. Despite success, 50-70% of patients develop osteoarthritis (OA) within 10-15 years [1]. Standard x-ray imaging is insensitive to cartilage changes that occur early in OA development, however, quantitative MRI (qMRI) T2 relaxation time is a more advanced technique, able to detect those changes before irreversible damage occurs [2]. Gait biomechanics, namely higher knee adduction moment (KAM) and lower knee extension moment (KEM), were shown to be associated with worsening cartilage health 6 months after ACLR [3, 4]. These early outcomes occur during a period of rehabilitation of the ACLR where biomechanics are still undergoing substantial changes. It remains unclear whether gait biomechanics is associated with cartilage health after the biomechanical changes are reaching a plateau [5].

Aim: The aim of this study is to determine the association between gait biomechanics and cartilage health 3 years post-ACLR.

Methods: Participants 3 years post unilateral ACLR aged 18-50 will be recruited. The sample size will be determined to achieve 80% power in a linear regression analysis. Gait kinematics and kinetics will be collected using motion capture cameras (VICON, USA) and a force plate (AMTI, USA), which will then be processed to calculate KAM and KEM. Bilateral knee scans will be taken on a 3T Siemens Magnetom Prisma and T2 qMRI, sensitive to extracellular matrix organization, will be acquired at 10 echo times between 9.7-97 ms [6]. ITK-SNAP software will segment the tibiofemoral cartilage into 12 anatomical regions of interest (ROI) (ITK-SNAP, USA). Voxel-wise exponential decay curves will be fitted for each ROI in MATLAB to generate T2 relaxation time maps [2]. An interlimb relaxation time ratio (ACLR/contralateral) will be calculated for each ROI where higher ratios are indicative of worse cartilage health [2]. To determine the association between biomechanics and interlimb relaxation time, a stepwise linear regression will be performed. The predictors will be KAM, KEM, potential meniscal injuries, and walking speed while the relaxation time ratios will be the dependent variable.

Expected Results: It is expected that higher KAM and lower KEM values are associated with higher T2 interlimb ratios and worse cartilage health.

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EFFECT OF FORCE APPLICATION DIRECTION RELATIVE TO LUMBAR CURVATURE ON SEGMENTAL STIFFNESS MEASUREMENTS

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Introduction: Posteroanterior spinal stiffness assessment using mechanical indentation has been used to quantify lumbar spine mechanical behavior in both research and clinical contexts [1,2]. Stiffness measurements are sensitive to multiple factors, including tissue properties, subject positioning, and loading profiles [5]. The influence of point of application directionality, however, remains unknown. Previous work has examined the effect of force direction in the sagittal plane [3,4], but it remains unclear whether applying force perpendicular to the ground (Ground) versus perpendicular to the spinal curvature (Spine) influences measured stiffness values. Given the inherent lordotic curvature of the lumbar spine, Ground force application may alter load transmission through spinal tissues, potentially affecting stiffness estimates. Understanding this distinction is important for improving the consistency and interpretation of spinal stiffness measurements across both biomechanical and clinical applications.

Aim: To determine whether lumbar segmental stiffness values differ when measured using Ground versus Spine orientated force applications at vertebral levels L1-L5. A secondary objective is to examine whether individual differences in lumbar curvature influences these measurements.

Methods: Twenty-two participants (11 male, 11 female) will undergo lumbar spinal stiffness assessment using a mechanical indentation system applied to the spinous processes of L1-L5. A controlled preload of 8 N and a maximum force of 80 N will be applied posteroanteriorly to each segment. Three trials will be completed at each vertebral level under two order randomized conditions: force applied perpendicular to the Ground, and force applied perpendicular to the lumbar Spine. Stiffness will be calculated from force-displacement relationships. A paired two-tailed Student's t-test will compare stiffness values between the two force application methods at each segment level.

Expected Results: Based on cadaveric response to tissue testing seen in previous literature, the Spine force application is expected to yield higher stiffness values than Ground application, particularly at the lower lumbar levels (L4-L5) where the lordotic curvature is most pronounced [3,4]. Understanding these effects may improve interpretation of spinal stiffness measurements and inform more standardized testing approaches in both research and clinical settings.

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VALIDATION OF THEIA 3D MARKERLESS MOTION CAPTURE FOR QUANTIFYING UPPER EXTREMITY KINEMATICS

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Introduction: Marker-based motion capture (MoCap) systems are widely regarded as the gold-standard for quantifying human kinematics. Markerless MoCap offers a promising alternative that addresses several limitations of common marker-based kinematics approaches. Despite its potential, research validating markerless MoCap for upper extremity kinematics remains limited. This study aims to evaluate the validity of novel markerless MoCap technology for estimating shoulder, elbow and wrist joint angles by comparing markerless (Theia3D) outputs with those from a marker-based system.

Methods: Kinematic data from 13 (5M,7F) participants were captured simultaneously with 10 Vicon and 8 Sony HD cameras. Each participant completed three identical sessions, which consisted of a series of range of motion (ROM) trials. Vicon Nexus and Theia3D were used to process, and Visual 3D was used to calculate upper extremity joint angles for the shoulder (3 degrees of freedom), elbow (2) and wrist (2). Two rotation sequences were used: XZY for shoulder flexion movements and ZXY for all other trials. RMSD and concordance correlation coefficients (CCC) were calculated between the Vicon and Theia time-series data, and ICC(3,1) was used to assess the consistency of ROM values across the three sessions.

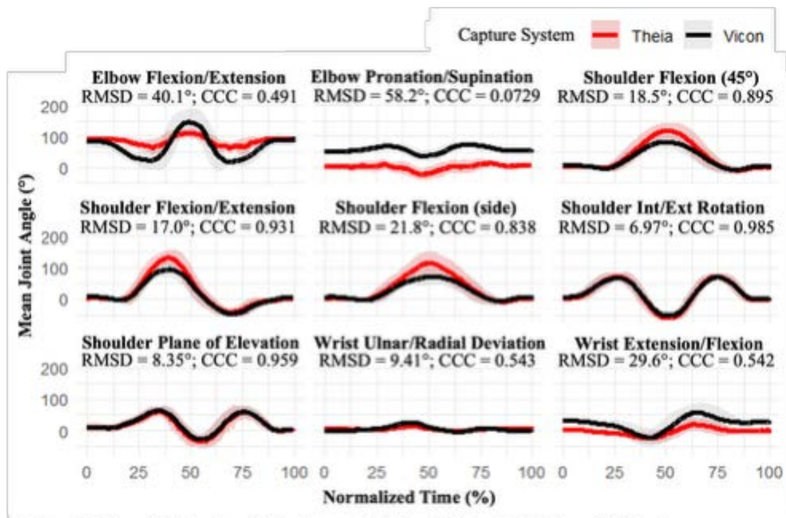

Figure 1: Comparing Theia 3D and Vicon mean joint angles of nine upper extremity movements, including RMSD and CCC values

Results: Results from nine right-arm ROM conditions are reported. Figure 1 shows the mean joint angles over time with RMSD and CCC values presented within each panel. The highest agreement between systems occurred in shoulder internal/external rotation (0.985), while the lowest correlation occurred for elbow pronation/supination (0.073). Theia showed higher ICC values for elbow flexion/extension (0.771) and shoulder plane of elevation (0.822) compared to Vicon (0.488 and 0.639, respectively), whereas Vicon produced higher ICCs for all remaining movements.

Discussion: These results show that Theia3D demonstrates strong agreement with traditional marker-based MoCap for several shoulder movements, although substantial differences remain for shoulder flexion movements (18.5°, 17.0°, 21.8°). Elbow and wrist motions also show lower agreement, indicating further refinement of markerless tracking for these joints is warranted. Advancing and validating Theia3D for shoulder, elbow, and wrist motions will be an important step in enabling markerless motion capture to play a larger role in upper extremity focused research.

TORQUE-MATCHED MOTOR POINT STIMULATION THERAPY ENHANCES CORTICOSPINAL EXCITABILITY

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Introduction: Functional electrical stimulation therapy (FEST) combines transcutaneous electrical stimulation with voluntary effort to promote neuroplasticity and functional recovery [1]. Conventional FEST typically uses a single electrode pair, which may constrain muscle recruitment due to spatially fixed activation and limiting torque generation. This generalized approach does not account for the heterogeneous organization of muscle and may fail to optimally engage neuromuscular pathways. In contrast, multiple motor point stimulation (mMPS) targets electrically sensitive regions within muscle, enabling greater and more spatially distributed recruitment and enhancing joint torque [2]. Beyond these neuromechanical benefits, mMPS may increase neural drive and more effectively engage corticospinal and spinal pathways. The purpose of this study was to determine whether mMPS therapy (mMPS with concurrent voluntary effort, mMPST) facilitates greater excitability in supraspinal and spinal levels compared with conventional single-electrode stimulation therapy (SEST).

Methods: Six healthy participants completed three conditions: mMPS, mMPST, and SEST. mMPS targeted seven quadriceps motor points, whereas SEST used a single electrode pair across the anterior thigh (40Hz, 400µs). Isometric knee extension torque quantified neuromechanical output, with therapy conditions performed submaximally. Electromyography was recorded from proximal vastus medialis and rectus femoris motor points. Corticospinal excitability was assessed via motor evoked potentials (MEPs) and spinal afferent excitability via posterior root muscle reflexes (pRMRs), measured at baseline and 20, 40, and 60 minutes post-intervention.

Results: mMPST increased rectus femoris MEPs, remaining elevated up to 1hr postintervention compared with SEST and mMPS. mMPS conditions produced more sustained corticospinal excitability than SEST. Vastus medialis pRMRs increased immediately following both mMPS conditions and remained elevated up to 1hr postintervention with mMPST.

Discussion/Conclusion: At matched torque, mMPST enhances corticospinal and spinal excitability compared with SEST, suggesting greater neuromechanical engagement despite equivalent mechanical output. These findings support mMPST as a promising strategy to improve the neuromodulatory effectiveness of FEST.

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SPINE EXTENSION IN DANCERS: DO DANCE POSES EXCEED VOLUNTARY RANGE OF MOTION?

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Introduction: Low back pain (LBP) is the leading cause of musculoskeletal pain worldwide [1], and is often caused by mechanical factors [2]. Compared to the general population, LBP is especially prevalent in dancers [3], who frequently perform movements involving repeated spine hyperextension in their training and performance [4]. However, little is known about the spinal extension range of motion (ROM) achieved by dancers, or the extent to which extension angles in dance poses approach or exceed maximal voluntary ROM.

Aim: This study aims to quantify and compare thoracic and lumbar spine ROM in dancers and non-dancers, as well as to determine the spine extension angles achieved by dancers during common dance poses.

Methods: Dancers and age-matched recreationally active non-dancers will be recruited. Electromagnetic motion capture sensors (Liberty, Polhemus, Colchester, VT, USA) will be placed along the spine at C7/T1, T12/L1, and L5/S1 to measure thoracic and lumbar ROM. Participants will complete a standardized ROM assessment including flexion/extension, lateral bending, and axial rotation. Dancers will then perform four extension-based dance poses in random order: bridge, cobra, arabesque, and attitude. Sensor data will be used to calculate segmental and global spine angles. Between-group differences in ROM will be evaluated using a one-way ANOVA. Within the dancer group, extension angles achieved during dance poses will be compared to maximal voluntary extension measured during ROM testing using a repeated-measures ANOVA.

Expected Results: It is anticipated that dancers will exhibit greater thoracic and lumbar ROM in both flexion and extension than non-dancers. Additionally, dancers are expected to exceed the maximum extension angle observed in the ROM assessment during the dance poses, suggesting that dancers place their spines at or beyond their measured maximal ROM while assuming various positions.

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UPPER-LIMB ROBOTIC ASSESSMENT OF COGNITIVE-SENSORIMOTOR INTEGRATION IN INDIVIDUALS WITH MULTIPLE SCLEROSIS

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Introduction: The execution of activities of daily living requires a close integration between sensorimotor and cognitive functions. In individuals with Multiple Sclerosis (MS), this affects both sets of functions. This leads to upper-limb impairments and cognitive deficits involving processing speed, attention, executive functions, and memory [1]. However, in clinical practice, these domains are typically assessed separately, limiting the understanding of their interaction. Robotic technologies enable quantitative assessment of upper-limb movements during cognitive task execution, allowing the investigation of cognitive-sensorimotor integration and related performance alterations [2].

Aim: This study aims to validate a robotic upper-limb cognitive-sensorimotor assessment system by evaluating its feasibility, its ability to discriminate between functional profiles, and the influence of cognitive processes on sensorimotor performance in individuals with or without MS.

Methods: 60 participants between 18 and 65 years old will be recruited for this study, consisting of 30 MS and 30 age-matched non-MS participants**.** They will use a robotic wrist device (EDUSA® PRO-R [3], Figure 1) that assesses wrist kinematics and provides visual feedback through a virtual reality environment. Participants will complete a one-day, 90-minute session consisting of an eligibility questionnaire, a brief familiarization session with the device, 8 robotic tasks, and 5 non-robotic cognitive tests, followed by self-assessment questionnaires related to participants' performance. The robotic tasks include 3 sensorimotor tasks assessing range of motion, motor performance, and proprioception, and 5 cognitive-sensorimotor tasks assessing attention, working memory, information processing speed, and cognitive flexibility during motor execution. The last non-robotic cognitive tests are administered in a cognitive-only context, allowing comparison between cognitive performance with and without sensorimotor interaction.

Figure 1: Memory task with EDUSA® PRO-R.

Expected Results: Individuals with MS are expected to show significantly different performance compared to age-matched unimpaired participants. The proposed system is expected to provide precise and quantitative measures enabling accurate characterization of impairment levels.

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DETERMINING INDIVIDUAL MUSCLE CONTRIBUTIONS TO FEASIBLE FORCE SETS: APPLYING FEASIBILITY THEORY TO SIMULATED SQUAT TASKS

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Introduction: Whole-body (WB) movement tasks require the central nervous system to coordinate many lower limb segments and muscles to produce endpoint forces against the environment (equal and opposite to ground reaction forces) for motion [1]. Individual muscle contributions to movement are difficult to quantify and interpret due to the complexity and high dimensionality of multi-joint, multi-muscle systems and high intra- and inter-individual variability, limiting our understanding of muscle coordination strategies [2]. Traditionally, optimization is used to reduce dimensionality and determine a single "optimal" muscle coordination pattern for a movement task given a pre-defined objective function [3]. Feasibility theory computes the set of all forces (i.e., the feasible force sets, FFSs) that can be produced at the limb endpoint in a given posture, while reducing dimensionality and encompassing all possible muscle coordination patterns [3]. By relating the mechanical work between internal and external degrees of freedom, individual muscle contributions to endpoint FFSs can be extracted [3].

Aim: To determine individual muscle contributions to lower limb endpoint FFSs in various simulated squat postures and evaluate the influence of muscle mechanical parameters.

Methods: In this simulation study, feasibility theory will be applied to a musculoskeletal model designed for high hip and knee flexion tasks [4]. Feasibility theory maps from muscle activation space to limb endpoint FFS (Figure 1) [3]. The FFSs will be computed across twelve distinct squat postures. Individual muscle contributions to FFSs will be assessed by systematically removing each muscle. A sensitivity analysis using Monte Carlo simulations will examine the influence of muscle mechanical parameters (i.e., maximum isometric force, normalized fibre length, tendon slack length, and moment arm) on muscle contributions to FFSs. The FFS size and shape, indicating the mechanical capability of the limb in the given posture, will be compared across conditions via support functions used in convex analysis.

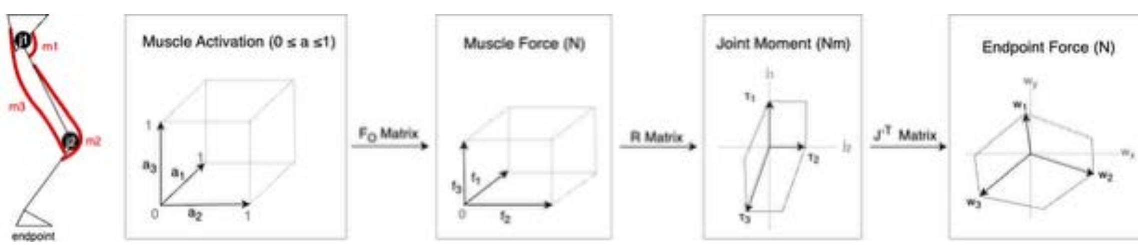

Figure 1. Example of mapping from high-dimensional muscle activation space (# dimensions = # muscles) to low-dimensional endpoint force space (# dimensions = # degrees of freedom) using feasibility theory. A simple planar, 2 joint, 3 muscle lower limb forward kinematics model is shown, mapping from muscle activation to muscle forces, joint moments, and the endpoint FFS via force capacity (*Fo*), moment arm (*R*), and Jacobian (J^{-T}) matrices.

Expected Results: Advanced understanding of individual muscles' capacity to contribute to WB movements, the influence of muscle mechanical parameters on these muscle contributions, and a novel framework for interpreting variability in muscle coordination patterns observed *in vivo*.

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EXAMINING AXIAL TORSION-INDUCED CHANGES IN THE INTERLAMELLAR MATRIX OF THE ANNULUS FIBROSUS

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Introduction: Intervertebral disc herniation is characterized by nucleus pulposus displacement through the annulus fibrosus (AF). During herniation, structural damage from the innermost to the outermost layers of the AF often results in interlamellar matrix degradation, ultimately contributing to delamination or separation between lamellar layers [1]. The interlamellar matrix plays a critical role in maintaining AF integrity by binding adjacent lamellae and resisting separation under loading, thereby contributing to disc stability and appropriate mechanical behaviour under physiological conditions [2]. While axial torsion has not been strongly linked to AF interlamellar matrix damage [3], the mechanisms underlying matrix degradation during torsional loading remain unclear. Axial torsion subjects the AF to combined tensile and shear stresses, increasing the likelihood of structural damage and fissure formation that may contribute to accelerated disc herniation [3].

Aim: To investigate how axial torsion affects the mechanical properties of the interlamellar matrix of the AF given its critical role in preventing IVD herniation.

Methods: Skeletally mature bovine caudal functional spinal units (FSUs) will be obtained from a single source to minimize biological variability. Bovine causal vertebrae lack facet joints, allowing for more uniform torsional load distribution. Specimens will be stored at −20°C and thawed at room temperature prior to testing. Once thawed, surrounding soft tissues will be removed and the two most caudal FSUs, with a thin muscle layer to avoid dehydration, will be excised. FSUs will be secured into a custom twist jig and then mounted in a uniaxial electromechanical materials testing system (model C43.304, MTS, Eden Prairie, MN). FSUs will be randomized into one of two loading protocols: 1000N static compression in a neutral posture or 1000N static compression with 12° of static axial torsion. Following loading, multilayered AF samples will be dissected and undergo lap shear testing to quantify interlamellar matrix strength.

Expected Results: It is anticipated that the interlamellar matrix of bovine caudal discs will be compromised following static axial torsion under compressive load and that a decrease in interlamellar matrix strength will be observed.

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THE INFLUENCE OF SUSTAINED MAXIMAL ISOMETRIC WRIST FLEXION AND EXTENSION ON ANTAGONIST MAXIMAL FORCE AND MUSCLE ACTIVITY

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Introduction: The wrist extensors of the forearm, which function as the primary wrist joint stabilizers, exhibit consistently high muscle activity during hand and wrist tasks, even when contracting as antagonists [1]. Despite this unique function, wrist extension fatigue and wrist flexion fatigue result in surprisingly similar motor performance impairments [2]. An improved understanding of how the wrist flexors and extensors function as antagonists during fatiguing contractions is needed to help clarify their impact on distal upper limb motor performance.

Aim: To determine how a sustained maximal isometric wrist flexion or wrist extension contraction influences antagonist maximal voluntary contraction (MVC) force and muscle activity.

Methods: Muscle activity was collected from the flexor digitorum superficialis (FDS) and the extensor digitorum (ED). Participants were seated with their dominant forearm secured in a custom device. For the sustained contraction, participants (with an open hand) exerted maximal isometric wrist flexion or wrist extension force (two separate sessions) down into a force transducer placed against their distal metacarpals until they could no longer maintain 25% of their pre-fatigue MVC. Participants then performed intermittent MVCs of the antagonist wrist action by either flexing or extending up into a second force transducer at 0, 1, 2, 4, 6, 8, and 10 minutes post fatigue.

Preliminary Findings: As anticipated, ED muscle activity appears to be significantly higher during sustained wrist flexion than FDS activity during sustained wrist extension (ED: 24.4 ± 13.1% of MVE, FDS: 4.0 ± 2.5% of MVE). However, despite this higher activity, the sustained contractions resulted in similar MVC force loss immediately after contraction cessation (Extension: 91.3 ± 6.6% of MVC, Flexion: 89.5 ± 9.6% of MVC) and on average throughout the post-fatigue MVCs (Extension: 94.6 ± 7.6% of MVC, Flexion: 91.7 ± 6.0% of MVC, Figure 1).

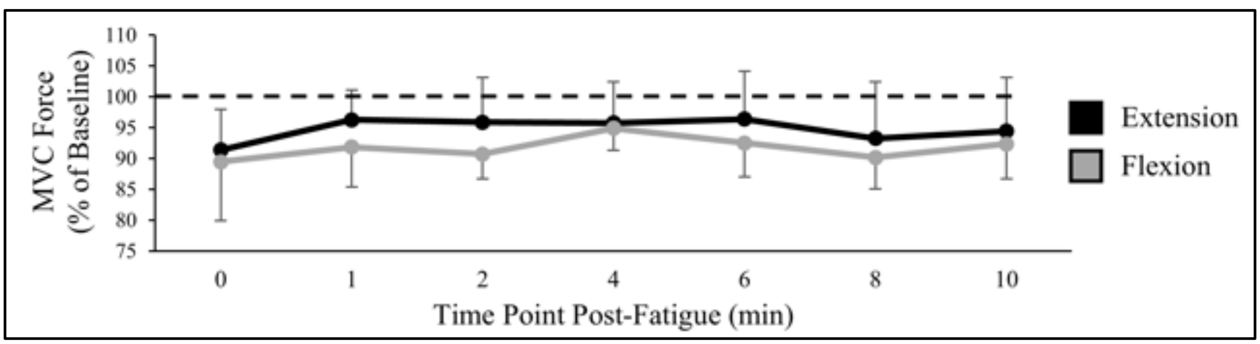

Figure 1: Group means ± SD (n = 13) for MVC forces (expressed as a percentage of baseline MVC force) performed at 0, 1, 2, 4, 6, 8, and 10 minutes post-fatigue. Black lines correspond to wrist extension MVCs, while grey lines correspond to wrist flexion MVCs. The dotted black line represents baseline (pre-fatigue) MVC force.

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A DOSE-RESPONSE STUDY OF CALCITONIN-MEDIATED REGULATION OF OSTEOCYTE AND OSTEOCLAST ACTIVITY IN OSTEOARTHRITIC BONE

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Introduction: Osteoarthritis (OA) is a progressive joint disease characterized by cartilage degradation and subchondral bone remodeling driven by dysregulated osteoclastogenesis. Calcitonin is a peptide hormone that suppresses osteoclast activity via calcitonin receptor activation on osteoclasts [1] and modulates osteocyte-derived sclerostin (SOST) expression, thereby influencing osteoblast-mediated bone formation [2,3]. Altering the balance between RANKL and its decoy receptor osteoprotegerin (OPG), calcitonin may indirectly regulate osteoclastogenesis [3]. Prior studies indicate that systemic calcitonin suppresses biochemical markers of bone resorption in a dose-responsive manner [4]. However, the longitudinal, dose- and time-dependent influence of calcitonin on osteocyte signaling and osteoclastogenic activity in human OA bone has not been examined [5]. A 3D-printed perfusion bioreactor system provides a controlled platform for calcitonin dose-response experiments.

Aim: To quantify the dose- and time-dependent effects of salmon calcitonin (sCT) on osteocyte signaling and osteoclastogenic activity in human OA trabecular bone.

Methods: Trabecular bone cores (10×10 mm) will be harvested from humeral heads of six patients undergoing shoulder arthroplasty (three healthy, three OA). Cores will be distributed across four treatment conditions: Control (no sCT), 0.1nM, 1nM, and 10nM sCT. Explants will be cultured in 3D-printed perfusion bioreactors under continuous media flow. Media will be collected at Days 0, 7, 14, and 21 and assayed for metabolic activity, cytotoxicity, TRAP activity, calcium release, and ELISA quantification of RANKL, OPG, and SOST. On Day 21, bone cores will undergo live/dead confocal microscopy, DNA extraction for total genomic content, and micro-CT imaging.

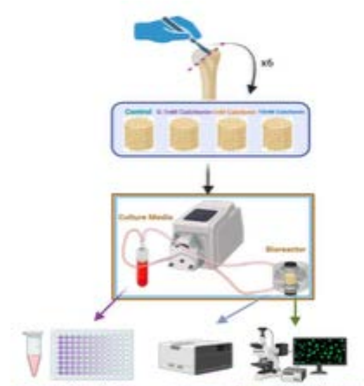

Figure 1: Study Methodology

Expected Results: We expect sCT to suppress osteoclastogenesis in a dose-dependent manner, evidenced by decreased TRAP activity, reduced calcium release, and a lower RANKL/OPG ratio [4,5]. Osteocyte-derived SOST is expected to increase relative to controls [2,3].

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THE INFLUENCE OF HIP EXTENSOR MUSCLE COORDINATION ON THREE-DIMENSIONAL HIP KINEMATICS & KINETICS DURING BODYWEIGHT SQUATS

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Introduction: The hip joint is essential in multi-joint control during whole-body movements, and regularly incurs large extensor demands. At the hip joint, gluteus maximus (GMAX) and the hamstrings muscle group (HAMS) are the most effective hip extensors.[1] However, GMAX also produces hip external rotation (ER) and abduction (ABD) while the HAMS cause hip internal rotation (IR) and adduction (ADD). Hip IR and ADD during dynamic tasks have been linked to numerous hip and knee musculoskeletal disorders.[2,3] Preferentially recruiting GMAX more than HAMS to meet hip extensor demands may avoid hip IR and ADD, reducing hip and knee joint loading. However, the mechanism by which coordination of the GMAX and HAMS influences hip joint motions and loading during whole-body, multi-joint movements is not yet understood.

Aim: This research seeks to investigate the relative activation of the GMAX and HAMS to determine its influence on hip kinematics and kinetics during a bodyweight squat task.

Methods: Kinematics, ground reaction forces, and hip muscle EMG will be collected from 24 participants during bodyweight squat tasks in the following ordered conditions: 1) non-cued; 2) cued GMAX; 3) non-cued (washout); and 4) fatigued GMAX. In the cued GMAX condition, participants will squeeze their glutes together, and isometrically push the feet against the floor laterally and towards ER, which has been shown to increase GMAX activation.[4] Participants' GMAX will be fatigued using an elevated isometric bilateral bridge with a resistance band around the distal thighs, shown to fatigue GMAX and not the HAMS in piloting (Fig. 1). GMAX fatigue will be confirmed by at least a 10% reduction in the mean power frequency of the EMG. GMAX and HAMS integrated EMG (iEMG), and hip ER and ABD net joint moment (NJM) impulse will be obtained by integrating linear enveloped EMG and NJMs over the descent phase of the squat tasks. Linear mixed-effects models will examine relationships between GMAX:HAMS iEMG ratios, frontal and transverse plane hip NJM impulses, and peak hip IR and ADD angles.

Expected Results: Compared with non-cued conditions, cueing and fatiguing the GMAX will increase and decrease relative GMAX-to-HAMS activation, respectively. Greater GMAX:HAMS iEMG ratios are expected to increase hip ER and ABD NJM impulses and decrease peak hip IR and ADD angles, whereas lower ratios are expected to decrease ER and ABD NJM impulses and increase peak IR and ADD angles.

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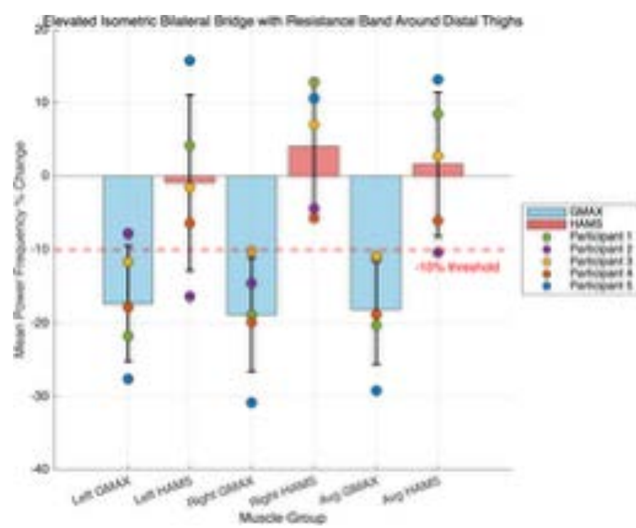

Fig. 1: Percent change in mean power frequency of the gluteus maximus and hamstrings following the elevated isometric bilateral bridge fatigue protocol.

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 how changes in activation topology relate to sensations of pain or tenderness [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 [2]. 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]. Pressure pain threshold (PPT) testing is commonly used to quantify localized muscle tenderness, but 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: 15 healthy young males 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 (i.e., location*visit).

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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EVALUATION OF LABRAL BEHAVIOUR FOLLOWING CAM OVER-RESECTION AND LABRAL RECONSTRUCTION: A SUBJECT-SPECIFIC FINITE ELEMENT ANALYSIS STUDY

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[2]Robarts Research Institute

Introduction: Femoroacetabular impingement (FAI) is a hip joint abnormality characterized by pathological contact between the femoral head and acetabulum, frequently resulting in labral damage and early-onset osteoarthritis [1]. Surgical cam resection aims to restore physiological joint mechanics; however, over-resection has been linked to reduced hip stability and poor clinical outcomes [2]. Labral reconstruction is often performed to mitigate these effects, yet the mechanical environment of the reconstructed labrum remains poorly understood. Finite element analysis (FEA) offers a framework for evaluating the mechanical consequences of these interventions, though its application to thin, complex anatomical structures such as the acetabular labrum remains a significant challenge.

Methods: High-resolution computed tomography (CT) scans from a cadaveric hip specimen were acquired in the native and reconstructed labrum conditions across multiple joint configurations, including flexion (0°, 60°, 90°) and axial rotation (internal, neutral, external) [3]. Anatomical structures were segmented in Simpleware and reconstructed into three-dimensional solid meshes, which were imported into Abaqus for FEA. Material properties were assigned based on literature values, physiologically relevant boundary conditions were implemented, and a common load was applied across iterations. Mesh quality was systematically evaluated to identify regions of element distortion, and refinement strategies were implemented to improve numerical stability. Pending convergence, simulations will quantify labral stress distributions across all configurations.

Results: Initial simulations yielded elements with small or negative volume. Comparative assessment of mesh structure revealed consistent patterns of distortion localized to regions of high curvature and thin geometry, with increased prevalence in configurations involving greater flexion and internal rotation. These regions of poor element quality are consistent with areas where high stress gradients would typically be expected in finite element analysis, and thus elevated stress values are expected in these localities with convergence of the model.

Discussion and Conclusions: These findings highlight the critical influence of mesh quality and geometric representation on the stability and reliability of subject-specific FEA of the acetabular labrum, with regions of numerical instability likely corresponding to areas of high stress gradients. Preliminary results further suggest that cam over-resection with labral reconstruction may increase localized mechanical demand across joint configurations, particularly under high flexion and internal rotation. Collectively, this work underscores the importance of optimized meshing strategies, element formulation, and geometric preprocessing for the accurate simulation of thin fibrocartilaginous structures, while demonstrating the potential of this framework for future analysis of labral mechanics.

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COMPARING JERK EXPOSURE AND PERCIEVED DISCOMFORT DURING MANUAL AND POWERED STAIR CHAIR CONVEYANCE

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Introduction: Paramedics are at an increased risk of injury due to repetitive patient transfers using stair chair equipment [1]. While previous work has found that powered devices decrease operator injury risk compared to manual devices, the choice to select a lift assist device within the paramedic field is also influenced by factors such as patient comfortability [2,3]. Jerk has been used in the design of passenger-carrying systems as it captures the rate of change of acceleration and may be a useful metric relating to discomfort. The purpose of this study was to (1) examine whether jerk exposure predicts patient discomfort ratings during stair chair conveyance, accounting for chair type, task type, and age cohort, and (2) explore factors contributing to chair preference from user feedback.

Methods: A cohort of 22 younger (24 yrs ± 2.7) and 12 older (69 yrs ± 6.0) adults were conveyed through stair conveyance tasks in a manual and powered stair chair. An Inertial Measurement Unit (Noraxon USA Inc., Scottsdale, AZ, USA) was placed on the participants sternum to characterize jerk. Participants used the CP-50 scale to characterize their discomfort. Post conveyance interviews were conducted to explore factors contributing to chair preference which were analyzed using thematic analysis. Time-series acceleration data from each trial were filtered and mean and RMS jerk were calculated. Linear mixed effects models were used to test whether jerk was related to CP-50 after accounting for chair type, task type, and age group.

Results: Mean ($df = 118.9$, $R^2 = 2.5$, $p = 0.23$) and RMS ($df = 112.1$, $R^2 = 1.4$, $p = 0.32$) jerk were not related to discomfort. There was a significant group x chair interaction in both models indicating that the older group responded differently in the powered chair. Within group simple effects pairwise comparisons between chair type indicated that both groups showed a significant decrease in CP-50 while in the powered chair (Younger: 8.14 ± 8.37; Older: 2.07 ± 7.78) compared to the manual (Younger: 14.13 ± 8.33; Older: 13.38 ± 7.86), however the older group CP-50 decreased by 8.75 points more than the younger group ($t = -2.85$, $p = 0.005$). Post conveyance interviews indicated that 94% (32/34) of participants preferred the powered device. The thematic analysis suggested that this preference was due to factors such as positive sensory experiences, decreased perceived operator effort, and a wider physical interface.

Discussion and Conclusions: Jerk did not appear to influence CP-50 score; however, the powered chair showed a decrease in CP-50 despite having the same Mean jerk. The thematic analysis may provide further insight into this decrease as perceptions of comfort and chair preference aligned with psychological factors rather than a mechanical influence.

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TRP'D UP: TOPICAL MENTHOL AND CAMPHOR ALTER ANKLE PROPRIOCEPTION

Ashley V. Vanderhaeghe[1] Laura C. Marrelli[1], Tushar Sharma[1] Luke Cleland[1], Leah R. Bent[1]
[1]Human Health Sciences, University of Guelph, Guelph, ON

Introduction: Proprioception refers to the body's ability to sense its position and movement in space [1]. Cutaneous mechanoreceptors contribute to ankle position sense, critical for balance. Temperature can modulate cutaneous feedback, where heating increases afferent sensitivity and cooling reduces it [2]. These changes in cutaneous information may be mediated by temperature-dependent changes in blood flow and/or activation of thermosensitive transient receptor potential (TRP) channels in the skin. TRPV3/4 channels can be activated by heat and compounds such as camphor, while TRPM8 responds to cooling and menthol [3]. Although it has been demonstrated that external heating and cooling influence proprioception, it remains unclear whether chemical activation of TRP channels produces similar effects. Therefore, this study examined the effects of menthol and camphor on ankle proprioception during passive joint position matching (JPM).

Methods: Thirteen (8F; 23.6 ± 2.7 years) participants performed a passive JPM task across three days, receiving either sham, 10% menthol, or 10% camphor on the dorsum of their test ankle across 3 separate days. The target and matching ankle started at a consistent neutral position before each trial. Practice and baseline trials were performed prior to intervention. Following cream application, the target ankle was rotated to 6° of dorsiflexion (DF), 6°, 12°, and 18° of plantarflexion (PF), in a random order. The participant's matching ankle was passively moved until indicated that the angle felt the same as the target ankle. Twenty-four trials were performed 4 angles by 3 time points: 10, 20, and 30 minutes, block randomized by angle. Absolute and directional error were assessed.

Results: A three-way repeated-measures ANOVA (3 creams x 4 angles x 3 times) for absolute error revealed no significant main effects or interactions. Based on a priori hypotheses, data were collapsed across joint angle, and a significant main effect of cream was observed ($p = 0.010$).The post hoc (Bonferroni) revealed increased error in the menthol condition compared to sham ($p = 0.014$). A significant main effect of time was also found ($p = 0.018$), specifically seen with an increase in error from 20 to 30 minutes ($p = 0.005$). Similar to absolute error, directional error showed no significant effects in the three-way analysis; however, when collapsed across angle, a significant cream × time interaction emerged ($p = 0.019$), with increased error in the menthol condition from 20 to 30 minutes ($p < 0.001$). No significant effects were observed for camphor.

Discussion and Conclusions: Collectively, these findings indicate that topical menthol produces a time-dependent degradation of ankle proprioceptive accuracy across a range of angles. The increase in proprioceptive error at 20–30 minutes coincides with the time-dependent activation of TRPM8 channels by menthol, leading to alterations in cutaneous afferent input [4]. The underlying channel-driven mechanism requires further investigation and may inform future work exploring chemical modulation of proprioception. Significance: These results inform clinical use of topical creams at the ankle, suggesting that these products should be used with caution.

References:[1] Moon MM et al. (2021). *BMB Rep* 54(8); p. 393–402. [2] Schlee G et al. (2009). *Clin Neurophysiol* 120(8); p. 1548–1551. [3] Lei J & Tominaga M (2025). *J-Stage* 75(1); p. 100005. [4] Namer, Bastian et al. (2005). *J Neurophysiol* 94(6); p. 3795–3801.

MUSCLE-BONE INTERACTIONS IN SHOULDER OSTEOARTHRITIS: A QUANTITATIVE CT STUDY OF AGE, SEX AND DISEASE PROGRESSION

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

Introduction: Shoulder osteoarthritis (OA) is a multifactorial condition affecting cartilage, bone, and surrounding soft tissues, often resulting in pain, functional decline, and surgical intervention. While rotator-cuff muscle quality and bone density are both critical to shoulder mechanics and clinical outcomes, they are typically studied in isolation using semi-quantitative or indirect measures. Consequently, the relationship between muscle degeneration and regional bone quality across the progression from non-OA to end-stage OA shoulders remains poorly understood.

Aim: The aim of this study is to quantify how rotator-cuff muscle density and fatty infiltration vary with age, sex, and disease status, and to assess their relationship with glenoid and proximal humeral volumetric bone mineral density (vBMD) using quantitative computed tomography (CT).

Methods: A retrospective CT-based design will be used, including a non-OA cohort (n = 200) of adult men and women spanning the adult lifespan and an end-stage OA cohort (n = 200) consisting of pre-operative clinical scans. The supraspinatus, infraspinatus, and subscapularis muscles will be segmented using semi-automated methods to extract muscle density and fatty infiltration based on Hounsfield Units. Glenoid and proximal humeral regions will be segmented using anatomically defined regions of interest, and vBMD will be estimated using a phantomless internal calibration approach. Multiple linear regression will be used to evaluate associations, with age treated as a continuous variable and sex and OA status included as covariates.

Expected Results: It is hypothesized that muscle density will decrease and fatty infiltration will increase with age in non-OA shoulders, while end-stage OA shoulders will demonstrate lower muscle density, higher fatty infiltration, and lower vBMD, along with altered muscle–bone relationships.

CAUTION UNDER VISUAL COMPLEXITY:
REDUCED SPEED AND SAFETY MARGINS USED IN VIRTUAL NAVIGATION

Emily Marino[1], Kristen De Melo[1], Lori Ann Vallis[1]
[1]Department of Human Health Science, University of Guelph, Guelph, ON

Introduction: Visual information is critical for guiding safe locomotion, particularly when navigating complex environments or responding to conflicting visual cues [1]. This study presented a modified cognitive Simon Task within a dual-task paradigm [2] designed to investigate how spatial cues influence visually guided locomotion in two different virtual environments.

Methods: Participants (n=24; 12 M; age 21.7 ± 2.9 years) with no history of impaired cognitive function/physical impairments were fitted with a HTC Vive Pro 2 Virtual Reality (VR) headset (HTC Corporation, Taiwan) and retroreflective markers (OptiTrack, 120 Hz; Corvallis, USA) and instructed to walk through two VR environments (trail; hallway) while avoiding a virtual sinkhole. Direction of transient changes around the sinkhole were cued by arrows that appeared at the top of the virtual scene in one of three locations: congruent (e.g. leftward arrow on left side of screen), incongruent (e.g., leftward arrow on right side of screen) or neutral (center of the screen). We hypothesized that a complex visual environment (trail) and incongruent visual cues would yield cautious gait patterns, e.g. reduced velocity and smaller clearance of the sinkhole.

Results: Significant interaction effects ($p<0.05$) of environment and visual cue were observed for center of mass (COM) velocity and maximum perpendicular distance (MPD) from sinkhole. Post-hoc testing revealed reduced COM velocity (*not shown*) and reduced MPD in the complex (Trail) visual environment (Figure 1). Incongruent cues further contributed to cautious gait patterns.

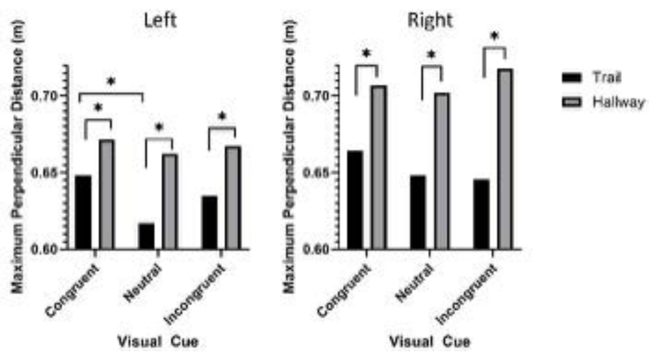

Figure 1. Mean maximum perpendicular distance (m) for both cue directions. An interaction effect of environment and visual cue ($p< 0.05$) was observed.

Discussion: Findings suggest visual complexity and visual cues encourage a more cautious gait under dual task conditions, as shown in part by reduced COM velocity. Additionally, decreased MPD indicates impaired obstacle avoidance and altered route planning strategies. These findings highlight the important role of cognition in response selection during locomotion. Increased perceptual demands can impair movement planning, with implications for fall risk and safe navigation in complex real-world environments [2]. Future work will examine training strategies to enhance dual-task performance in older adults, whose falls risk is elevated [3].

References:

[1] Matthis, J et al. (2017). *Proceedings of National Academy of Sciences.* 114(32) E6720-E6729
[2] Pitman, J et al. (2025). *Journal of Motor Behavior*. 57(4); p. 431-443
[3] Zhou J et al (2023). *Lancet Healthy Longevity*. 4(3):e98-e106.

Poster Session 2

Thursday May 21 (6:00PM – 7:00PM)

Poster #	Name	Affiliation	Title
1	**Molly Malette**	McMaster University	Effects of Mental Fatigue on Muscle Activity and Performance
2	**Sadie Finch**	University of Waterloo	Trunk Position Influence on Biomechancial Demand Distribution
3	**Tom Boers**	Western University	The Influence of Age and Competition Level on Ankle Stiffness During Running
4	**Travis Winteler**	Brock University	Forearm Muscle Activity During Grip Strengthening Exercises
5	**Derrick Lim**	University Health Network	Muscle Recruitment Using Conventional FES and Spatially Distributed Sequential Stimulation
6	**Claudia Hall**	Wilfrid Laurier University	Cyclic Flexion and Disc Mechanics
7	**Mitchell Brydon**	Wilfrid Laurier University	Chronic Ankle Injury and Orthotics
8	**Aurora Battis**	Brock University	The Effects of Skin and Muscle Targeted Vibrotactile Feedback on Standing Balance and Postural Control
9	**Tyler Brown**	Brock University	Measuring Hand force s for Automotive Assembly
9	**David Imeson**	University of Waterloo	Effects of Ladders on Manual Materials Handling
11	**Harish Balasubramanian**	Wilfrid Laurier University	Low Back Pain and Orthotics
12	**Faris Ibrahim**	Western University	Influence of Biological Sex on Dynamic Lumbar Spine Stability Following Trunk Muscle Fatigue
13	**Madi Hunter**	Brock University	Two Person Nurse Patient Handling
14	**Melanie Altamirano**	Brock University	Sex Differences in forearm Motor Unit Properties
15	**Erinn McCreath Frangakis**	Waterloo	Spinal Stiffness Variation by Lumbar Vertebral Level
16	**Stephanie DiNunzio**	University Health Network University of Toronto	A Wearable E-Textile Neuroprosthesis
17	**Ainsley Durnin**	University of Waterloo	Uniarticular and Biarticular Muscle Function During Squat Tasks

18	**Aliza Siebenaller**	University of Guelph	Spinal Deformity and Muscle Degeneration
19	**Joanna Misquitta**	McMaster University	The Influence of Height and Sex on Two-Person Team Lifting
20	**Peter Ditner**	University of Windsor	Assessment of the Efficacy of a Powered Back Support Exoskeleton for Home Health Care Patient Transfers
21	**Ethan Brito**	Ontario Tech University	Effects of DPI Mouse Settings on Upper Limb Range of Motion
22	**Jamie Biggar**	University of Windsor	Differences in Head Impacts Across Age Divisions in Youth Hockey
23	**Renée Hachey**	Queen's University	Predicting Running Fatigue with Smartwatch Data
24	**Rayna Ghosh**	University Health Network	Internal Gait Perturbation Using Dysfunctional Functional Electrical Stimulation
25	**Adam Highfield**	Brock University	Human to Humanoid Gait Reproduction and Perception
26	**Kate Posluszny**	University of Waterloo	Personal Support Workers' Lumbar Extensor Moments
27	**Kate Krivenko**	Waterloo	Examining the Changes in Passive Tissue Properties of the Lumbar Spine Following a Single Sitting Bout and Active Recovery
28	**Daniel Cousins**	Brock University	Electrode Placement Techniques for forearm Electromyography
29	**Danielle Peters**	University of Waterloo	Ultrasound Shear Wave Elastography: Standoff and Orientation Effects
30	**Areeba Anwer**	McMaster University	Stroke Rate and Drag Factor Influence Power and force During Ergometer Rowing
31	**Kayli Machura**	Western University	Lumbar Erector Spinae Activation Patterns Using High-Density Surface Electromyography
32	**Ellora Khandekar**	University Health Network	Developing Patient Education Materials to Aid the Informed Consent Process for Biomechanics Studies
33	**Deeksha Kumar**	Wilfrid Laurier University	Flexion-Induced Creep Alters Annulus Mechanics
34	**Lea Gerditschke**	Trent University	The Influence of Resistance Training Status on forearm Muscle Activity, Wrist Kinematics, and Revised Strain Index Scores During Simulated Painting and Tarping Tasks
35	**Elizabeth Pirritano**	Brock University	Foot Core Adaptations in Adolescent Ballet Dancers: Effects of Pointe Training and Sport Specialization
36	**William Lowrie**	Queen's University	Does Early Functional Electrical Stimulation Improve Gait Biomechanics After Anterior

			Cruciate Ligament Reconstruction? a Pilot Randomized Controlled Trial
37	**Mohammadreza Kheshti**	Western University	Labral Mechanics After Femoroacetabular Impingement (Fai) Related Surgery
38	**Joti Hundal**	University of Waterloo	Developing a Digital Reconstruction Framework for Fragmented Hominin Scapulae
39	**Laura Marrelli**	University of Guelph	Heel Cutaneous Stimulation on MU Behaviour During Sustained Plantarflexion
40	**Logan McDonald**	Trent University	Investigating the Association Between Progressive Forearm Fatigue Development and Isometric Wrist Force Accuracy
41	**Rosalyn Roth**	Waterloo	The Influence of Indenter Head Design on Spinal Stiffness Measurement and Repeatability
42	**Hunter Schulz**	Western University	Preventing Musculoskeletal Disorders in Ophthalmologists: Evaluating Ergonomic Slit Lamp Designs
43	**Ben Mazin**	McMaster University	Common Risk Factors Between MSD and Psychological Outcomes
44	**Ella Rae**	Trent University	Comparing forearm Muscle Activity, Wrist Kinematics, and Revised Strain Index Scores Between Resistance-Trained and Untrained Individuals During a Simulated Tire Change Task
45	**Jameson Vanstone**	University of Waterloo	Validation of Xsens Low-Back Kinematics
46	**Mara Girleanu**	McMaster University	Clusters of MSD Psychosocial Factors
47	**Soheila Moradi**	University of Waterloo	Exacerbation of Patellofemoral Pain Alters Knee Joint Mechanics
48	**Yuechen Liu**	Carleton University	Feasibility of Stress Monitoring During Student Exams
49	**Isabella Tierney**	University of Waterloo	Development of a Hill-Type Shoulder Muscle Model
50	**Hayden Hartwick**	University of Windsor	Head Impact Speeds and Player Anticipation in Youth Hockey
51	**Umar Yousufy**	Brock University	Understanding the Role of the Foot Core System in Countermovement Jump Performance
52	**Maya Pappas**	Wilfrid Laurier University	Effects of Lower Limb Fatigue on Balance During Foot Contact Perturbations
53	**Mary Robakowski**	University of Waterloo	Clincal-Microct Image Registration
54	**Jordan Rogers**	Brock University	Effects of a Single Session of Neuromuscular Electrical Stimulation to the Tibialis Anterior on Balance Control

Effects of Mental Fatigue on Muscle Activity and Performance During Dynamic Pushing

Molly E. Malette, Ryan Chhiba, Peter J. Keir
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Introduction: Mental fatigue has been shown to impair physical performance by elevating muscle activity and reducing task accuracy, which may increase injury risk in the workplace [1]. Modern work environments often require sustained attention, multitasking, and fast-paced work, yet the combined impact of cognitive demands and physical effort on task execution and muscle activity is not well understood. A recent study in our lab found increased muscle activity without noticeable visual changes in performance [2]. This study aimed to quantify the influence of mental fatigue on task accuracy and muscle activity during four dynamic pushing tasks.

Methods: Twenty-two participants completed four dynamic pushing tasks with and without mental fatigue. Participants watched a documentary and completed the protocol, followed by a Stroop task to induce mental fatigue, after which the protocol was repeated. Tasks required cyclic pushing of handles between predefined close and far target positions with 2.5 kg of resistance on each handle for 60 s. The four conditions were: (i) 15 cycles/minute, (ii) 30 cycles/minute, (iii) 15 cycles/minute with 30% handgrip, and (iv) 30 cycles/minute with 30% handgrip. Participants were instructed to reach target positions accurately without over or undershooting. EMG was collected bilaterally from seven upper-extremity muscles, along with right hand grip force, displacement, and ratings of both perceived exertion and mental fatigue.

Results: Participants reported higher levels of mental fatigue in the Stroop condition across all tasks. No differences in muscle activity between conditions were observed (e.g. mean right triceps EMG during the 30 cycle/min gripping task: documentary 5.57 ± 3.92 vs. Stroop 6.00 ± 3.86 %MVE). However, trends in task performance were observed. Participants demonstrated a slight increase in task accuracy under the Stroop condition, reflected by a higher proportion of movements reaching the target without overshooting. Additionally, differences in timing were observed, with participants in the control condition tending to reach the target earlier, whereas in the Stroop condition timing was closer to the intended rhythm.

Discussion: Contrary to our previous work [2], mental fatigue did not lead to increased muscle activity or decreased performance. Participants demonstrated better targeting accuracy and timing under the Stroop condition, although these effects were not statistically significant. Specifically, participants appeared to be more vigilant, with slower movement and less overshooting. Previous research has highlighted that mental fatigue can be mitigated when motivated, especially via feedback [3]. The nature of the tasks, including the constrained motion with defined targets and constant visual feedback, may have negated the anticipated effects of mental fatigue. These findings highlight that the effects of mental fatigue may depend on the nature of the task. Constrained tasks may act to mitigate the effects of mental fatigue, while more open-ended tasks may be susceptible to increased muscle activity and increased risk of musculoskeletal disorders.

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THE INFLUENCE OF TRUNK POSITION ON BIOMECHANICAL DEMAND DISTRIBUTION ACROSS THE TRUNK- LOWER EXTREMITY DURING WHOLE-BODY MOVEMENTS WITH INCREASING MECHANICAL DEMANDS

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Introduction: Goal-directed whole-body (WB) movement tasks have a fundamental mechanical objective which must be met for successful task performance. WB movements generated by the lower limbs can be achieved using a multitude of multi-joint control strategies due to the numerous degrees of freedom in the musculoskeletal system [1]. Owing to its large mass, trunk position is an important factor during WB movements and has been shown to alter lower extremity joint kinetics during dynamic activities [2,3]. However, the effect of trunk position on the distribution of biomechanical demands during tasks with varying WB demands remains unknown.

Aim: To investigate how trunk position modulates the distribution of biomechanical demands across the trunk-lower extremity linkage, in tasks with increasing WB mechanical demands.

Methods: Four WB movement tasks with increasing mechanical demands will be performed: bodyweight squats, squat jumps, countermovement jumps, and drop vertical jumps. Tasks will be performed in three trunk positions: natural, inclined, and upright, with motion coached to be at the level of the hip. The tasks and conditions will be block randomized, with the natural trunk conditions performed first so that the altered trunk positions do not affect the participants' natural movement. A passive motion capture system (Qualisys, Göteborg, Sweden) will collect full-body kinematics while two in-ground force plates (AMTI, Watertown, Mass, USA) measure ground reaction forces (GRFs) and moments. Ankle, knee, hip, and lumbar spine net joint work (NJW) will be calculated as the time integral of net joint power (dot product of net joint moment and joint angular velocity), along with WB center of mass (WB-COM) work (time integral of the dot product of GRFs and WB-COM velocity). NJW incorporates 3D kinematic and kinetic joint measures into a single scalar variable, reducing dimensionality. Lumbar spine and bilateral hip, knee, and ankle NJW contributions to WB-COM work will be used to quantify biomechanical demand distribution.

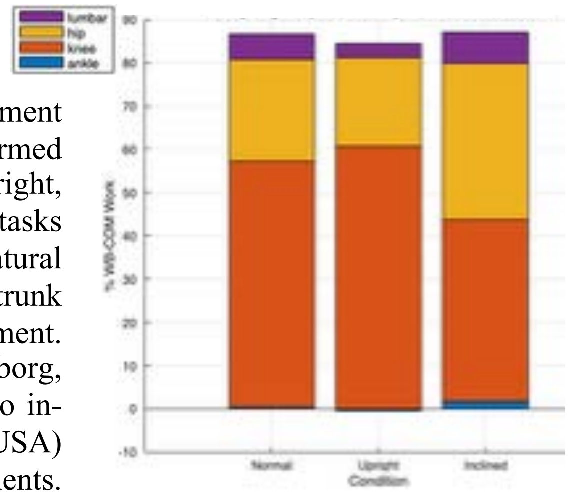

Fig. 1 - Ascent phase of a bodyweight squat

Expected Results: We hypothesize that altering trunk position will modulate joint contributions to WB-COM work, with greater differences observed in more demanding tasks. Specifically, anterior trunk inclination will increase hip joint contributions, while an upright trunk will increase knee joint contributions (Fig. 1). This research will advance mechanistic understanding of how trunk position influences biomechanical demand distribution during movements with varying WB demands, while providing a foundation for future investigations into neuromuscular control, muscle contributions to movement, multi-joint coordination, and joint loading during WB tasks.

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THE INFLUENCE OF AGE AND COMPETITION LEVEL ON ANKLE STIFFNESS DURING RUNNING

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Introduction: The plantarflexors play a key role in gait, with ankle stiffness uniquely contributes to force attenuation and propulsion [1]. Aging is associated with a decrease in plantarflexor function and ankle stiffness [2]. While recreational running does not protect from the age-related decline in musculoskeletal function, faster running speeds/interval training may help to maintain ankle function throughout the lifespan [3]. This study assessed the influence of age and competition level on ankle stiffness during running.

Methods: 32 participants were stratified into age (Younger = 18-30, Older = 40-60 years) and competition level groups (Younger Recreational = 9, Younger Competitive = 10, Older Recreational = 7, Older Competitive = 6). Three-dimensional running biomechanics were captured using a force-instrumented treadmill and an 8-camera motion capture system during two 10-minute bouts of running at a self-selected and standardized speed (3.33m/s for males and 2.66m/s for females). Ankle stiffness was calculated as the slope of the ankle moment–angle relationship across early and late stance and normalized to height (m) and body weight (N) (Figure 1). Separate 2 (age) by 2 (competition level) ACOVA models (covaried for sex) compared absorptive and propulsive ankle stiffness during standardized and self-selected speed running.

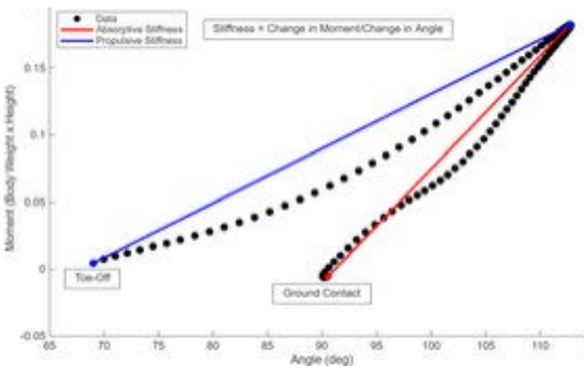

Figure 1: Ankle Angle-Moment relationship during the stance phase of running. Ankle stiffness was calculated as the slope of the moment–angle relationship, with absorptive stiffness shown in red and propulsive stiffness in blue.

Results: During the standardized speed run, after adjusting for sex, older runners had greater absorptive ankle stiffness than younger runners regardless of competition group ($F(1, 27) = 6.08$, $p = .020$, $\eta p^2 = .184$), while competitive runners had greater propulsive ankle stiffness than recreational runners regardless of age ($F(1, 27) = 5.99$, $p = .021$, $\eta p^2 = .182$). During the self-selected speed run, after adjusting for sex, competitive runners had greater propulsive ($F(1, 27) = 9.345$, $p = .005$, $\eta p^2 = .257$) and absorptive ($F(1, 27) = 5.442$, $p = .027$, $\eta p^2 = .168$) ankle stiffness than recreational runners regardless of age.

Discussion and Conclusions: Aging and competition level influence ankle function during distinct phases of stance. Results have implications for both performance and injury risk during running, because greater propulsive ankle stiffness may facilitate more efficient gait, while greater absorptive ankle stiffness may be associated with bone stress injuries.

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FOREARM MUSCLE ACTIVITY DURING GRIP STRENGTHENING EXERCISES

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Introduction: Damage to the Ulnar Collateral Ligament (UCL) is a common injury amongst baseball pitchers. Due to the high volume and repetition of pitches, an increased load is placed on the UCL once the forearm muscles begin to fatigue [1]. To counteract the load placed on the UCL, the flexor digitorum superficialis (FDS) supports the UCL by countering elbow torque [2]. However, it is difficult to measure individual finger flexor compartments of FDS with surface electromyography. This study aimed to assess the effect of grip strengthening devices on forearm muscle activity while exploring the use of motor point detection to measure activity of each individual FDS finger compartment.

Methods: 10 university aged adults (6M/4F 22 ± 1.6 years) completed a repeated measures protocol involving 3 grip devices: Grip Master, Handexer, and FlexPro Grip. Participants performed gripping tasks with both a maximal and submaximal intensity. Pediatric sized Ag/AgCL electrodes (Grass Technologies, USA), with an 11 mm interelectrode distance, were applied over flexor carpi ulnaris/radialis (FCU/FCR) and compartments of FDS. The location of each FDS compartment (index, middle, ring, little) was determined via stimulation to find the motor point by applying a low-intensity electrical stimulation to the muscle. Data were sampled at 2000Hz, linear enveloped at 6Hz and normalized to maximal voluntary contractions (MVC). Average muscle activity was determined during contractions and compared across conditions.

Results: The maximal grip intensity yielded significantly greater muscle activity than the submaximal intensity for all muscles (Figure 1). The main effect of exercise was not significant for any of the muscles. Muscle activity in the FDS compartments across all conditions is listed lowest to highest: ring (35.1 ± 12.1 %MVC), index (46 ± 19.9 %MVC), middle (47.3 ± 22.9 %MVC), and little finger (49.6 ± 20.2 %MVC).

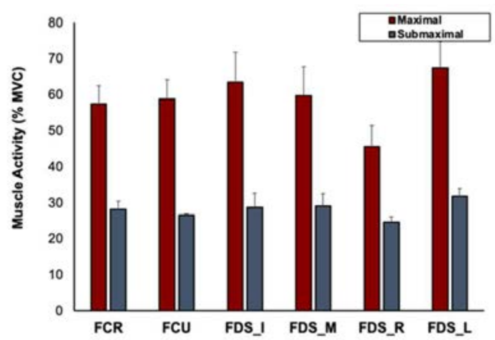

Figure 1: Average muscle activity for maximal and submaximal tasks.

Discussion and Conclusions: Grip device did not influence muscle activity of the FCR, FCU, and FDS. Our motor point approach to finding FDS compartments was critical for minimizing forearm muscle crosstalk. The FDS provides elbow stability [1] and has lacked investigation due to measurement complexity. Many variables influence muscle development, and the idea that higher activity directly relates to gains in strength or hypertrophy should be treated with caution [3].

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MUSCLE RECRUITMENT USING CONVENTIONAL FES AND SPATIALLY DISTRIBUTED SEQUENTIAL STIMULATION IN THIGH MUSCLES

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Introduction: Functional electrical stimulation (FES) elicits artificial muscle contractions, enabling individuals with spinal cord injury (SCI) to regain functional movements. FES applied to the quadriceps femoris (QF) and hamstrings (HAM) is commonly used in interventions such as FES cycling and rowing to promote cardiovascular and muscular health. Standard FES protocols typically involve placing a pair of large electrodes on the proximal and distal ends of QF and HAM. While this setup is assumed to activate the entire muscle group, there is limited evidence supporting this assumption. Furthermore, to address the issue of rapid muscle fatigue due to FES, spatially distributed sequential stimulation (SDSS) is a novel technique that splits the single cathode electrode into four smaller electrodes to mimic physiological compartmentalization in muscle recruitment. There has not been any research on the recruitment of muscles due to SDSS as well.

Aim: This study aimed to investigate the degree of muscle activation across QF and HAM compartments during twitch contractions induced by conventional FES and SDSS.

Methods: Ten able-bodied participants will be recruited. Motor points corresponding to individual QF and HAM compartments will be identified, and surface EMG electrodes will be placed adjacent to each point. Maximum M-wave amplitudes (Mmax) will be obtained via localized stimulation at each site. Subsequently, a conventional FES protocol and SDSS will be applied using a standard electrode pair placed at the proximal and distal ends of the QF and HAM. The resulting M-wave responses will be recorded at each EMG site and normalized to the corresponding Mmax values.

Expected Results: We expect to measure percent recruitment in QF and HAM from conventional FES and SDSS. If conventional FES can fully activate QF and HAM, we expect its EMG response to plateau to similar levels as during Mmax. When comparing conventional FES and SDSS, we expect that at higher levels of stimulation intensity, SDSS will match conventional FES in muscle recruitment as Ye et al. show similar levels of power output when stimulating at 80% maximum tolerable for both conventional FES and SDSS[1].

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ISOLATING THE EFFECT OF FLEXION MAGNITUDE DURING CYCLIC FLEXION-COMPRESSION LOADING ON ANNULUS FIBROSUS MECHANICS

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Introduction: Low back pain is the most prevalent musculoskeletal condition worldwide [1], often associated with injury and/or degeneration of the intervertebral disc (IVD), particularly the annulus fibrosus (AF). Complex loading involving combined flexion and axial compression has been identified as a greater risk factor for IVD injury than uniaxial loading alone [2]. When applied cyclically, injury risk and disruption of the AF are further increased [3]. However, in cyclic testing, variables such as loading rate, duration, and number of cycles may act as confounders. To isolate the effect of flexion magnitude on the AF, these variables must be carefully controlled.

Aim: The aim of the proposed study is to isolate the effect of cyclic flexion magnitude, combined with axial compression, on the mechanical properties of the AF.

Methods: Six-month-old porcine cervical spines will be frozen and thawed at room temperature for 18 hours prior to testing. Two functional spine units (FSUs; C3/4 and C5/6) will be dissected from each spine and randomly assigned to one of four conditions: 0° (control), 5°, 10°, or 15° of cyclic flexion with 1200N of axial compression. All specimens will be preconditioned under 300N of axial compression for 15 minutes prior to testing, then undergo 3000 flexion cycles over 200 minutes using a material testing system (MTS C43, Eden Prairie, MN, USA). Each cycle will include a loading phase with a constant velocity across all flexion magnitude but a recovery phase that varies by group to ensure a cycle duration of 4 seconds. This will ensure both an equal number of cycles regardless of flexion magnitude as well as an equal cycle duration and subsequently equal cumulative loading. Following cyclic testing, samples will be excised from the posterior AF for mechanical testing. Multilayer samples will undergo delamination using a 180° peel test at a rate of 0.5mm/s (UStretch, CellScale, Waterloo, ON, Canada) to assess interlamellar matrix properties. Single-layer samples will be tested in tension at 2% strain/s until failure (BioTester, CellScale, Waterloo, ON, Canada) to assess intralamellar matrix properties. One-way ANOVAs will be used to compare mechanical properties across experimental groups.

Expected Results: It is anticipated that segments exposed to higher flexion magnitudes will exhibit decreased interlamellar mechanical properties, including reduced peel stiffness and strength. Additionally, the intralamellar matrix is expected to demonstrate decreased tensile stiffness compared to control and lower flexion magnitude conditions.

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BIOMECHANICAL EFFECTS OF FOOT ORTHOSES ON INDIVIDUALS WITH CHRONIC ANKLE INSTABILITY DURING FUNCTIONAL TASKS

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Introduction: Lateral ankle sprains are one of the most common musculoskeletal injuries. Chronic ankle instability (CAI) is a condition characterised by residual ankle joint deficits, both functional and mechanical in nature, resulting from significant or recurrent lateral ankle sprains. Individuals with CAI have been shown to experience increased ankle inversion and vertical forces under the lateral foot during initial contact [1], contributing to instability and episodes of the affected ankle “giving way”. Current clinical treatment protocols for CAI are ineffective in 30-40% of patients [2], indicating a need for innovation. Emerging evidence suggests that foot orthotics may provide additional mechanical and neurosensory support to assist treatment.

Aim: To evaluate the acute effects of standard and textured foot orthotics on ankle and lower limb kinematics, muscle activity, and center of pressure (COP) in individuals with CAI during functional tasks.

Methods: Twenty adults with CAI will be recruited and compared with twenty healthy control participants with no confounding lower-limb injuries. Participants will be asked to perform trials of jogging, lateral hopping, and walking on both a level surface and on uneven terrain. Tasks will be performed under three within-group footwear conditions: wearing Brooks Ghost 14 running shoes, with the standard insoles replaced by 1) an over-the-counter orthotic, and 2) a textured orthotic condition. Kinematic data of the foot and lower limb will be collected using an Optotrak Certus™ 3D motion capture system (Northern Digital Inc., Ontario, Canada). Surface electromyography (EMG) of the peroneus longus, tibialis anterior, and medial gastrocnemius will be recorded bilaterally. COP data will be collected using embedded force platforms.

Expected Results: Orthotic use is expected to acutely reduce ankle inversion, promote a more medially directed COP trajectory, and reduce activation demands (reduced magnitude) of the peroneus longus during movement.

Conclusion: Given the high prevalence of CAI and variable response to current rehabilitation approaches, foot orthotics remain an underexplored adjunct intervention in CAI treatment, which have the potential to improve clinical outcomes.

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THE EFFECTS OF SKIN AND MUSCLE TARGETED VIBROTACTILE FEEDBACK ON STANDING BALANCE AND POSTURAL CONTROL

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Introduction: Proprioception is the ability to perceive joint and body position and is informed by several different receptors embedded within the skin, muscles, and joints [1]. Tactile feedback can include sensations of pressure, stretch, and vibration, which can affect the coordination of body movement [2]. Previous work has demonstrated non-volitional postural responses to vibrotactile stimuli designed to preferentially target mechanosensitive afferents in the skin [3], and muscle [4]. However, it remains unclear which of the two vibrotactile stimuli elicits the larger effect, how they interact, and if such responses can be attenuated in selected conditions.

Aim: To assess the effects of two vibrotactile stimuli applied to the skin and muscles of the trunk on the control of static posture in healthy, young individuals.

Methods: 20 healthy, young participants will be recruited for this study. Participants will be outfitted with surface electromyography (EMG) electrodes over the rectus abdominis (RA) and lumbar erector spinae group (LES) to monitor muscle activity, and dorsal fin rigid bodies to capture lumbar joint angles. Further, ground reaction forces will be analyzed to measure center of pressure (CoP) changes. Two types of body-worn tactors (C2 and EMS; EAI Bioengineering) will deliver targeted vibrotactile stimuli to the skin and/or muscle. Participants will complete two 15-second quiet standing trials in six conditions on a firm surface in either single vibration or co-vibration locations at the trunk flexors/extensors. Further, co-vibration trials may consist of matched (e.g., C2-C2) or unmatched (i.e., C2-EMS) stimuli to agonist-antagonist locations. The specifications of the waveforms applied by each tactor will mirror previous work (C2: 250 Hz, 0.7 mm peak-to-peak amplitude; EMS: 70 Hz, 2 mm peak-to-peak amplitude) [3,4]. The first 5 seconds of each trial will have no vibration, then 5 seconds of the vibration stimulus, then 5 seconds of no vibration. Foot placement will be standardized between participants and trials, and participants will be instructed to stand naturally with no instruction on how to respond to the stimulus to ensure that the postural adjustments are non-volitional.

Expected Results: It is hypothesized that the CoP localization and trunk orientation changes will be larger in response to the EMS tactor stimulus than the C2 tactor stimulus. Further, that matched co-vibration will elicit no changes, but that unmatched co-vibration will exhibit larger changes favoring the EMS stimulus direction. These results will enhance the understanding regarding muscle and skin targeted mechanical stimuli interact to facilitate the control of body posture during standing. Future studies will aim to explore how experimental pain conditions affect the relative postural responses to each form of vibration.

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VALIDATING A FORCE MEASURING GLOVE FOR ASSESSING GRIP AND HAND FORCES IN AUTOMOTIVE ASSEMBLY

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Introduction: Musculoskeletal disorders (MSDs) account for 30% of total lost time claims in the United States each year with upper limb MSDs contributing the most [1]. Ergonomic tools designed to quantify MSD risk require reliable force (task intensity) inputs from the ergonomist. Hand and wrist forces are difficult to quantify in the field; thus, ergonomists rely on subjective ratings of perceived exertion/intensity. Devices have attempted to solve this problem by instrumenting the hand with pressure mapping sensors; however, these technologies have not been widely adopted due to limitations in force range, signal drift, and low sampling rates [2]. The AXS Force Glove (AXS Motionsystem Ltd) contains proprietary fluid-based sensors which claim to overcome many of the technical limitations of pressure sensors.

Aim: To validate the accuracy and reliability of the AXS Force Glove compared to a research grade load cell using simulated button pressing and gripping tasks.

Methods: 30 participants will complete 72 isometric wrist/digit flexion and gripping contractions against a load cell while wearing the AXS Force Glove (Figure 1). In part A, participants will complete flexion contractions to target the index finger, distal palm, and radial palm sensors in 2 force conditions (20N and 60N) and 2 duration conditions (1-second hold and 5-second hold). In part B, participants will complete isometric grip contractions in 3 grip conditions (power, pinch, and key) in 2 force conditions (50N and 100N) and 2 duration conditions (1-second hold and 5-second hold). Differences between the AXS Force Glove and load cell will be compared using a mixed-effect ANOVA model with post-hoc analysis and partial eta-squared to investigate significance and magnitude of measurement differences based on sensor, grip type, force magnitude, and sample duration. Systemic and proportional bias between the AXS Force Glove and the load cell will be investigated through Bland Altman analysis.

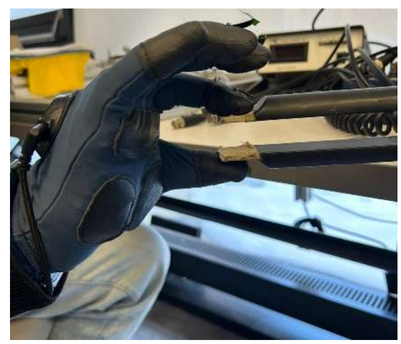

Figure 1: Participant wearing glove, completing pinch.

Expected Results: The AXS Force Glove is expected to produce measurements which are comparable to the load cell and within acceptable ranges based on traditional ergonomic assessment tools. It is expected that factors such as sensor location, grip type, force magnitude, and sample duration will not affect measurement differences.

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EFFECTS OF LADDER TYPE AND ORIENTATION ON JOINT MOMENTS AND STABILITY DURING MANUAL MATERIALS HANDLING

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Introduction: In Ontario musculoskeletal disorders (MSDs) accounted for nearly 34% of all lost time claims to the workplace safety insurance board (WSIB) between 2020 and 2024 [1]. Within the retail sector specifically, 41% of all claims during this period were the result of sprains or strains [1]. Manual materials handling (MMH) tasks performed from ladders and step stools are common in retail environments and impose unique biomechanical challenges on workers which may exacerbate the risk of developing MSDs or falling [2,3]. Specifically, performing MMH on ladders can result in elevated arm postures, greater reach distances, constrained bases of support for the feet, [3,6] all of which may amplify shoulder joint loading while reducing postural stability [2,3,4]. Additionally, little evidence exists on how self-perceived safe reach distances change as the result of ladder use. Despite these potential challenges to biomechanical demands and risk exposures, current ergonomic risk assessment tools provide no validated adjustments for ladder-based lifting tasks.

Aim: This study will quantify net joint moments of the shoulder, the minimum margin of stability (MMOS), and changes in self perceived safe reach distances during an MMH task across ladder conditions and multiple reach distances and box masses. This work will provide evidence to help refine safe-practice guidelines or risk assessment tools for performing MMH on ladders.

Methods: Thirty healthy adults (15 male, 15 female) will complete 56 trials across combinations of four ladder conditions, two load magnitudes, three anterior-posterior reach distances, and one “balance prioritization” trial where participants are asked to prioritize balance over all other task constraints. Full body kinematics will be collected using an optoelectronic motion capture system. Kinematic data will be analyzed using Visual 3D, where top-down inverse dynamics will be used to calculate peak net shoulder joint moments for each trial. Additionally, full body CoM position and CoM velocity during each trial will be used to assess postural stability based on the MMOS derived from the extrapolated center of mass model and base of support formed by the feet [5].

Expected Results: It is expected that outcomes will differ between ladder and no-ladder conditions, with ladder use (step stool or step ladder) leading to increased joint moments and reduced stability. These differences are expected to be amplified under more demanding MMH task conditions, such as handling heavier boxes and reaching outside the midline. Additionally, it is expected that ladder type (step stool vs. step ladder) will produce distinct biomechanical and stability demands, such that in all task configurations use of the step ladder will result in greater peak net joint moments and decreased postural stability.

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EFFECTS OF FOOT ORTHOTICS ON DYNAMIC STABILITY IN INDIVIDUALS WITH 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 acute effects of custom foot orthotics |(CFOs) 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).

Methods: Thirteen (13) participants with CLBP (n=13, age range of 18-57) have been 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 secondary gait characteristics measures during dynamic conditions. Each participant performed trials in all 3 conditions: 1) level walking and stair descent task, 2) hard (even terrain) and soft (uneven terrain) surface, and 3) with and without (CFOs). Secondary measures on the therapeutic effects of the intervention will be assessed over the duration of 6 weeks with assessments during the 1st, 3rd, and 6th weeks of orthotic intervention. 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.

Results: Preliminary findings of CFOs significantly increased both Medial-Lateral COM-BOS max (p=0.0012) and Medial-Lateral COM-BOS min (p=0.0281) in comparison to no CFOs. Additionally, significant effect of surface condition; standard deviation of gait velocity (p=0.0034) and step width (p=0.0140) were greater when walking over the uneven terrain condition.

Discussion/Conclusion: Individuals with CLBP improved their dynamic stability using an acute intervention of custom foot orthotics during gait movements. However, there is no significant acute changes in gait ambulation between foot orthotic conditions suggesting a different mechanical change or the need for repeated long-term kinematic analysis to measure effects of a custom foot orthotic intervention, mechanically over time.

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INFLUENCE OF BIOLOGICAL SEX ON DYNAMIC LUMBAR SPINE STABILITY FOLLOWING TRUNK MUSCLE FATIGUE

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Introduction: Low back pain is the leading cause of disability worldwide, affecting approximately 619 million people [1], with Impaired trunk control is frequently associated with as a key factor [8]. Spinal stability is maintained through passive structures, active muscular support, and neural control [7]. Dynamic lumbar spine stability is the neuromuscular systems ability to control trunk movement in response to perturbations during dynamic tasks. Neuromuscular fatigue disrupts muscle activation and coordination [2], with trunk extensor fatigue having the potential to influence dynamic lumbar spine stability [3]. Individual responses to fatigue vary: while 53% of individuals show no change in stability, while 47% demonstrate changes in dynamic stability [4]. Of those with observable changes, 17% become less stable and 30% become more stable [4]. Biological sex may contribute to these differences. Females are generally more resistant to fatigue, whereas males tend to exhibit greater fatigue-induced changes in lumbar mechanics [5, 6], including reduced reflex control, increased joint laxity, and decreased stability.

Purpose: to examine whether sex influences changes in dynamic lumbar spine stability following Trunk fatigue

Methods: Trunk kinematics will be captured using Qualisys motion capture, with Dynamic lumbar stability assessed using the maximum Lyapunov exponent (λ max) [4] derived from 3D thorax-to-pelvis kinematics, with sagittal-plane motion expected to contribute most strongly due to the flexion–extension nature of the task. Electromyography (EMG) of the lumbar and thoracic erector spinae and abdominal muscles will be used to assess muscle activity, quantified using normalized RMS amplitude relative to maximum voluntary contractions (MVC). EMG median frequency will be calculated for erector spinae to explore fatigue-related changes. A co-contraction index will also be calculated to assess simultaneous trunk muscle activation. Dynamic lumbar spine stability (DLS) will be assessed pre- and post-fatigue via 30 repetitions of a trunk flexion–extension task at a standardized tempo, using a fixed reach target and constrained pelvis. The fatigue protocol will consist of a repetitive, stoop-dominant box-lifting task from floor to waist height at a standardized tempo. The load will be set at 30–40% of each participant's estimated maximum, based on a 3RM box-lift. The task continues until RPE or failure to maintain tempo/technique (e.g., excessive knee flexion or loss of hip-hinge pattern) for two consecutive repetitions

Expected Results: It is anticipated that males are expected to demonstrate greater reductions in stability following fatigue, while females are likely to exhibit smaller changes or maintain stability. Furthermore, Females may demonstrate different neuromuscular activation patterns following fatigue, whereas males may exhibit greater fatigue-related changes in movement control.

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QUANTIFYING SPINE AND SHOULDER KINEMATICS DURING SINGLE AND TWO PERSON PATIENT HANDLING TASKS

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Introduction: Nurses are the backbone of healthcare systems worldwide, but their jobs are often disrupted by musculoskeletal injuries sustained during complex patient-handling tasks. One in three nurses report pain that affects their ability to complete tasks required for their profession [1]. Patient care activities account for 80% of the cumulative compression force on the lumbar spine and cause peak spinal loads of up to 4700N [2]. Safe lifting guidelines and practices vary across hospitals, demonstrating little consistency both between hospitals and governing organizations. Many tasks performed during patient care, including repositioning in bed, bed-to-chair transfers, and sit-to-stand transfers in bed, require >1 nurse to complete. Injuries are most reported in the shoulder and lower back, at 57% and 60%, respectively [3]. This risk of injury has led to an overall decline in the nursing population, resulting in inadequate staffing that puts patient safety at risk.

Aim: Use markerless motion capture and a battery of strength tests to gain insight into single and two-person patient handling biomechanics.

Methods: 60 female participants will be recruited from the Brock Nursing program to complete three patient-handling tasks. This project will be completed in two sessions. Session 1 will involve the capture of anthropometric and strength measures. Measures will include height, mass, and age, followed by grip strength measured via a grip dynamometer and maximum deadlift. These measures will be used in the participant pairing process and to normalize data during analysis. Session 2 will involve three patient transfers, in a randomized order: 1) Reposition in bed with the use of a slide sheet, 2) Bed-to-chair transfer with the use of a transfer belt, 3) Transfer from a hospital bed to a stretcher. All transfers will be performed 3 times using both a male and female mannequin set to the 50th percentile body mass. Video will be captured with 13 Sony RX0II cameras sampling at 60Hz and will be imported into Theia3D's Markerless Motion Capture software (Theia Marker-less Inc., Kingston, ON, CA) to obtain kinematics. Coordinate data will be imported into Visual 3D (C-Motion Inc.; Germantown, MD, USA) for further analysis. Measures will include CoM displacement, shoulder and trunk joint angles, postural symmetry, and movement variability between handlers.

Expected Results: For the single-nurse task, taller nurses are expected to have greater trunk flexion and spinal twisting, while shorter nurses are expected to experience less due to the patient's similar height on the bed. For the repositioning and bed-to-stretcher tasks, the larger of the two nurses, based on anthropometric measurements, will have greater trunk flexion and experience greater shoulder loads because the bed is adjusted to the shorter nurse's height.

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INVESTIGATING SEX DIFFERENCES IN FOREARM MOTOR UNIT PROPERTIES ACROSS VARIED GRIP AND WRIST TORQUES

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Introduction: A motor unit (MU) is one of the key functional elements linking the nervous and musculoskeletal systems. Muscle contraction force is controlled by the number of active MUs, their firing rates, and coordination. While MU analysis provides valuable insights into neuromuscular control, research on MU properties in females is limited. Understanding MU sex differences is crucial, especially in the medical field, as females tend to experience poorer motor recovery outcomes post-stroke, requiring more tailored training intensities for optimal adaptation [1]. Sex differences in MU discharge rates and recruitment thresholds at submaximal contractions have been reported, however, sex differences in peak-to-peak amplitude remain unclear [2]. MU properties in forearm muscles may vary across tasks, specifically wrist flexion, handgrip, and a dual task involving both actions [3]. It has been reported that the type of task 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, having the potential to demonstrate differential activation in dual-tasks [3].

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

Methods: Forty participants (20 M, 20 F, 18-24 years) will perform wrist flexion, handgrip, and dual-task contractions, all completed in a supinated forearm posture. Wrist flexion force will be measured using a load cell (JR3 Inc., Woodland, CA, USA), and grip force will be measured using a handgrip dynamometer (MIE Medical Research Ltd, Leeds, UK). Dual-task conditions will involve simultaneous wrist flexion and grip force measurements. Two 96-channel (4mm IED, 16x6 array) high-density electrode grids will be placed over the FCR. MU properties will be recorded using HD-sEMG (OT Bioelettronica, Torino, Italy) and decomposed. Participants will complete two protocols during a two-hour session. Protocol 1 includes five task conditions: wrist flexion (15% and 30% MVC), handgrip (15% and 30% MVC), and a dual task (30% combined force; 15% each), performed as trapezoidal contractions (10% MVC/s; three trials). Protocol 2 consists of progressive ramp contractions to 80% MVC (10% MVC/s) for each task (three trials). MU decomposition will assess peak-to-peak amplitude, recruitment threshold and discharge rate during each task condition. Sex differences in MU properties will be analyzed across conditions to investigate potential sex-related neuromuscular adaptations.

Expected Results: MU properties are expected to vary by task, with wrist flexion exhibiting the highest peak-to-peak amplitude and discharge rates, followed by the dual-task condition, and handgrip. Sex differences are anticipated, with females exhibiting higher discharge rates and recruitment thresholds, while males are expected to have larger peak-to-peak amplitudes.

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AN INVESTIGATION INTO OBJECTIVE LUMBAR SPINAL STIFFNESS & CLINICAL IMPLICATIONS

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Introduction: Clinical assessment of the lumbar spine commonly includes segmental palpation via a posterior-to-anteriorly directed force. This test results in an inference of spinal stiffness, informing target treatment [1]. Because this methodology is subjective, devices have been developed to reduce clinician-based variability and objectify findings. The purpose of this study was to ascertain the variability of stiffness measurements across consecutive lumbar spine segments using such a device. It was hypothesized that there would be no difference in stiffness measurements.

Methods: Participants (n=36) were recruited from the University of Waterloo graduate student population (50% female; 25 ± 3 years; 1.73 ± 0.10 m; 72.3 ± 17.1 kg). Individuals were included if they had no history of low back injury (e.g., surgery, malignancy, etc.). Participants were randomly allocated to two groups, which determined the order of segment testing: cranial-caudal (e.g., L1-L5) or caudal-cranial (e.g., L5-L1). A spinal indentation device [2] then applied known preloads (8 N) and forces (80 N) to each lumbar spinal segment. Load-displacement values were measured, and lumbar segmental stiffness was calculated. Stiffness values were averaged and smoothed using a 6th-order polynomial function.

Results: A significant *spinal level x randomization order* interaction was found (p=0.03), where individuals tested cranially to caudally had increased lumbar spinal stiffness values compared to those tested caudally to cranially *(Figure 1)*.

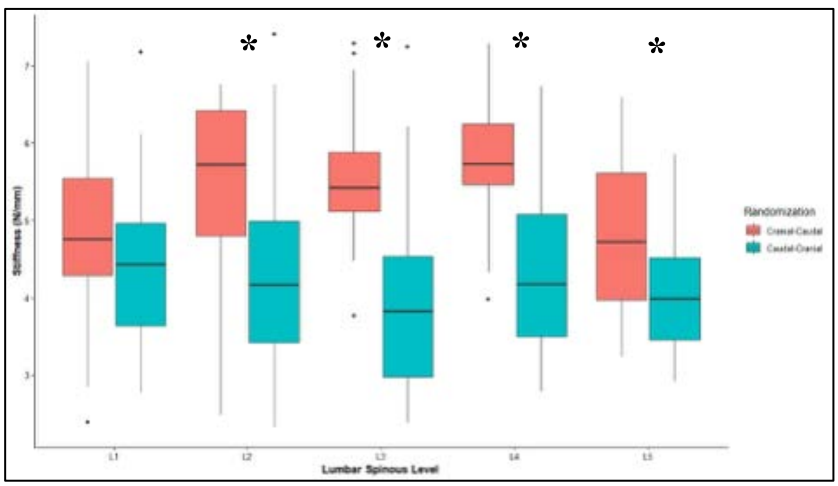

Figure 1: Boxplot illustrating stiffness values (N/mm) at each tested spinous level, separated by randomization allocation. Levels with significant differences between randomization are denoted with (*).

Discussion and Conclusions: This study is the first to assess a spinal indentation device on segmental lumbar spinal stiffness measurements. These results suggest that when testing consecutive spinal segments, order matters, and may influence assessment results. Breakpoint analysis to partition these stiffness metrics will be utilized to provide further insight into the interpretation of these results.

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A WEARABLE E-TEXTILE NEUROPROSTHESIS FOR RETRAINING POSTURAL CONTROL IN SPINAL CORD INJURY

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Introduction: Functional Electrical Stimulation (FES) has proven effective for retraining standing balance in spinal cord injury (SCI) [1], yet its clinical translation is hindered by several factors, creating a significant barrier to the high-dosage therapy necessary for neuroplastic recovery. Current neuroprosthetic systems rely on expensive, cumbersome equipment, such as force plates and motion capture cameras to measure center of pressure (COP) and joint angles, as feedback for closed-loop control. Wearable inertial measurement units (IMUs) have recently been shown to provide a low-cost alternative for tracking these metrics. Furthermore, traditional surface electrodes require precise, individual placement for each therapy session, a process that is time-consuming and often inaccessible for patients with limited dexterity. Textile-integrated electrodes address these limitations by pre-positioning electrodes within a single garment, streamlining the setup process for the user.

Aim: This study aims to develop a wearable, textile-based interface capable of continuous postural monitoring and FES, providing a more feasible alternative to traditional laboratory equipment for retraining standing balance.

Methods: The neuroprosthesis utilizes textile-embedded dry electrodes made of a carbon nanotube polymer composite to deliver FES for control of 8 degrees of freedom in the lower limbs. For postural monitoring, five IMU sensors (Adafruit Industries, NY, USA), which can be easily removed for laundering, are positioned at the sacrum, thighs, and shanks to capture joint angles and estimate COP. Two centralized 3D-printed magnetic connectors (one on each leg) facilitate facile connection of electrodes and sensors to an external controller. Electrical connections throughout the textile are sewn in the leggings with conductive threads (Madeira, NH, USA).

Figure 1: Renderings of leggings design created in CLO 3D (CLO Virtual Fashion, Seoul, South Korea).

Expected Results: Renderings of the proposed design are shown in Figure 1, where red squares indicate the position of the IMU sensors, and golden squares indicate the locations of the electrodes in the leggings. We anticipate the embedded IMUs will accurately estimate lower-limb joint angles and COP to enable closed-loop FES control for standing balance.

Discussion & Conclusion: This textile-based neuroprosthesis provides a portable, accessible alternative to cumbersome laboratory equipment, enabling autonomous and reliable balance rehabilitation, thereby facilitating a shift toward patient-led, at-home high-dosage therapy.

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INVESTIGATING LOWER LIMB UNIARTICULAR AND BIARTICULAR MUSCLE FUNCTION DURING SQUAT TASKS WITH VARYING MECHANICAL DEMANDS

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Introduction: The claim that uniarticular and biarticular muscles have distinct functions has long been debated but remains a fundamental, unanswered question in human movement control. Uniarticular muscles are proposed to do positive mechanical work to produce positive joint work during whole-body movements, while biarticular muscles do little-to-no work (near isometric contraction) to coordinate adjacent joint moments and transfer mechanical power [1]. Dynamical simulations [2] have challenged the claim that biarticular muscles have unique function and *in vivo* animal studies have found mixed evidence [3,4]. Using ultrasound to measure fascicle kinematics enables novel estimations of *in vivo* muscle work during movement [5]. Furthermore, previous research on biarticular muscle function in humans has focussed on maximal-height vertical jumping [1,2], leaving uncertainty as to whether unique function would generalize to submaximal tasks.

Aim: Investigate uniarticular and biarticular muscle function during squat tasks with varying mechanical demands.

Methods: Full-body kinematics, ground reaction forces, and EMG of sixteen unilateral muscles, including all major uniarticular and biarticular extensors and flexors of the lower limb, will be collected. B-mode ultrasound will track muscle fascicle kinematics of gluteus maximus (uniarticular) and biceps femoris (biarticular), to calculate shortening velocities. The nominal condition will be a maximum depth bodyweight squat, controlling movement speed, stance posture, and arm position [6]. Loaded conditions (+20 and 40% body mass) will then be performed with the same posture. Inverse dynamics analysis will calculate lower limb net joint moments, joint power, and joint work during the squat. Muscle activation will be derived using normalized linear enveloped EMG integrated over squat ascent. Repeated-measures linear mixed-effects models will evaluate how load influences joint work, muscle activation, and fascicle shortening velocities.

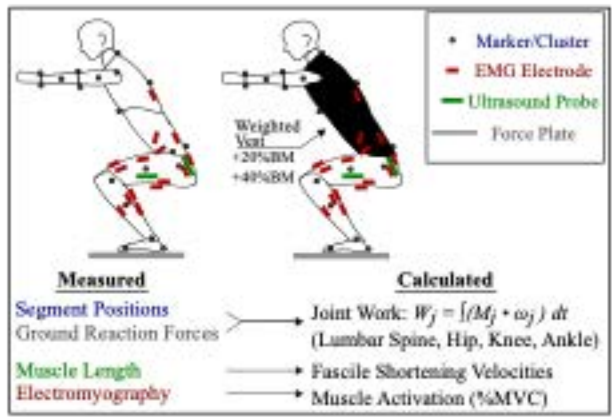

Fig. 1: Experimental set-up and outcome variables.

Expected Results: It is hypothesized that increasing load will proportionally increase activation of uniarticular extensors and be strongly correlated with joint work. Biarticular muscle activation will not exhibit increases with load nor be correlated with joint work but will be correlated with relative hip-knee net joint moments. This research contributes fundamental knowledge of muscle function, providing a mechanistic foundation for investigations aimed at understanding neuromuscular control of whole-body movements.

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CAN ASYMMETRIC PARASPINAL MUSCLE DEGENERATION DRIVE SPINE DEFORMITY IN MICE?

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Introduction: Studies have found that paraspinal muscle degeneration occurs in an asymmetrical pattern in patients with adult degenerative scoliosis [1]; however, it remains unclear if these muscular imbalances can drive deformity. Intramuscular glycerol injections have previously been used to induce paraspinal muscle degeneration and manipulate the sagittal plane spinal curvature in mice [2]. The purpose of this study was to evaluate the effects of asymmetric lumbar and thoracic paraspinal muscle degeneration on spinal deformity in mice.

Methods: 27 female C57BL/6 mice were divided into three groups: control (n=6), ipsilateral (IL) (n=9), and contralateral (CL) (n=12). Paraspinal muscle degeneration was induced by injecting glycerol in the multifidus and erector spinae. IL group injections were of the right lumbar and thoracic regions, while the CL group injections were in the right lumbar and left thoracic regions. Injections were administered at 4 timepoints, each two weeks apart, and mice were sacrificed two weeks after the last injection. Control animals received no injections. MicroCT scans at 0, 4, and 8 weeks were used to measure spinal curvature (Cobb angle) in the coronal and sagittal planes.

Results: In the coronal plane, there was a significant interaction between injection group and time (p=0.05), despite mean Cobb angles remaining small (< 6º) at all timepoints. Post-hoc analysis found the CL group to have higher mean coronal Cobb angles compared to the IL (p=0.01) and control (p=0.03) groups at week 8. In the sagittal plane, there was a significant interaction between injection group and time (p<0.001). Post-hoc analysis found mean sagittal Cobb angles decreased significantly over time in the CL group (Figure 1).

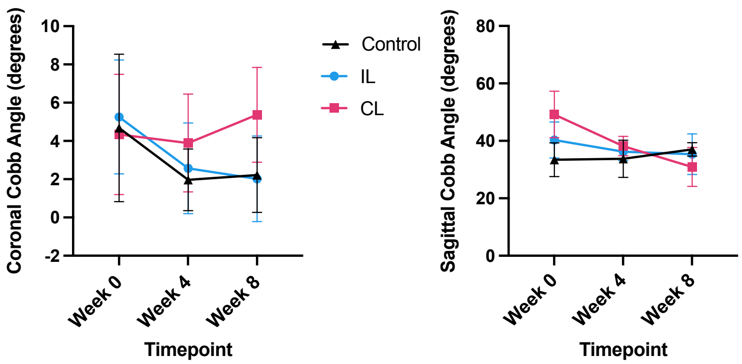

Figure 1: mean±SD coronal and sagittal plane Cobb angles in the control, ipsilateral (IL), and contralateral (CL) groups at 0, 4, and 8 weeks

Discussion and Conclusions: While there were some differences observed in coronal plane Cobb angles, they were too small to be considered clinically scoliotic. Surprisingly, the CL pattern of paraspinal muscle degeneration significantly reduced the sagittal plane Cobb angles (kyphotic curvature) over time. Baseline sagittal plane Cobb angles were higher in the CL group compared to the control and IL groups which may explain why a more significant change was observed.

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THE INFLUENCE OF HEIGHT AND SEX ON TWO-PERSON TEAM LIFTING

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Introduction: Team lifting is a manual materials handling technique that is employed when two or more individuals lift an object, often a heavy load that exceeds individual lifting capacity. Although frequently used in the workplace, current guidelines and research are limited. The purpose of this study was to examine the effects of height and sex on joint kinematics and kinetics during two-person lifting tasks when pairs of lifters were matched and unmatched for height.

Methods: Twenty-three female and eighteen male participants were paired with a height-matched (≤5cm) and unmatched (≥10cm) partner of the same sex. Each pair performed four manual materials handling tasks (knee-to-waist and chest lifts, left-right and forward-backward carries) using a 42.6 kg rectangular lifting device. Upper body motion and applied hand forces were recorded using marker-based motion capture and four 6-DOF force transducers. Joint angles and moments for the shoulder, elbow, and trunk were determined using Visual3D.

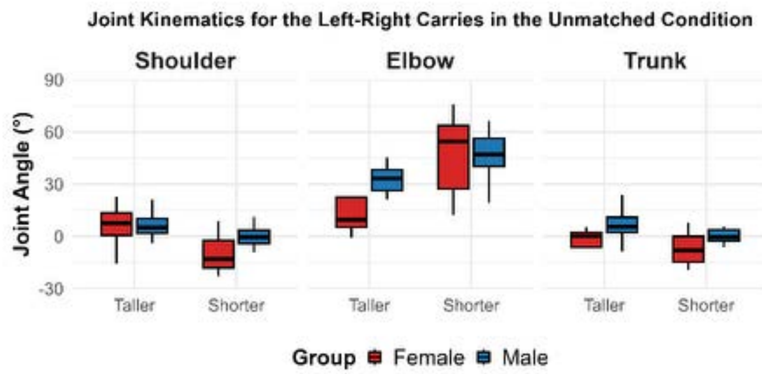

Figure 1: Joint kinematic data for the shoulder, elbow, and trunk during left-right carries in the unmatched condition.

Results: During the knee-to-waist lifts, there was a significant effect of height, where shorter lifters had significantly greater shoulder extension and elbow and trunk flexion compared to taller lifters for both sexes across both conditions; elbow joint angle differences were amplified in the unmatched condition. During knee-to-chest lifts, male lifters had greater elbow flexion than female lifters regardless of condition or height but there were no significant differences in shoulder angle. During the carries, shorter lifters had greater shoulder and trunk extension and elbow flexion compared to taller lifters, particularly in the unmatched condition. Shorter male lifters had greater elbow flexion than shorter female lifters in the matched condition and in the matched and unmatched conditions for taller lifters. These changes in upper body posture were also noted in applied forces and internal shoulder, elbow, and trunk joint moments.

Discussion and Conclusions: Height differences during two-person team lifting requires lifters to adopt unique postures which largely depend on both the lifting task and the sex of the lifters. Taller lifters tend to adjust their posture using their shoulders, whereas shorter lifters adjust using their elbows and trunk. The observed postures lead to differences in joint loading and, as a result, injury risk, between both shorter and taller as well as male and female lifters. The present study provides evidence for the role of height and sex differences in two-person team lifting to formulate more detailed guidelines for the use of team lifting in the workplace.

Assessment of the Efficacy of a Powered Back Support Exoskeleton for Home Health Care Patient Transfers

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Introduction: Work related musculoskeletal disorders (WMSD) have a large impact on the field of healthcare, in both hospital and home health care. Washington state workers compensation data for home health care workers showed WMSDs are the leading cost of lost time claims, with a cost of 34.6 million dollars, and that the lower back was the most frequently injured area [1]. Further, home health care workers often face uncontrollable working environments that lack accommodation, transfer aides and space since they are working in their patients' private homes [2]. Passive back support exoskeletons (BSE) have been investigated for use in patient transfers and have shown a 12-16% decrease in erector spinae muscle activation [3]. There is currently a lack of research surrounding the effectiveness of powered BSE use during patient transfers.
Aim: The purpose of this study is to assess differences in lower back joint kinematics, EMG and rate of perceived exertion between a powered BSE condition and a control (no support) condition for patient transferring tasks within a simulated home health care scenario.
Methods: The study will include 24 participants (12 male, 12 female) recruited from the Department of Nursing at the University of Windsor. Participants will be required to complete four patient transferring tasks using a mannikin (mass of 100kg). The four tasks are wheelchair to shower chair over barrier, shower chair to wheelchair over barrier, wheelchair to toilet transfer, toilet to wheelchair transfer. The participants will complete two experimental conditions, one with the German Bionics Apogee powered BSE, and a control condition with no exoskeleton. Each participant will complete ten trials per task, and rate of perceived exertion will be recorded after the tenth trial of each task. Participants will be outfitted with the Xsens Awinda inertial motion capture system (Movella, Enschede, Netherlands) to collect kinematics. Electromyography (EMG) data will be collected bilaterally from the lumbar and thoracic regions of the erector spinae, external obliques, rectus abdominus and the biceps femoris.
Expected results: It is expected that the powered BSE condition will result in a decrease in rate of perceived exertion compared to the control condition. Peak trunk flexion angle is also expected to increase with the use of the powered BSE. For the EMG data, the lumbar and thoracic erector spinae muscles, external oblique, and rectus abdominus are expected to see a decrease in mean EMG when compared to the control condition. However, it is expected that there will be no change in mean EMG for the biceps femoris.
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THE EFFECT OF MOUSE DPI SETTINGS ON UPPER-LIMB KINEMATICS DURING FIRST PERSON SHOOTER E-SPORTS GAMING

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Introduction: The rapid growth of Esports has brought about an increase in upper-limb musculoskeletal (MSK) injuries due to the large physical demands placed on the body[3]. Gaming requires prolonged, repetitive postures and rapid fine-motor mouse movement, which impose substantial MSK risk to the wrist, forearm, and shoulder muscles [1,3]. Mouse sensitivity, which is affected by the mouse's dots per inch (DPI) setting, is an important parameter to Esports athletes. DPI indicates how many pixels a cursor moves per inch of physical mouse movement (Figure 1). Gamers generally prefer lower DPI settings (400-800) for high-precision, tactical first-person shooter games to improve control and accuracy, but this results in larger mouse movements likely to extend the upper extremity into more extreme postures.

Figure. 1: Visual Representation of DPI[4]

Aim: This study will investigate the effects of varying mouse DPI settings (400, 800, 1600) on the upper-limb range of motion (ROM) and rating of perceived discomfort (RPD) during first-person shooter (FPS) tasks.

Methods: A within-subject repeated measures design will be conducted on healthy university students. Participants will be fitted with 11 Xsens inertial measurement sensors placed on the upper-limb. Each participant will perform two AimLab tasks: Spider-Shot (precision-based) and Strafe-Track (tracking-based), once using both mice (Logitech G502 and Vandal Pro), using randomized order of DPI and mouse conditions. Upper extremity joint angles and mouse location will be tracked. Participants will verbally report pre- and post-localized discomfort ratings of the upper body and dominant limb using a 0-10 scale accompanied by an anatomical reference diagram.

Expected Results: It is hypothesized that increasing DPI will be associated with reduced range of motion. The largest differences are expected between 400 and 1600 DPI, with lower DPI resulting in substantially greater and faster movements. The Vandal Pro, a prototype mouse with an attached wrist rest, may reduce range of motion compared to the Logitech G502 across all conditions. An inverse relationship is expected between DPI and RPD, where decreasing DPI values correlate with higher levels of discomfort. It is anticipated that as individuals undergo greater levels of displacement and ROM, they are often sustaining more extreme postures, resulting in an increased risk of upper-limb MSK injuries.

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DIFFERENCES IN HEAD IMPACT OCCURENCE AND IMPACT MECHANISM ACROSS AGE DIVISIONS (U11 – U18) IN MALE YOUTH ICE HOCKEY

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Introduction: Concussions are traumatic brain injuries (TBI) and a major public health concern in youth sports. Children and adolescents, whose brains are still developing, experience slower recovery and more persistent symptoms after concussion [2,3]. Sports like ice hockey, football, and soccer are leading causes of youth concussions [1], but there is a higher concussion risk, and the likelihood of head impacts is more frequent in ice hockey [4]. Research on head impact exposure across hockey age divisions is limited, and current methods may underestimate exposure and overlook factors such as anticipation and body position of the impacted player when head impacts occur.

Aim: The study objectives are: (1) to identify and compare levels of head impact exposure across age divisions in youth hockey; (2) to assess the roles of anticipation and body positioning using the Carolina Hockey Evaluation of Children's Checking (CHECC) scale [5]; (3) to expand current datasets on youth hockey head impact exposure.

Methods: A portable, multi-camera video-based system comprised of 10 Hero9 Black cameras (Figure 1) was used to record 43 youth hockey games (U11-U18) over the 2025-2026 season at the Atlas Tube Recreation Centre in Lakeshore, Ontario. The mounts with cameras, power packs and fans were secured tightly to steel plates with magnets in elevated positions around the rink. The cameras were aligned so that all parts of the ice surface could be seen by at least two cameras at all times. The video footage will be reviewed in the lab using video editing software (VLC Media Player) to determine where and how the head impacts occurred and to assess anticipation for players who experienced a head impact while being checked. Exposure measures and anticipation will be compared across age groups (9–12 years of age: U11-U13; 13–14 years of age: U14-U15); 15–17 years of age: U16-U18).

Figure 1: Custom wooden mount with GoPro camera, fan, and power pack.

Expected Results: It is expected that head impact exposure will be greater in older players due to the increased intensity of the sport at higher levels. It is hypothesized that most head impacts across all age divisions will be unanticipated, with the least anticipated hits occurring in younger players due to their relative inexperience with checking.

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FLAGGING FATIGUE: PREDICTING FATIGUE STATE DURING RUNNING USING SMARTWATCH DATA

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Introduction: Recreational running is one of the most popular forms of physical activity, yet approximately one in two runners sustain an injury each year that forces a break from running [1]. Fatigue plays a key role in this risk, exacerbating biomechanical deviations such as excessive pelvic tilt, altered foot strike, increased vertical oscillation, and reduced knee flexion, all of which have been linked to injuries including plantar fasciopathy and patellofemoral pain [2]. Existing fatigue detection algorithms rely on electromyography, multiple inertial measurements units, textile-based sensors, or motion capture systems, often limiting their use to laboratory settings [3]. Despite the widespread adoption of smartwatches among recreational runners, no validated tool currently exists to detect fatigued running using only smartwatch data.

Aim: The aim of this study is to develop a predictive model that identifies fatigued running states using smartwatch-derived data alone.

Methods: *Participants.* Twenty healthy recreational runners (female and male) with no musculoskeletal or cardiopulmonary impairments will complete three testing sessions over two weeks. *Equipment.* All running will occur on an instrumented treadmill and markerless motion capture (OpenCap, USA) will be used to collect kinematics. The Borg Rating of Perceived Exertion (RPE) scale will be used to assess subjective exertion throughout the protocol. Participants will be instrumented with indirect calorimetry (Cosmed K5, Italy) and a smartwatch (Ultra 2, Apple, USA). *Protocol.* On Day 1, participants will complete a preferred running speed test and a modified VO_2max test to characterize running mechanics across various fatigue levels. On both days 2 and 3, participants will complete a 34-minute run at their preferred speed, with randomized intervals of increased grade (5%, 7.5%, 10%, and 12.5% incline) to evoke fatigue. *Analysis.* Day 1 data will be used to establish 'ground truth fatigue states' (1: non-fatigued to 3: fatigued) using a combination of a Gait Deviation Index (GDI) to reflect kinematic indicators of fatigue and the Respiratory Exchange Ratio (RER) to reflect cardiovascular indicators of fatigue. Days 2 and 3 data will be used to train and evaluate supervised machine learning models, including linear regression, decision trees, and long short-term memory neural networks, to predict fatigue state from smartwatch gait metrics alone (heart rate, speed, slope, step rate, stride length, ground contact time, and vertical oscillation) using a leave-one-out cross-validation framework.

Expected Results: I expect to be able to identify fatigued running states using smartwatch-derived data alone with accuracy exceeding 75% [2]. If successful, this proof-of-concept tool would lay the foundation for extending fatigue detection to outdoor, overground running. A tool to alert recreational runners to fatigue-related deterioration in running form could potentially reduce injury risk and improve long-term participation among the millions who use commercial smartwatches.

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INTERNAL GAIT PERTURBATION USING DYSFUNCTIONAL FUNCTIONAL ELECTRICAL STIMULATION: A PILOT MOTION CAPTURE ANALYSIS

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Introduction: Falls during walking are commonly studied using external perturbation paradigms such as slips, trips, or treadmill-based disturbances. While these approaches are effective for evaluating reactive balance, they may not fully capture internally generated disruptions in motor control. Understanding how the nervous system adapts to perturbations during gait is critical for developing effective neurorehabilitation strategies, and perturbation-based paradigms have been widely adopted to investigate gait stability and recovery responses [1,2]. Dysfunctional functional electrical stimulation (DFES) introduces an alternative approach by applying mistimed, phase-specific muscle activation during walking, thereby generating controlled internal perturbations. Unlike external perturbations, DFES enables the study of internally driven disturbances that may better reflect altered neuromuscular control. Prior findings from our lab demonstrated that stimulation of the rectus femoris (RF) at 50% and biceps femoris (BF) at 75% of the gait cycle produced quantifiable perturbations in gait kinematics. The purpose of this study was to determine whether DFES-induced internal perturbations lead to short-term adaptations in gait during the post-stimulation phase, as assessed using motion capture-derived kinematics.
Methods: Three neurologically intact participants completed treadmill walking trials consisting of baseline walking (5 minute), DFES (12 minutes), and post-stimulation walking (8 minutes). DFES was applied separately during two trials for the rectus femoris and biceps femoris using surface electrodes, with stimulation triggered relative to gait phase. Kinematic data were collected using a Raptor-E Motion Capture System (Motion Analysis Corp., CA, USA). Marker trajectories were used to extract joint kinematics and temporal gait parameters across conditions.
Results: Preliminary findings indicate that DFES produced measurable perturbations in gait kinematics during stimulation, particularly in stride length and toe clearance. Perturbations were consistently observed across participants, despite the small sample size. RF stimulation was associated with immediate disruptions in gait mechanics, while BF stimulation produced alterations in stride timing. Short-term aftereffects were observed in the post-stimulation phase, suggesting brief adaptive response after DFES.
Discussion/Conclusion: These results support the feasibility of DFES as an internal perturbation paradigm for studying gait adaptation. Unlike traditional external perturbation approaches, DFES enables controlled disruption of muscle activation during ongoing locomotion. Motion capture data from this pilot study demonstrate that both RF and BF stimulation can induce quantifiable changes in gait mechanics. This approach has potential applications in studying motor adaptation and informing rehabilitation strategies for populations with impaired gait.

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HUMAN TO HUMANOID GAIT REPRODUCTION AND PERCEPTION

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Introduction: Human gait is a complex, coordinated process governed by biomechanical constraints, neuromuscular control, and dynamic stability requirements. Quantifying these characteristics and translating them into computational models remains a key challenge in both biomechanics and humanoid robotics. This study presents an integrated framework combining markerless motion capture with reinforcement and imitation learning to model and reproduce human gait patterns in a physics-based humanoid system.

Aim: To investigate how biomechanical variation in human gait, represented within a continuous feature space, can be learned and reproduced in a humanoid system, and how these variations influence human perception of movement.

Methods: Using 10 Sony RX0 II cameras, three-dimensional kinematic data will be captured at 60 Hz and extracted using Theia3D or MediaPipe Pose. These data will be used to construct a low-dimensional representation of gait patterns using statistical decomposition methods (e.g., PCA). Rather than defining discrete “male” and “female” gait patterns, gait will be represented along a continuous feature space capturing the primary modes of biomechanical variation across 20 male and 20 female participants. Sex will be treated as a grouping variable to examine how distributions differ within this feature space, rather than as a defining axis of motion [2,3]. These experimentally derived gait samples will be retargeted into the Booster K1 humanoid Robot and used as reference motion profile for a reward structure. A simulated humanoid agent will be trained in a physics-based environment using Proximal Policy Optimization (PPO) [4]. Secondly, the resulting gait policy’s will be presented to untrained raters, who will evaluate perceived movement characteristics using a forced-choice or rating-based protocol. Statistical analyses will compare perceived gait scores across participant groups and examine whether variation in robotic movement generated from the learned gait space produces distinguishable perceptual outcomes [2].

Expected Results: The trained model(s) will reproduce key features of human gait in a physical simulation and inorganic machines, including coordinated inter-limb timing, realistic joint trajectories, and stable forward progression. Importantly, the inclusion of biomechanically meaningful constraints improved both movement realism and stability compared to purely kinematic imitation approaches [1]. Prior work shows that observers rely on distributed body regions, particularly the shoulders and pelvis, when interpreting gait characteristics [2]. As such, variation within the learned gait feature space is expected to produce distinguishable movement patterns consistent with underlying biomechanical differences, rather than discrete gait types [3].

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COMPARING PERSONAL SUPPORT WORKERS' LUMBAR EXTENSOR MOMENTS CALCULATED USING DYNAMIC INSOLE DRIVEN BOTTOM-UP MODELS AND PEAK HAND FORCE DRIVEN TOP-DOWN MODELS

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Introduction: Community-based personal support workers (PSWs) need effective interventions to reduce the high prevalence of low-back musculoskeletal disorders. Effective interventions require insight on exposures; however, knowledge of PSWs' low back loads is sparse, and few methods are available to measure lumbar exposure data in-field with sufficient rigor. This study aims to test how peak lumbar (L_4/L_5) extensor moments calculated using top-down quasi-dynamic model differed from those calculated using a dynamic bottom-up model with ground reaction forces (GRFs) estimated using a field-ready insole sensor.

Methods: Kinematic and kinetic data were collected from 20 PSWs (17F, 3M) simulating 12 PSW tasks [1]. Top-down quasi-dynamic and bottom-up inverse dynamic rigid link models were developed in Visual3D x64 Professional™ (HAS-Motion Inc., Kingston, ON, Canada) to calculate PSWs' lumbar extensor moments. Model inputs included whole-body 3D kinematics collected using a 12-camera Vicon© motion capture system (Centennial, CO, USA), and peak hand forces collected with a Mark-10© force gauge (Copiague, NY, USA) (top-down analysis) or dynamic GRFs collected using Loadsol® pro-mlp (Novel Electronics Inc., St. Paul, MN, USA) (bottom-up analysis). Wilcoxon Signed Rank tests were conducted with JASP© (Amsterdam, Netherlands) to compare differences between the top-down and bottom-up estimated peak extensor moments.

Results: Statistically significant differences in PSWs' lumbar extensor moments emerged in all five patient care tasks (blue) and two patient handling tasks (red) (Figure 1).

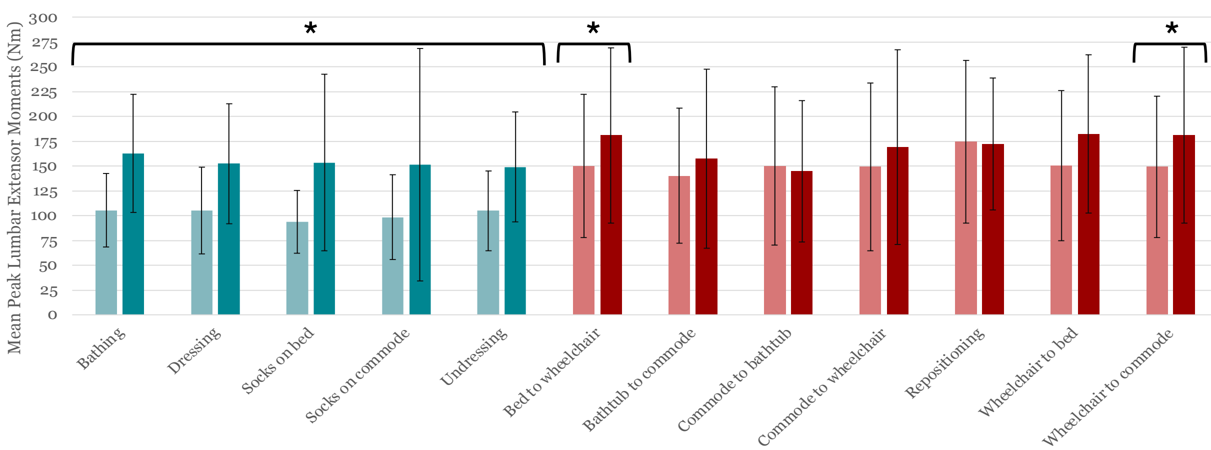

Figure 1: Mean peak extensor moments estimated using the top-down analysis (light) versus the bottom-up analysis (dark) for each task. Asterisks (*) indicate statistically significant (*p*<.05) differences.

Discussion and Conclusions: Since hand force matching was only successful in estimating the handling task's peak hand forces, top-down models may be influenced by subjective errors and limited forces. Bottom-up models may provide more reasonable extensor moment estimates when the bilateral feet are the primary base of support (i.e., when not required to kneel or lean on a bed).

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EXAMINING THE CHANGES IN PASSIVE TISSUE PROPERTIES OF THE LUMBAR SPINE FOLLOWING A SINGLE SITTING BOUT AND ACTIVE RECOVERY.

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Background: Individuals adopt a flexed lumbar posture when sitting, which alters loading conditions in the lumbar spine. Prolonged lumbar flexion places significant load on posterior tissues, which over time introduces changes in viscoelastic tissues such as ligaments, intervertebral discs, fascia, and other passive tissues. Alterations in these tissues ultimately compromise the passive contributions to spinal stability, which may cause injury and accelerated tissue degeneration [1,2]. While it is known that flexion leads to viscoelastic changes, a better understanding of changes in flexion passive stiffness following different work-to-rest ratios remains necessary prior to making ergonomic recommendations.

Aim: To investigate the timeline of viscoelastic tissue changes during a single bout of sitting and subsequent recovery through analyzing changes in the lumped lumbar passive stiffness.

Methods: Twenty-four (12M, 12F) will be recruited to complete this study. First, participants' habitual sitting postures will be determined at their typical workstations over an hour-long period. Participants will be instrumented with two tri-axial accelerometers, on the L1 and S1 spinous processes which will act as tilt sensors to calculate lumbar spine flexion. Mean lumbar flexion angle will be expressed relative to percentage of maximum standing flexion and used as a covariate in statistical analysis. On another day, participants will complete three simulated computer work protocols of varying durations (5, 10, 20 minutes) followed by a 2-minute walking break. Participants will be instrumented with individual passive reflective markers and lumbar and pelvic marker clusters that will be tracked by Arqus9 infrared cameras (Qualisys, Goteborg, Sweden). Lumped lumbar passive stiffness will be measured via a custom mechanized frictionless passive jig at baseline, immediately after each sitting block, and following the active recovery. The moment-angle curve will be analyzed via breakpoint analysis [3], partitioning the curves into the low, transition, and high stiffness areas. Two-way mixed measures analyses of covariate variance (ANCOVAs) will be performed separately on data following sitting and recovery conditions to compare between sitting durations (baseline, 5, 10, 20 minutes) and biological sex (male or female), with habitual posture as a covariate variable. Post hoc pairwise comparisons will be performed using a Bonferroni correction.

Expected Results: It is expected that with increase in sitting duration there will be an increase in passive ROM due to viscoelastic tissue changes [4]. Additionally, the low stiffness zone range will expand, and transitions between stiffness zones will occur at higher lumbar flexion angles [5]. These changes may recover after a walking break following shorter sitting bouts (5, 10 minutes) but will not fully recover following a longer sitting bout (20 minutes). It is also expected that individuals whose habitual sitting posture is more flexed will experience less viscoelastic tissue changes following a sitting bout.

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MEASURE TWICE, APPLY ONCE: EVALUATING THE INFLUENCE OF FOREARM SURFACE ELECTRODE PLACEMENT ON DATA QUALITY

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Introduction: There are many aspects of the electromyography collection and analysis process that could lead to errors in the interpretation of muscle activity data. One critical aspect is the placement of electrodes, especially over the forearm where many muscles are in close proximity [1]. There are many electrode placement guides, including SENIAM, which are based on anatomical landmarks (AL) and textbooks that provide AL to approximate the motor point (MP) [2]. The alternative is to detect individual MPs and place the electrodes accordingly. This study evaluated if there is a difference in placement location, time and perceived discomfort between using AL or the detected MP and if the techniques influenced signal characteristics.

Methods: 20 participants (10M, 10F; 23.0±5.3 years) visited the lab twice, where electrodes were placed using one of two set-up techniques: 1) using ALs or 2) finding individual MPs. Six pairs of bipolar pediatric sized Ag/AgCl electrodes were applied over FCR, FCU, FDS, ECR, ECU and EDC. Forearm length and proximal forearm circumference were measured and participants performed maximal voluntary isometric wrist contractions (radial/ulnar/flexion/extension) against a load cell, in a neutral wrist posture, with the elbow flexed to 90°. Participants then performed wrist contractions at 3 force intensities (10%, 30%, 50% MVC) across all 4 directions, in a randomized order. Signals were bandpass (10-500Hz) then Butterworth low pass filtered (4^{th} order, dualpass, 6.4Hz cut-off). Outcome measures included mean voltage and mean power frequency.

Results: For all muscles except the FCR and FCU, there was up to a 1cm difference in the electrode locations between set-up techniques in either the medial/lateral or proximal/distal location, but never both. The MP method took significantly longer per muscle than AL (41.8±10.0s, 17.9±14.0s) and participants reported minor to mild discomfort in the process of identifying the MP. Average signal amplitude for FCR was 51% greater for the MP set-up compared to the AL, regardless of contraction type or intensity. ECR was 105% greater but the difference only became significant under 50% MVC. ECU had a greater amplitude for the MP method during flexion (17.2±2.1mV vs 8.0±0.9mV) and ulnar deviation (39.6±3.1mV vs 23.3±2.3mV). There was a significant difference in mean power frequency for FDS (171.2±22.52Hz vs 166.2±24.8Hz) and EDC (174.4±18.3Hz vs 186.3±27.4Hz) between the two electrode configurations. The difference in the amplitude and frequency domain between locations had a positive correlation with forearm length (r=0.50 and 0.49, respectively).

Discussion and Conclusions: The differences in electrode locations were small but had a significant impact on recorded data. Our results provide confidence in suggesting that best practice should include taking the time to find individual MPs.

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METHODOLOGICAL CONSIDERATIONS IN SHEAR WAVE ELASTOGRAPHY: EFFECTS OF GEL STANDOFF AND PROBE ORIENTATION ON MUSCLE AND ADIPOSE TISSUE MEASUREMENTS

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Introduction: Shear wave elastography (SWE) is an advanced non-invasive ultrasound technique that quantifies tissue stiffness by measuring the propagation speed of shear waves, allowing for the estimation of tissue elastic modulus (E) [1]. Despite its growing use, no standard methodology currently exists for acquiring optimal SWE measurements in soft tissues. Previous research has shown that imaging superficial tissues is challenging. Gel standoffs can be used to help position tissue within the probe's focal zone while dispersing probe pressure [2]. Additionally, probe orientation affects SWE by influencing the direction in which waves propagate through tissues; although orientations can vary, most studies align the probe longitudinally to muscle fiber direction [3]. However, little is known regarding optimal probe orientation for adipose tissue. Therefore, this study aimed to assess the effects of standoff use and probe orientation on SWE-derived E values at two clinically relevant thigh locations.

Methods: Ten females participated (age: 24.7 ± 2.1 years, BMI: 20.7 ± 2.4). Thigh soft tissue properties were measured using a research-grade ultrasound (GE LOGIQ E10) with a linear probe (L2-9VN-D) at two locations: peak pressure location during a lateral fall (PD; 6 cm distal, 3 cm posterior to the greater trochanter) and rectus femoris mid-belly (RF). Twelve randomized trials per location were performed (3 per condition: longitudinal/transverse × standoff/no standoff), with three frames acquired per trial. Tissue-specific E values were calculated using established acoustoelastic theory [1]. At each location, three-way repeated measures ANOVAs tested the effects of standoff, orientation, and tissue type on E variability (SD) and means.

Results: At the PD location, SD and mean E were influenced by tissue type and standoff, with significant standoff × tissue interactions ($p < 0.001$). SD and mean E values were lower with a standoff in muscle and deep adipose ($p < 0.01$), with no significant effect in superficial adipose. In contrast, at the RF location tissue type was the primary factor for both metrics (SD: $p = 0.004$; Mean: $p < 0.001$), with higher variability and modulus in muscle. Orientation yielded no significant effects at either location ($p > 0.05$).

Discussion and Conclusions: For reliable SWE measurements and decreased variability, tissue type and the use of a gel standoff should be considered. While standoffs are often thought to primarily affect superficial tissues, they significantly influenced mean and SD E values in deep adipose and muscle tissues. Tissue type remained the primary determinant of E, highlighting the importance of intrinsic tissue properties and tissue-specific measurements. These results emphasize that SWE measurements are influenced by factors such as standoff use and tissue characteristics, highlighting the need for consistent setup and careful protocol design to enable meaningful comparisons across studies.

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STROKE RATE AND DRAG FACTOR INFLUENCE POWER AND FORCE DURING ERGOMETER ROWING

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Introduction: Rowing is a power-endurance sport in which performance depends on the effective generation and coordination of force and power throughout the stroke cycle [1]. Stroke rate (SR) and drag factor (DF) are two key variables that influence power output and force production during ergometer rowing. However, their combined effects on power and force profiles remain poorly understood [2,3]. The purpose of this study was to determine how manipulation of SR and DF affects force and power profiles in experienced rowers. It was hypothesized that higher SR would be associated with lower peak force but greater mean power, and that increasing DF would elevate force by raising inertial resistance.

Methods: Fifteen experienced rowers were recruited from the McMaster University Rowing Team. Following a five-minute self-directed warm-up, participants completed nine 90-second bouts on a Concept2 rowing ergometer (Concept 2, Morrisville, VT, USA). Bouts were completed across three DF conditions (-5%, typical, and +5% of typical) and three SR conditions (28, 32, and 36 strokes per minute (spm)) randomized within each DF condition. Up to five minutes of rest was provided between bouts. Mean stroke power (W) and mean drive force (arbitrary units) were extracted for each bout and entered a 3×3 repeated measures ANOVA with stroke rate and drag factor as within-subject factors.

Results: Only main effects of SR and DF were found; no significant interaction was found for either mean drive force or mean stroke power. Mean drive force showed significant main effects for both SR ($p < 0.001$) and DF ($p = 0.003$), with greater force at 36 than 28 spm ($p = 0.005$) and lower force at -5% than typical drag ($p = 0.022$). Mean stroke power showed similar significant main effects of SR ($p < 0.001$) and DF ($p = 0.018$). Power increased from 28 spm (230 ± 60 W) to 32 spm (256 ± 61 W) to 36 spm (282 ± 64 W), with all pairwise comparisons being significant ($p < 0.001$). For DF, power was lower at −5% DF (246 ± 59 W) compared to both typical (264 ± 62 W, $p = .018$) and +5% DF (258 ± 62 W, $p < 0.001$), while typical and +5% DF did not differ ($p = 0.412$)

Discussion: These findings indicate that SR and DF act independently, not interactively, to influence power and force profiles during ergometer rowing. Power and force increased with SR, yet the magnitude of change in force was small relative to the power increase, suggesting rowers primarily achieve higher power through increased stroke rate. DF effects were only detected at the lower boundary, with no significant difference between typical and +5% conditions, suggesting that small increases in drag above an individual's baseline may be insufficient to produce detectable changes in mechanical output. These findings highlight the importance of accounting for both SR and DF when designing ergometer-based training or testing protocols, as the mechanical demands placed on rowers differ depending on which variable is manipulated. Future research should examine longer durations and relate SR and DF to on-water conditions.

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LUMBAR ERECTOR SPINAE ACTIVATION PATTERNS USING HIGH-DENSITY SURFACE ELECTROMYOGRAPHY

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Introduction: High-density surface electromyography (HD-sEMG) uses 2D electrode grids to capture muscle activity with high spatial resolution. Unlike traditional surface EMG, HD-sEMG can characterize neuromuscular control strategies, including the spatial distribution of motor unit recruitment across a muscle. Distinct regional activation patterns have been documented in the lumbar erector spinae during dynamic tasks and in individuals with low back pain [1][2]. Normative HD-sEMG data for this muscle in healthy populations remain scarce, limiting its use as a reference for biomechanical research.

Aim: The objective of this study is to characterize the spatial distribution of lumbar erector spinae muscle activation in healthy individuals using HD-sEMG-derived activation heat maps. This study aims to determine whether caudal regions of the lumbar erector spinae demonstrate greater activation relative to cranial regions during prone isometric back extensions.

Methods: Twenty recreationally active university-aged adults (10 male, 10 female) with no history of low back injury will be recruited via email and poster advertising. Electrode placement over the lumbar erector spinae will be guided by ultrasound device with data collected using the Novecento+ (OT Bioelettronica, Turin, Italy). Force will be measured using an analog dynamometer. Participants will perform multiple back extensions at different MVC intensities of 100% 60%, 30%, and 10% of MVC.

Expected Results: It is expected that HD-sEMG-derived activation heat maps will reveal a non-uniform spatial distribution of lumbar erector spinae activity, with greater activation concentrated in the caudal regions of the muscle during prone isometric back extension. Overall activation amplitude is expected to increase with MVC intensity, with the caudal activation bias persisting or becoming more pronounced at higher contraction levels. Given that participants are recreationally active and free of low back pain, bilateral activation patterns are expected to be relatively symmetrical. These findings would establish normative lumbar erector spinae activation patterns in healthy individuals, providing a reference for comparison with clinical populations.

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DEVELOPING PATIENT EDUCATION MATERIALS TO AID THE INFORMED CONSENT PROCESS FOR BIOMECHANICS STUDIES

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Introduction: Informed consent is essential for ethical research participation; however, complex procedures can be difficult for potential participants to fully understand through conventional informed consent processes [1]. This can lead to increased participant anxiety, reduced willingness to enrol, or withdrawal due to mismatched expectations [2]. Although patient education materials (PEMs) have been tested in surgical and medical informed consent processes, their use in non-surgical clinical trials remains underexplored and uncertain.

Aim: This qualitative study aims to determine educational needs of potential participants to provide fully informed consent in clinical trials conducted in a biomechanics laboratory at the Toronto Rehabilitation Institute. Our specific objectives are to determine whether previous participants believe PEMs would be helpful for the informed consent process and the ideal characteristics of these PEMs.

Methods: We will recruit 24 previous participants from two ongoing trials involving chronic stroke survivors and healthy older adults. Semi-structured interviews will explore participants' experiences with the existing consent process and their opinions on characteristics of PEMs. Data will be deductively coded using the Integrated Behavioural Model (Figure) to identify themes related to attitudes, norms, and perceived control influencing research participation.

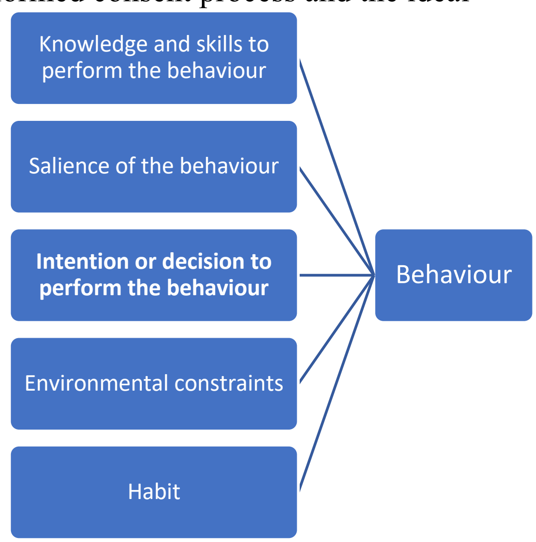

Figure: Integrated Behavioural Model adapted from Montaño & Kasprzyk., 2008 [3]

Expected results: Findings will inform the development and testing of PEMs tailored to enhance comprehension of complex research procedures and improve participant preparedness. This study will support the creation of evidence-based tools to strengthen informed consent processes within biomechanics research and may serve as a model for other research contexts.

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FLEXION-INDUCED CREEP & ITS IMPACT ON THE SPINE

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Introduction: Low back pain (LBP) is common in athletes participating in high-impact sports such as basketball, where repeated jumping, rapid directional changes, and prolonged sitting impose mechanical stress on the spine [1]. Sustained spinal flexion can produce creep, the gradual elongation of viscoelastic tissues under prolonged load, reducing passive stiffness and increasing spinal instability upon return to dynamic movement [2]. The annulus fibrosus (AF) maintains intervertebral disc (IVD) integrity by resisting tensile stress; however, prolonged flexion may alter annular mechanical behaviour and interlamellar adhesion [3]. This study aimed to determine how creep affects fracture biomechanics, AF mechanical behaviour, and disc height loss compared to a neutral posture.

Methods: Thirteen porcine cervical functional spinal units (C3/C4 and C5/C6; ~6 months of age) were randomly assigned to a creep condition (n = 6; 15° flexion, 500 N, 30 minutes) or a neutral control (n = 7; 0° flexion, 500 N, 30 minutes), following a 15-minute preload at 300 N. Post-loading, specimens underwent fracture testing (MTS Systems Corp., MN, USA), interlamellar peel testing (UStretch, CellScale, ON, Canada), and AF tensile testing (BioTester 5000, CellScale, ON, Canada). Disc height loss was derived from MTS displacement data. Independent t-tests ($\alpha = 0.05$) were used, with normality assessed via Shapiro–Wilk. Effect sizes were calculated using Cohen's *d*.

Results: Disc height loss over the 30-minute period was three times greater in the creep condition compared to the neutral condition ($p = 0.041$; Cohen's $d = 1.29$). However, creep did not significantly alter failure force or compressive stiffness ($p > 0.05$). No significant differences were observed in AF tensile or peel properties. However, toe-region stress in the AF tensile tests showed a large effect size (Cohen's $d = 0.90$), with creep resulting in lower toe region stress compared to the neutral condition.

Discussion and Conclusions: Sustained flexion decreased toe region stress in the AF and increased disc height loss without significantly affecting fracture mechanics. Reduced toe-region stress suggests a more compliant and potentially vulnerable AF, which may increase injury risk when athletes transition to high-intensity activity.

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THE INFLUENCE OF RESISTANCE TRAINING STATUS ON FOREARM MUSCLE ACTIVITY, WRIST KINEMATICS, AND REVISED STRAIN INDEX SCORES DURING SIMULATED PAINTING AND TARPING TASKS

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Introduction: Despite the many successes of traditional ergonomic interventions, forearm musculoskeletal disorders (MSDs) continue to be problematic within the workforce [1]. However, not all individuals develop MSDs, even for those working in the same occupational setting. This suggests that there may be certain mechanical/neuromuscular factors that contribute to MSD development. Previous research has demonstrated that chronically resistance trained individuals likely possess unique mechanical/neuromuscular adaptations compared to people who are untrained [2,3]. These adaptations may offer protective effects against MSD development; trained individuals produce less muscle activity in tasks with absolute force requirements, and they demonstrate greater joint RoM [2, 3]. However, it remains unclear how these adaptations might translate to the workplace and, by extension, provide protective benefits against upper limb MSDs.

Aim: To quantify how forearm muscle activity, wrist joint motion, and Revised Strain Index (RSI) scores differ between chronically resistance trained and untrained individuals during a simulated painting and a simulated tarping task.

Methods: Using surface electromyography, muscle activity will be collected from three forearm muscles of the dominant right arm: flexor digitorum superficialis, extensor digitorum, and extensor carpi ulnaris. Wrist motion will be quantified with a twin-axis digital goniometer (SG75, Biometrics, Newport, UK), and RSI scores will be derived from Borg CR-10 scale participant ratings, muscle activity, and wrist kinematics. Trained (engagement in resistance/strength training for at least 2 years, 3-4 times a week) and untrained participants (no engagement in resistance/strength training for at least 2 years) will perform two simulated workplace tasks: 1) painting a 2.2m^2 wall with a handheld paint roller, and 2) applying plastic tarp with a manual staple gun to 15 different sites located on bare studs spaced 400mm apart on-center (National Building Code of Canada).

Expected Results: When completing the simulated workplace tasks, it is expected that trained individuals, in comparison to their untrained counterparts, will likely exhibit less forearm muscle activity, more neutral wrist postures (relative to individual maximums), and decreased ratings of perceived exertion. Collectively, this is anticipated to translate to lower RSI scores. This would therefore suggest that trained individuals might be at a decreased risk for sustaining workplace upper limb MSDs and offer a potential initiative for new practices to support worker health.

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FOOT CORE ADAPTATIONS IN ADOLESCENT BALLET DANCERS: EFFECTS OF POINTE TRAINING AND SPORT SPECIALIZATION

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Introduction: Ballet places increasing mechanical demands on the foot due to repetitive plantarflexion and forefoot loading [1]. Pointe work further increases vertical loading requiring intrinsic muscle function, arch height changes under load, and sensory feedback to maintain alignment [1]. These components form the foot core system, including passive (bones and ligaments), active (muscles), and neural (sensory) subsystems, which contributes to foot stability and load distribution [2]. Barefoot exposure may influence foot core subsystems, while foot dominance may contribute to asymmetries in foot structure and function [3,4]. However, little is known about how these subsystems differ across stages of ballet training or how sport specialization relates to developmental outcomes in adolescent dancers; previous research suggests higher levels of sport specialization may be associated with lower physical literacy and reduced Health Related Quality of Life (HRQOL) [5].

Aim: To examine whether differences in foot core characteristics and sports specialization exist between adolescent ballet dancers prior to initiating pointe training and those with pointe experience and to explore associations between physical literacy and HRQOL in ballet dancers.

Methods: This cross-sectional study will recruit 56 adolescent dancers (pre-pointe or pointe-trained ≥1 year). The passive subsystem will be assessed using the Arch Height Index at 10% and 90% body weight. The active subsystem will be evaluated using ultrasound imaging (Clarius, L15 HD3 probe) to measure cross-sectional area of the abductor hallucis. The neural subsystem will be assessed using plantar two-point discrimination (Baseline Discrim-A-Gon). Sport specialization will be measured using the Jayanthi Sport Specialization Scale, physical literacy using the PLAYself questionnaire, and HRQOL using the Pediatric Global Health (PGH-7) instrument. Linear regression will assess differences in foot core measures by pointe status, with years of dance as a covariate. Physical literacy and HRQOL will be compared across sport specialization levels using one-way ANOVA, with $p < 0.05$ (JASP v.0.95.1).

Expected Results: Pointe dancers are expected to show differences in foot core characteristics, including greater intrinsic muscle size, altered arch height changes under load, and enhanced plantar sensory acuity compared to pre-pointe dancers. Greater barefoot exposure may be associated with differences in intrinsic muscle size, arch height changes under load, and plantar sensory acuity, while foot dominance may contribute to interlimb differences. Higher levels of sport specialization are expected to be associated with decreased physical literacy and HRQOL.

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DOES EARLY FUNCTIONAL ELECTRICAL STIMULATION IMPROVE GAIT BIOMECHANICS AFTER ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION? A PILOT RANDOMIZED CONTROLLED TRIAL

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Introduction: Following ACL reconstruction (ACLR) surgery, reductions in quadricep strength, knee flexion angles, and knee extensor moments are common [1]. These deficits reflect impaired neuromuscular activation and are linked to post-traumatic knee osteoarthritis [2]. Functional Electrical Stimulation (FES) enhances neuromuscular activation and has been shown to improve quadriceps strength following ACLR compared to standard rehabilitation alone [3]. However, its effects on gait biomechanics are unclear. The aim of this study is to determine whether adding FES to rehabilitation following ACLR improves gait biomechanics more than rehabilitation alone.

Methods: Twenty ACLR candidates aged 18-50 will be recruited. Exclusion criteria include previous ACL injuries, major health issues, or contraindications to FES (e.g., pacemakers). Intervention: Participants will be randomly allocated to two groups: Rehab+FES or Rehab Only. The Rehab+FES group will attend 12 lab sessions over 4 weeks using a Chattanooga Continuum Stimulator (Chattanooga, USA) with a foot sensor to deliver quadriceps FES synchronized with gait. Each session includes 10 minutes of walking with progressively increasing stimulation intensity, following a protocol adapted from prior work [3]. The Rehab Only group will receive no additional treatment. Data collection: Data will be collected at baseline and post-intervention. Gait data will be collected using Theia3D markerless motion capture (Theia Markerless, CAN) and AMTI force plates (AMTI, USA). Knee extensor and flexor strength will also be measured during maximal isometric voluntary contractions using a Humac Norm Dynamometer (HUMAC, USA). To compare the improvement between the two groups, peak knee flexion angle and peak knee extensor moment and neuromuscular control of the quadriceps and hamstrings (peak activations and delay) during gait will be compared between the groups using a linear mixed-effect model with fixed effects for group (Rehab+FES vs Rehab Only), time (baseline vs follow-up), and their interaction, with participant as a random effect.

Expected Results: The Rehab+FES group is expected to demonstrate greater improvements in peak knee flexion angle and knee extensor moment during gait, as well as quadriceps muscle activation, compared to the Rehab Only group.

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Labral Mechanics After Femoroacetabular Impingement (FAI) Related Surgery: An Integrated In Vitro Imaging Study

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INTRODUCTION

Cam-type femoroacetabular impingement (FAI) is a major cause of labral and cartilage injury and may progress to early osteoarthritis. Because the acetabular labrum plays a central role in joint stability, force distribution, and the suction seal, understanding how hip preservation procedures influence its deformation is critical. This study quantified labral strain across key surgical stages for FAI using a CT-integrated testing system, and imaging across multiple joint positions.

METHODS

Twenty paired cadaveric hips (age 61 ± 9 years; 10 male, 10 female) without prior pathology were mounted on a CT-compatible positioning rig after removal of soft tissues. Each hip was CT imaged (Canon Aquilion ONE) in nine combined positions of flexion (0°, 60°, 90°)and axial rotation (neutral, internal, external rotation). Following capsulotomy, eight 0.8 mm titanium beads (4 labral, 4 acetabular) were placed in a curvilinear pattern. Paired hips were randomized to two surgical sequences: Protocol A**:** cam over-resection, labral tear, repair, and reconstruction with posterior tibial tendon; Protocol B**:** labral tear, repair, reconstruction, and cam over-resection, where the capsule was repaired after each stage. A custom MATLAB workflow extracted bead coordinates and calculated radial strain at each stage, where statistical analyses were assessed with Friedman tests and post-hoc Wilcoxon comparisons ($\alpha = 0.05$).

RESULTS

In Protocol A, labral reconstruction consistently produced greater radial strain than the native and repaired states in all positions ($P < 0.01$; Figure 1.B1). In Protocol B, reconstruction with an open capsule increased strain at 90° flexion in internal rotation compared with native ($P = 0.03$; Figure 1.B2). With capsular closure at 0° flexion in external rotation, reconstruction also generated higher strain than both the native and repaired labrum ($P < 0.05$).

DISCUSSION

Labral reconstruction showed the highest strain, whereas cam over-resection and labral tears did not substantially change deformation compared to native hip. These findings also suggest the native labrum can keep the strain low after tissue changes. This work advances our understanding of how specific surgical steps alter labral mechanics and helps clarify whether increases or decreases in labral strain may place the hip joint at risk.

Title: Developing a Digital Reconstruction Framework for Fragmented Hominin Scapulae

Introduction:

Human evolution offers critical insights into the structure and function of the musculoskeletal system, informing both evolutionary adaptation and current biomechanics [1-2]. The field of bioarchaeology takes on a holistic approach enriched with cultural, ecological and morphological evidence used to interpret hominin mobility [3]. Implications of upper limb function and locomotion are limited in its interpretation due to the fragmentary state of remains, specifically the shoulder complex. Without accurate reconstruction of bony morphology, geometric relationships, and articular surfaces, we are unable to examine the evolutionary trajectory of the shoulder complex [4]. While advances in digital 3D reconstruction have enabled non-destructive analysis, standardized and validated methods for reconstructing scapulae from fragments remains underdeveloped.

Methods:

The study will aim to develop a reproducible digital reconstruction framework for fragmented scapulae, grounded in both experimental and comparative approaches. A reference data set of complete scapulae will be partially fragmented to simulate archaeological conditions. These fragments will then be utilized to test reconstruction approaches, allowing comparison between reconstructed models and the known original form. The model will use progressively limited anatomical landmarks as parameters to accurately reconstruct the scapulae.

Expected goals:

We plan to establish a robust methodological framework for reconstructing scapulae from incomplete remains, identifying key anatomical landmarks, articular surfaces, and geometric constraints necessary for accurate assembly. These findings would allow us to reconstruct necessary muscle pathways to infer function and range of motion, which can be compared across species. The resulting framework would enhance the reliability of scapular reconstructions used in bioarchaeology. The improvement of upper-limb reconstruction will expand the usability of fragmentary material, improve interpretations related to shoulder function, locomotor behavior and adaptation.

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TEAMWORK MAKES THE DREAM WORK: THE IMPACT OF CUTANEOUS SENSORY INPUT ON MOTOR UNIT FIRING BEHAVIOUR DURING SUSTAINED ACTIVATION.

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Introduction: Motor unit (MU) recruitment strategies, such as MU rotation and MU substitution, can mitigate neuromuscular fatigue and prolong force producing capacity [1]. Work from our lab has demonstrated that heel cutaneous stimulation (HL-STIM; excitatory to soleus) can prolong time to task failure during a submaximal plantarflexion [2]. Currently, the mechanisms underlying this are not well understood, but we suggest alternating MU activation may be involved [2]. Cutaneous stimulation has also been shown to alter MU recruitment gain, facilitating recruitment of higher threshold units [3]. Excitatory inputs from cutaneous stimulation could feasibly influence MU recruitment patterns, increasing the prevalence of strategies such as MU rotation and MU substitution, to mitigate fatigue.

Aim: To investigate the influence of HL-STIM on MU recruitment patterns of the plantar flexors during a sustained, low-level contraction.

Methods: While seated, 5 healthy, young adults (2F, age: 25±3yrs) performed 60-minute isometric plantarflexions at ~1% of their maximal plantarflexion force, separated by a 60-minute break. Two conditions were tested in random order; a control condition with no stimulation (NO-STIM), and HL-STIM. We measured force variability (coefficients of variation from the target force), surface electromyography (EMG) from the triceps surae and tibialis anterior, as well as soleus single MU activity using fine-wire EMG. To explore differences in MU behaviour across conditions we examined 1) the presence of, and 2) proportion of time intermittent MUs (MU de-recruited and re-recruited at least 3 times) were active, and 3) firing rates at onset of recruitment.

Preliminary Results: Thus far, 30 soleus MU were recorded (NO-STIM:16, HL-STIM:14). In both conditions, an intermittent pattern of MU recruitment was observed. This pattern was observed more frequently in HL-STIM (4/5 participants) than in NO-STIM (2/5 participants). Intermittently active MUs in NO-STIM were active for a greater proportion of the contraction (NO-STIM: 63±15%, HL-STIM: 56±26%). MUs recruited during HL-STIM showed slightly higher mean firing rates at onset (7.5±1.4Hz vs 6.4±0.8Hz in NO-STIM). Importantly, the increased firing rates seen with HL-STIM did not appear to alter force variability (NO-STIM:1.56±1.26$\%_{MVC}$, HL-STIM: 1.21±0.55$\%_{MVC}$). Our preliminary findings suggest that HL-STIM, through potential excitatory input, may modulate MU recruitment patterns during sustained low intensity contractions. Modulations such as a greater prevalence of intermittent MUs, reduced proportions of MU activation, and increased firing rates are consistent with increased patterns such as MU rotation and/or substitution. These changes may leverage the use of existing strategies to mitigate neuromuscular fatigue and therefore may have potential implications for athletic performance and daily mobility.

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INVESTIGATING THE ASSOCIATION BETWEEN PROGRESSIVE FOREARM FATIGUE DEVELOPMENT AND ISOMETRIC WRIST FORCE ACCURACY

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Introduction: Previous research has demonstrated that fatigue-induced impairments in wrist movement accuracy recover rapidly upon cessation of the fatigue-inducing contraction despite long-lasting impairments in maximal voluntary contraction (MVC) force [1,2]. Not only does this indicate that different fatigue metrics are likely not correlated, but it is also concerning from a workplace injury perspective; worker performance may be unimpaired despite potentially severe and undetected fatigue. It is therefore important to identify the magnitude of MVC force loss that must occur before impairments in motor performance are first observed.

Aim: To determine how progressive fatigue-induced MVC force losses correspond with wrist force accuracy and wrist force steadiness during an isometric wrist force matching task.

Methods: Participants were seated with their forearm secured in a custom device. For the fatiguing contractions, participants exerted maximal isometric wrist flexion or wrist extension force (different sessions) down into a force transducer placed against their distal metacarpals. For the force matching task, participants attempted to match successive targets of 10, 30, and 50% of their antagonist MVC force by exerting upwards against a second force transducer. Each target lasted for 5 seconds, and matching trials occurred both at baseline (before the fatiguing contraction) and after every 10% loss in agonist MVC force sequentially from 90 to 30% of baseline MVC force.

Preliminary Findings: While some performance metrics, such as variability, seem to exhibit a linear change that coincides with fatigue development, other metrics demonstrate a more obvious "threshold" effect. For example, time on target (defined as time spent within 1% of target force) seems to decrease after just 10% of MVC force loss (Flexion Baseline: 0.49 ± 0.19s, 90%: 0.26 ± 0.22s) (Extension Baseline: 0.51 ± 0.16s, 90%: 0.24 ± 0.22s) (Figure 1) before levelling off.

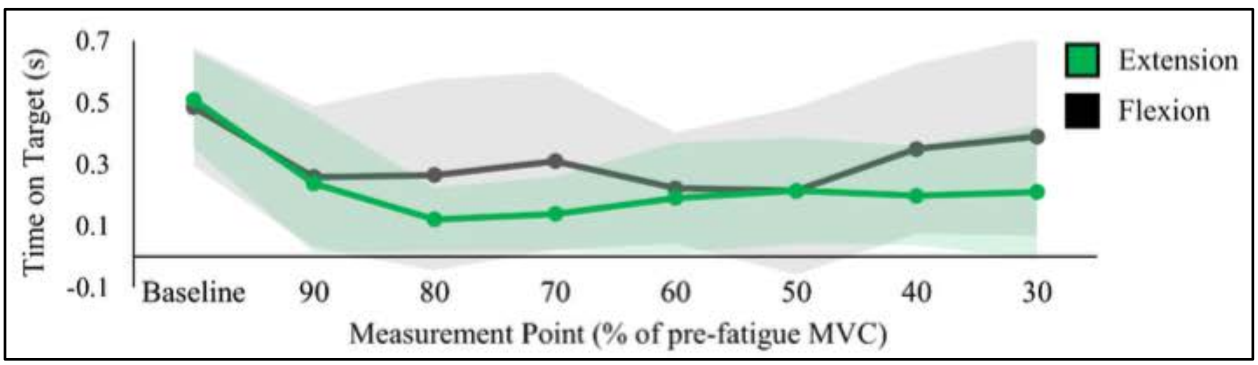

Figure 1: Group means ± SD (n = 12) for time on target (10% target) at baseline and every 10% of force loss. Green line represents wrist extension force matching; grey line represents wrist flexion force matching.

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EFFECTS OF INDENTER HEAD MATERIAL AND COMPOSITION ON SPINAL STIFFNESS MEASUREMENT OUTPUTS AND REPEATABILITY

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Introduction: Spinal indentation devices have been developed to provide objective measurements of spinal stiffness, reducing the subjectivity of manual assessment [1]. One such device, the X-PRESS-O [2], utilizes a deformable coffee ground indenter head to maximize contact and comfort, while producing force-displacement curves clinically relevant to low back pain assessment [2]. However, factors influencing these outputs and their repeatability, including indenter head material and composition, have yet to be explored [2,3]. The indenter head is a critical factor as it makes direct contact with the patient and transmits force, potentially influencing stiffness values and its utility for individuals with low back pain [3]. The optimal indenter head design will therefore require a balance of material compliance and repeatability.

Aims: To investigate how indenter head material and composition influence measured stiffness outputs, with a secondary analysis quantifying the repeatability within different indenter heads.

Methods: The X-PRESS-O will apply a pre-load force of 10 N and a maximum force of 100 N to a 3D-printed spinous process model. Five indenter heads composed of varying materials will be tested: a balloon completely filled with coffee grounds, a balloon half-filled with coffee grounds, a balloon filled with sand, D30, and foam. Fifteen consecutive indentation trials will be applied to the apex of the model for each indenter condition. Stiffness values will be calculated from the slope of the loading phase. A One-Way Analysis of Variance (ANOVA) will be used to compare stiffness values across indenter heads. Repeatability will be assessed using an Intraclass Correlation Coefficient with a Two-Way Mixed Effects Model (ICC(3,k)). Linear regression will be used to evaluate repeatability of stiffness outputs.

Expected Results: Indenter head material and composition are expected to significantly impact measured stiffness values and repeatability. Granular materials like coffee grounds and sand are expected to show reduced repeatability due to deformation, increased contact area, and internal compaction across trials. Structured materials such as D30 and foam are expected to demonstrate greater repeatability. This study is expected to identify an indenter head which optimizes both compliance and repeatability for consistent spinous process contact. These findings will inform the importance of indenter head design for obtaining reliable spinal stiffness measurements for clinical assessment of individuals with low back pain.

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Preventing Musculoskeletal Disorders in Ophthalmologists: Evaluating Ergonomic Slit Lamp Designs

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Introduction: Ophthalmologists are at an elevated risk for work-related musculoskeletal disorders,[1,2] and slit lamp examination has been identified as a major contributor due to repetitive and sustained awkward postures[3]. An Ergonomic Guide and Best Practice Recommendations for slit lamp examinations was recently developed, although its feasibility with traditional slit lamp designs versus ergonomically focused slit lamp designs (e.g. those with adjustable oculars) remains unknown.

Aim: The research objective is to evaluate traditional and ergonomically focused slit lamp designs against the recommendations outlined in the Ergonomic Guide to determine which designs better enable ophthalmologists to maintain the recommended working postures during slit lamp examinations. A secondary goal is to generalize this occupational-based Ergonomic Guide towards an exposure-specific guide.

Methods: Twenty ophthalmologists and trainees will participate in a within-subject repeated-measures study to evaluate cervical and lumbar spine postures during slit lamp examinations across three slit lamp configurations. Musculoskeletal symptoms, discomfort, fatigue, and useability will be assessed following each slit lamp design with The Nordic Musculoskeletal Questionnaire, Cornell Musculoskeletal Sedentary Discomfort Questionnaire, Whole-Body pain and fatigue Visual Analog Scales, and the NASA-Task Load Index. Biomechanical and postural analysis will be measured using inertial measurement units which will quantify head-trunk angle and lumbar spine angle in both sagittal and frontal planes.

Expected outcomes: It is hypothesized that postures adopted during traditional slit lamp use will not meet the Best Practice Recommendations, whereas ergonomically inclined slit lamp designs (e.g. those with ocular adjustability) will facilitate postures that more closely align with the recommended neutral positioning compared to the traditional slit lamp use.

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PSYCHOSOCIAL RISK FACTORS COMMON TO BOTH MUSCULOSKELETAL AND PSYCHOLOGICAL OUTCOMES IN THE WORKPLACE: A SYSTEMATIC REVIEW

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Introduction: Psychosocial factors in the workplace have been independently associated with both musculoskeletal disorders (MSD) and psychological health outcomes. However, the commonality in these factors and their contribution to both types of conditions remain unclear. The objective of this systematic review was to identify psychosocial risk factors in the workplace that were associated with both MSD and psychological outcomes.

Methods: A systematic review was conducted to identify papers that report on the relationship between psychosocial factors and both MSD and psychological outcomes. The electronic databases MEDLINE [Ovid], PsycINFO [Ovid], Sociological Abstracts [Proquest], and CINAHL were utilized for this search. With search terms such as "occupational stress", "musculoskeletal disorders", and "occupation". Only cross-sectional and longitudinal studies were included, and studies reporting on individual factors such as sociodemographic data were excluded. A risk of bias assessment was completed using the Institute for Work & Health Quality Appraisal Tool

Results: 5782 studies were identified through the search with 21 meeting criteria to be included in our analysis as they observed psychosocial risk factors, psychological outcomes, and MSD outcomes. Out of 21 included studies, 15 had significant associations with both MSD and psychological outcomes. Thematic grouping of risk factors was conducted to better understand how individual factors are associated with outcomes. The most common factor, social support and dynamics (including leadership support), was examined in 19 papers. Abuse was found to be the factor with largest proportion of papers linking it to both MSD and psychological outcomes. Evidence varied by occupational group and measurement method. Risk of bias was generally low, with participant differences contributing to quality.

Discussion and Conclusions: This review presents common psychosocial risk factors contributing to both musculoskeletal and psychological health outcomes in the workplace. Integrated interventions targeting these shared risk factors may have a greater impact on worker health, safety, wellbeing, and productivity.

COMPARING FOREARM MUSCLE ACTIVITY, WRIST KINEMATICS, AND REVISED STRAIN INDEX SCORES BETWEEN RESISTANCE-TRAINED AND UNTRAINED INDIVIDUALS DURING A SIMULATED TIRE CHANGE TASK

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Introduction: Previous research has provided indirect evidence that individuals who regularly engage in resistance training may exhibit less muscle activity compared to untrained individuals when completing tasks with absolute force requirements [1]. Similarly, evidence exists that resistance training experience is associated with increased joint range of motion [2], suggesting that trained individuals may be capable of maintaining more neutral joint postures when completing dynamic tasks. Taken together, these findings indicate that resistance-trained individuals may be at a lower risk of developing musculoskeletal disorders than their untrained counterparts. However, the influence of previous chronic resistance training experience on movements specific to workplace tasks remains insufficiently studied.

Aim: To determine how forearm muscle activity, wrist motion, and Revised Strain Index (RSI) scores differ between resistance-trained individuals and individuals with no resistance training experience during a simulated tire change task.

Methods: Participants will be placed into one of two groups: 1) resistance trained, defined as having engaged in resistance training for at least 3x/week for ≥2 years, or 2) untrained, defined as having not engaged in any regular strength training for ≥2 years. In the first session, participants will be familiarized to the simulated tire change task, which will include loosening 5 tightened lug nuts with a breaker bar and re-tightening the same 5 lug nuts with a torque wrench set to 108 Nm. In the second session, muscle activity will be collected from the flexor digitorum superficialis (FDS), the extensor digitorum (ED), and the extensor carpi ulnaris (ECU) while participants complete the loosening and tightening tasks. Wrist kinematics will also be collected using a twin-axis digital goniometer with end-blocks attached to the dorsal surface of the third metacarpal and the midline of the distal forearm. Synchronized muscle activity and wrist motion, combined with participant Borg CR-10 ratings, will then be used to calculate a modified RSI. All outcome measures will be analyzed using an amplitude probability distribution function (APDF) utilizing probability levels of 0.1, 0.5, and 0.9.

Expected Results: Given previous literature [1,2], the resistance-trained group is expected to exhibit less muscle activity, more neutral wrist postures, and lower RSI scores during the simulated tire change tasks. This will be displayed through lower amplitudes across all three probability levels of the APDF.

References:
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VALIDATION OF XSENS LOW-BACK KINEMATICS IN OCCUPATIONAL TASKS

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Introduction:
Inertial measurement unit (IMU) systems provide a portable alternative for capturing movement outside controlled laboratory environments[1]. IMU's that are typically placed high on the trunk, relative to their pelvis sensors, have challenges representing spinal curvature and specifically low-back flexion angles when using traditional approaches, which is why Xsens has recently employed a Spherical Linear Interpolation (SLERP) model to improve low-back orientation[2]. As the accuracy of this model during occupational tasks has not been validated, the purpose of this study was to evaluate the agreement between Xsens MVN Biomech 2.0 trunk-to-pelvis angle estimates and a marker-based motion capture system during occupational tasks.

Methods:
Thirteen healthy adults (8M, 5F) completed simulated workplace tasks including floor-to-shoulder crate lifting (5.7kg), palletizing (5.7kg), packaging objects, a push/pull sled (22.7kg), and full spine range-of-motion trials. Participants were instrumented with full body passive reflective markers and 17 IMUs (Xsens Awinda, Movella, Enschede, Netherlands). Trunk orientation Euler angles were computed with "High" (T1) and "Low" (T12) clusters and pelvis for comparison to the Xsens outputs. Correlation between systems was assessed using Pearson's Correlation Coefficients and Bland-Altman analyses were conducted to quantify bias and limits of agreement.

Results:
Xsens-derived low-back angles showed high to very high correlation to both the High (0.87-0.95) and Low trunk clusters (0.84-0.95) in the sagittal plane across occupational tasks. The transverse plane (High: 0.43-0.89, Low: 0.09-0.62) and frontal planes (High: 0.33-0.86, Low: 0.39-0.72) exhibited low to moderate correlations across all tasks, with high correlation in the transverse (0.89) and frontal (0.86) plane for the High condition in packaging. Bland-Altman analysis in the sagittal plane showed low bias (High: -0.49°, Low: 2.43°) across peak flexion to peak extension for lifting tasks, with moderate ICC (High: 0.67, Low: 0.52).

Discussion and Conclusions:
The Xsens SLERP-based spine model demonstrated high correlation in sagittal plane movements, but low correlation values in the transverse and frontal plane with the highest correlation occurring in the High cluster. While sagittal plane measures of low back orientation appear to correlate closely with marker-based measures and full range-of-motion values were similar, absolute angle differences should be accounted for.

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BRIDGING PHYSICAL AND PSYCHOSOCIAL FACTORS IN LONG-TERM CARE MUSCULOSKELETAL DISORDERS

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Introduction: Musculoskeletal disorders (MSDs) are a leading cause of occupational disability worldwide, with a disproportionate burden in long-term care (LTC), where workers routinely perform demanding resident-handling tasks [1]. Although physical risk factors are well established, psychosocial factors such as low control and inadequate support also shape MSD risk [2]. Yet, these factors are typically studied in isolation, limiting the understanding of how they interact within real injury contexts [3]. This study examines which psychosocial factors most frequently co-occur with MSD incidents in LTC.

Methods: A quantitative, incident-based analysis was conducted on 270 LTC workplace injury claims from Bruyère Health Saint-Louis (Ottawa, Canada; 2021–2024). Incidents were coded using the Job Demand-Control-Support (JDCS) model and RADIUS framework, integrating structured variables with narrative descriptions to capture contextual exposures. Analyses included descriptive statistics, psychosocial factor prevalence, relative risk comparisons, hazard distribution, set intersection analysis, and latent class analysis, with the aim of identifying patterns of co-occurrence and patterns within the dataset.

Results: Of 270 incidents, 96 (35.6%) were classified as MSDs. Physical demands were present in all MSD cases, with physical exposures (52.1%), workload (50.0%), and cognitive demands (36.5%) also frequently observed. MSDs were more likely to involve low control (RR = 2.45) and low support (RR = 2.17), while high demand did not distinguish MSD from non-MSD incidents (RR = 0.90). Most MSD cases involved three to five co-occurring psychosocial factors, peaking at four (48.1%). Latent class analysis identified three injury profiles: (1) constrained-control and support physical strain, (2) cumulative workload strain, and (3) reactive high-intensity physical strain.

Discussion and Conclusion: MSD risk in LTC does not arise from physical demand alone, but from how physical demands are embedded within psychosocial contexts. While demand is universal, it is the presence of reduced control and support that differentiates when and how injury occurs, positioning demand as a baseline condition rather than a sufficient cause. The identification of three distinct injury pathways further indicates that MSDs emerge through multiple, context-dependent mechanisms. Together, these findings suggest the need for integrated prevention strategies that address concurrent exposures.

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EXACERBATION OF PATELLOFEMORAL PAIN LEADS TO ALTERED KNEE JOINT MECHANICS AND SELF-REPORTED PAIN

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Introduction: Patellofemoral pain (PFP) affects nearly 22.7% of the population annually [1]. Persons with PFP employ quadriceps avoidance strategies, reducing knee flexion angles and extensor moments, presumably to lower patellofemoral joint contact forces [2]. However, such compensations may increase the rate of vertical ground reaction force (VGRF) development, which has been linked to elevated tibiofemoral joint contact forces and OA progression in this population [3]. In this study, we utilized a pain exacerbation protocol to examine relationships among self-reported pain, changes in knee joint mechanics, and VGRF loading rate.

Methods: Lower limb kinematics and ground reaction forces were obtained from 45 women (23.7±3.1 years, 63.8±10.9 kg, 1.6±0.5 metres) with PFP during stair descent before and after a pain exacerbation protocol. Following the initial stair descent trials, participants underwent a pain exacerbation protocol previously demonstrated to increase PFP symptoms while avoiding muscle fatigue [3]. The protocol consists of descending a staircase 15 times while wearing a backpack loaded to 35% of the participant's body mass. Self-reported pain was measured pre and post using visual analogue scale (VAS). Relationships between pre-to-post changes in peak knee flexion, peak knee extensor moment (PKEM), average VGRF loading rate, and pain were examined using Pearson correlations with a Bonferroni correction applied ($p < 0.008$).

Results: Negative correlations were observed between Pain-PKEM and VGRF-PKEM ($p<0.008$), while the Pain-Knee Flexion and Knee Flexion-VGRF correlations were insignificant ($p>0.05$). Moreover, a significant positive correlation between Pain-VGRF was observed (Figure 1).

Discussion and Conclusions: After a pain exacerbation protocol, women with PFP displayed reduced knee extensor moments and an increase in VGRF loading rate and self-reported pain. Reduction in the knee extensor moment may be a compensatory strategy used by persons with PFP to minimize symptom aggravation while descending stairs. However, this may incur greater loading at other lower limb joints, including the tibiofemoral joint.

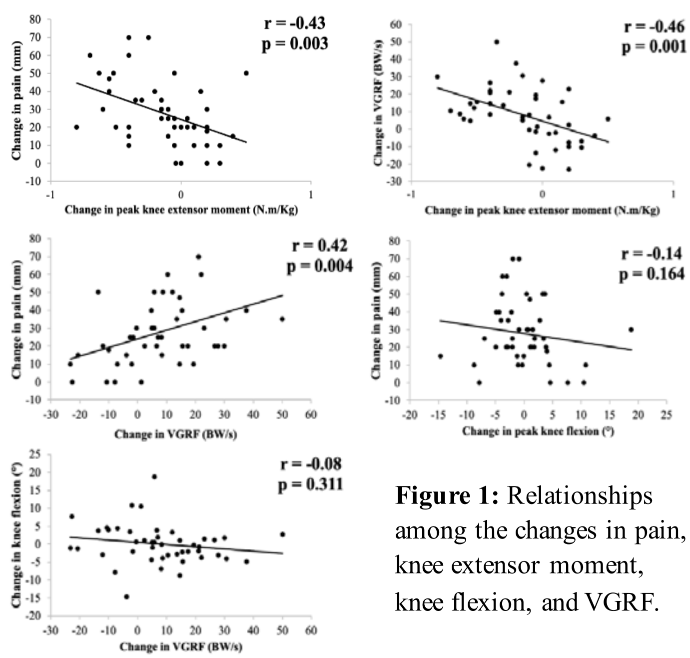

Figure 1: Relationships among the changes in pain, knee extensor moment, knee flexion, and VGRF.

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FEASIBILITY OF STRESS MONITORING DURING STUDENT EXAMS

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Introduction: Laboratory studies have made major contributions to understanding stress by using standardized, well-validated tasks that elicit physiological and psychological responses under controlled conditions. However, these paradigms typically capture specific forms of induced stress in settings where the broader personal consequences are constrained by the experimental context. University examinations, by contrast, provide an opportunity to study stress in a naturally occurring, high-stakes context in which performance carries meaningful real-world consequences for students. In this study our goal is to evaluate whether physiological monitoring of students taking exams is feasible.

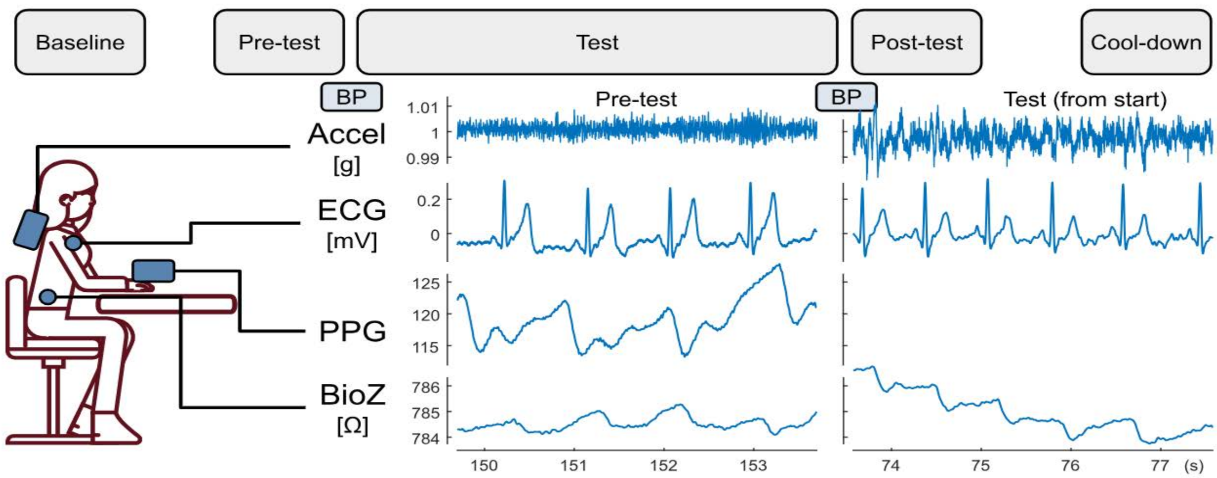

Figure: Test monitoring scenario and sensor locations (left), timeline of measurements (top) and sample signals during pre-test and test measurements (right). Note PPG measurements failed during this subject's test.

Methods: Recruited university students (N=7) taking mid-term examinations in biology and engineering courses. Subjects wore a compact, non-invasive sensor (Lithic-2 by TNHBiosystems, Ottawa, Canada). We recorded concurrent ECG, Pulse plethysmography (PPG), Blood Pressure (BP), Bioimpedance (BioZ), and Accelerometer (at the shoulders, for detection of movement and posture change). Signals were recorded during baseline sessions on days preceding the exam date, as well as 15 minutes before, throughout (80 minute exam) and then for 15 minutes following.

Results: Recorded signals were generally of high quality; however episodic movement artefacts (fidgeting and posture change) were common throughout the exam times. We saw clear differences between baseline, pre-test and post-test recordings relative to recordings during the test. The data show changes in heart rate and breathing patterns (BioZ) including periods of breath-holding. The accelerometer allowed discrimination of fidgeting behaviours.

Discussion and Conclusions: Results show that we can capture high-quality data during real examination scenarios, and that examinations produce objectively measurable physiological stress responses.

HILL-TYPE MUSCLE ACTUATORS APPLIED TO A BIOMECHANICAL MODEL OF THE HUMAN SHOULDER VIA FORWARD KINEMATICS

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Introduction: This study presents the integration of Hill-type muscle actuators into a novel multibody kinematic model of the human shoulder in MapleSim™ (Maplesoft, Waterloo, ON, Canada) to enable a forward dynamic simulation of muscle-driven motion. The shoulder is modeled as a closed kinematic chain consisting of the glenohumeral, scapulothoracic, acromioclavicular, and sternoclavicular joints, with Hill-type musculotendon units providing actuation. Unlike conventional implementations, this model builds on a parameterized scapulothoracic contact formulation to better capture physiologically relevant scapular motion.

Aim: While many publications focus either on musculoskeletal force prediction or on advanced multibody formulations, these approaches are typically developed independent of each other. This work aims to bridge that gap by embedding Hill-type actuators into a kinematically advanced shoulder model through a forward dynamics pipeline. Using forward dynamics allows for the computation of individual muscle forces and joint reaction forces in predictive simulations.

Methods: A neural excitation optimization framework will be implemented to compute muscle excitations required to drive an abduction/adduction movement. These excitations are transformed into muscle activations through first-order activation dynamics [1]. Musculotendon lengths and velocities are computed from the system kinematics and muscle origin/insertion points, enabling evaluation of normalized muscle states. These values are fed into the rigid-tendon Hill-type formulation to calculate the muscle forces [1]. To ensure anatomical consistency, muscle attachment points from an existing musculoskeletal dynamic model [2-3] are mapped onto the MapleSim model using a joint-based scaling and frame-alignment procedure. This pipeline has been integrated into MapleSim using the multibody dynamics library and a custom Differential-Algebraic Equation function to evaluate the muscle forces being generated.

Expected Results: The proposed framework enables simulation of muscle-driven shoulder motion using forward dynamics, allowing estimation of individual muscle forces and joint reaction forces throughout the movement. Although results are ongoing, this approach is expected to provide insight into muscle coordination patterns and joint loading, with potential applications in understanding shoulder pathologies and evaluating surgical interventions such as total and reverse shoulder arthroplasty.

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EXAMINING THE RELATIONSHIP BETWEEN HEAD IMPACT SPEEDS AND PLAYER IMPACT ANTICIPATION IN YOUTH ICE HOCKEY

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Introduction: Concussions are common and often under-reported in youth ice hockey [1]. The severity of a concussion may be influenced by both the collision's biomechanics and behavioural factors [1]. In particular, higher head rotational and linear velocities have been associated with increased brain strain [2], while athlete anticipation has been proposed as a potential modifier of impact severity, although findings have been inconsistent [1]. Furthermore, previous research using sensor-based recordings has been limited by small sample sizes [3].

Aim: This study will examine the relationship between linear head speeds and player anticipation associated with head impact events during youth ice hockey games.

Methods: A retrospective analysis of video footage (captured using seven GoPro Hero9 Black cameras with 47^{o} fixed field of view lenses) from 21 youth ice hockey games (U15-U16) will be conducted. Head impact events will be identified and analyzed using Kinovea (2025.2) motion analysis software. Multiple resultant linear head speed characteristics associated with each head impact event will be quantified, including peak head speed, pre and post head impact speed, and the rate of change of head speed during impact. The reliability of head speed estimates will be determined for different camera locations and directions of play progression relative to the camera views. For those impact events involving player checking, the checked player will be assigned an anticipation score using the Check Head Contact Evaluation Checklist (CHECC) [3].

Expected Results: It is hypothesized that peak head speed, the change in head speed (pre-post impact), and the rate of change of head speed during impact will be greater in checked players who did not anticipate the collision compared to those players who showed good anticipation.

References:
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COUNTERMOVEMENT JUMP PERFORMANCE

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Introduction: The passive and active subsystems of the "foot core" (FC) stabilize the foot during dynamic tasks [1]. Although, the FC influences jump height [2], it's role in take-off and impact acceleration and foot joint stiffness during the countermovement jump (CMJ) is unclear.

Aim: Examine how the passive and active FC subsystems relate to jump height (JH), take-off acceleration (TOA), impact acceleration (IA), and joint stiffness during the CMJ.

Methods: This cross-sectional design examined how the passive/active subsystems relate to CMJ performance. Predictor variables were passive and active FC subsystems. The passive FC subsystem was measured using the Arch Height Index (AHI) bilaterally at 10% and 90% of mass. The active FC subsystem included measurement of the right and left abductor hallucis (ABH), flexor digitorum brevis (FDB), and abductor digit minimi (ADM) cross-sectional area (CSA) (Clarius, L15 HD3 probe). Criterion variables were JH, right and left TOA and IA and qusai-joint stiffness; averaged across 5 repetitive CMJs (Plantiga accelerometers, Vancouver, British Columbia; Fs = 416Hz). A Shapiro-Wilks Test ($p < .05$) examined normality, and preliminary analyses included paired/independent sample t-test to assess limb/sex differences and Pearson's Correlation (r) to determine relationship between variables and in SPSS (v.29).

Preliminary Results: Significant moderate correlations were observed between right .and left ABH (R: r = .688, p = .002; L: r = .462 p = .023) and ADM CSA (R: r = .451, p = .027; L: r = .549, p = .005) and right FDB CSA (r =.592, p = <.001) with JH. Also, a significant strong correlation was noted between left FDB and JH (r = .724, p = <.001). Significant moderate correlations were observed between right ABH (r = .457, p = .025) and FDB CSA (r = .457, p = .025) with right TOA, and between left FDB CSA and left IA (r = .593, p = .002). Significant sex differences were found in right and left ABH and FDB CSA, left ADM CSA, JH, and joint stiffness (Table 1). AHI at 10% (p = .014) and 90% (p = .019) significantly differed bilaterally.

Table 1. Mean ± SD for predictors/criterions

Variables	Females (n =14)	Males (n = 10)
10% AHI	R: 0.21 ± 0.04 L: 0.23 ± 0.03	R: 0.21 ± 0.03 L: 0.24 ± 0.03
90% AHI	R: 0.20 ± 0.04 L: 0.22 ± 0.04	R: 0.20 ± 0.03 L: 0.22 ± 0.03
ABH CSA (cm^2)	**R: 1.38 ± 0.35** **L: 1.29 ± 0.34**	**R: 2.01 ± 0.46** **L: 2.01 ± 0.06**
FDB CSA (cm^2)	**R: 1.28 ± 0.41** **L: 1.23 ± 0.29**	**R: 1.79 ± 0.53** **L: 1.83 ± 0.19**
ADM CSA (cm^2)	R: -0.34 ± 0.21 **L: -0.36 ± 0.13**	R: -0.23 ± 0.21 **L: -0.15 ± 0.19**
JH (cm)	**26.21 ± 8.46**	**42.82 ± 11.79**
TOA (m/s^2)	R: 8.50 ± 3.12 L: 8.98 ± 4.62	R: 11.09 ± 3.55 L: 9.94 ± 3.88
IA (m/s^2)	R: 10.65 ± 3.00 L: 10.40 ± 2.44	R: 12.92 ± 3.21 L: 12.78 ± 3.78
Stiffness	**542.26 ± 256.26**	**723.36 ± 254.29**

*R = right; L= left; **Bolded** = significant (p < .05) sex differences. ADM CSA = log 10 transformation

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THE EFFECTS OF EXERCISE-INDICED FATIGUE ON REACTIVE BALANCE CONTROL

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Introduction: Reactive balance control is critical for maintaining stability during unexpected perturbations and plays an important role in fall prevention. Exercise-induced fatigue has been shown to impair neuromuscular function, potentially compromising postural stability. While previous research has shown that fatigue increases center of pressure - center of mass (COP-COM) displacement [1] and that plantar flexor muscles are among the first to activate during reactive balance responses [2], the specific effects of localized ankle fatigue on reactive balance responses during gait remain unclear. Therefore, the purpose of this study was to investigate the effects of exercise-induced peripheral fatigue on reactive balance control during walking.

Methods: Participants completed a fatigue protocol targeting the ankle musculature using an isokinetic dynamometer (HUMAC System., ON, CA) until a 30% reduction in peak torque was achieved. Following fatigue, participants performed walking trials on a perturbation platform designed to induce unexpected disturbances (floor surface rotated) during the single stance phase of gait. Kinematic data were collected using an Optotrak motion capture system (Optotrak., ON, CA) while ground reaction forces were recorded via embedded force plates. Electromyography (EMG) activity was measured from the gastrocnemius, tibialis anterior, quadriceps, and hamstring muscles. Key outcome measures included center of pressure–center of mass (COP-COM) displacement, center of mass–base of support (COM-BOS) displacement, muscle activation magnitude and muscle activation timing.

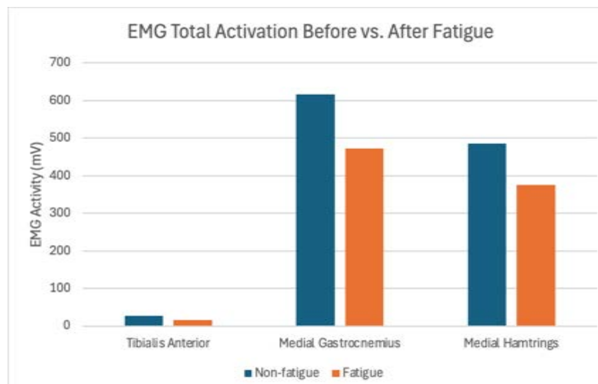

Figure 1: A reduction in muscle activation after fatigue

Results: Ankle fatigue altered neuromuscular responses during walking, with muscles showing a reduction in total activation when fatigued (Figure 1), along with earlier onset during perturbations and earlier cessation. This suggests a compensatory response that is initiated more quickly but cannot be sustained when fatigued.

Discussion and Conclusions: These findings suggest that localized ankle fatigue impairs reactive balance control by altering muscle activation timing and overall activation patterns. This has important real-world implications, as fatigue during everyday walking on unpredictable surfaces may increase fall risk.

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Image Registration Between Clinical and Micro Computed Tomography Scans

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Introduction: Microcomputed tomography (µCT) is an imaging methodology that has applications in tracking osteoarthritis disease progression not possible with clinical CT imaging. The higher spatial resolution can detect alterations in bone structure such as trabecular remodeling, osteophyte formation, and subchondral bone plate thickening [1]. However, higher resolution limits the size of the scanned region. When looking at the µCT image in isolation, it can be difficult to determine what region of the bone the scan is from. Therefore, our goal is to align a µCT scan from below the humeral neck and to a clinical CT scan of the proximal humerus. This process, known as image registration, allows aligning multiple images to a single coordinate system [2].

Aim: To create a methodology to register µCT scans from the region below the humeral neck to the corresponding clinical CT scans of the proximal humerus.

Methods: Paired CT and µCT scans will be selected from a preexisting in-lab database. In the clinical scans, a smaller region of interest will be determined surrounding the humeral head to reduce non-bone content and narrow the focus of the registration process. The scans will then be segmented using Materialise Mimics Core (Materialise NV, Leuven, Belgium). An initial manual registration will be done using Autodesk Fusion 360 (Autodesk Inc, California, United States). The two images will be opened in a multi-image view, and the µCT scan will be manually transformed onto the clinical scan. The manually transformed µCT scan and the corresponding clinical CT will then be opened in Dragonfly 3D World (Comet Technologies, Quebec, Canada). The two images will then be registered to one another using the built-in Image Registration workflow. Qualitative and quantitative validation will then be performed to determine the accuracy of the process.

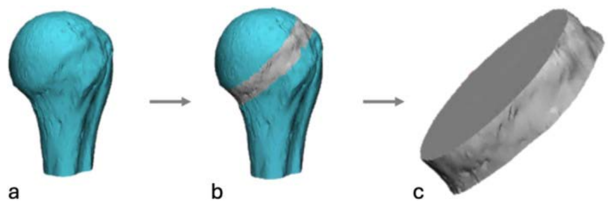

Figure 1: Proximal humerus segmentation (a); location of the µCT scan area shown in gray (b); segmentation of µCT scanned area (c) [3]

Expected Results: The expected results will be a data series where the µCT image that is registered to the corresponding clinical CT image. There is potential to automate certain steps in the process that could be explored in future studies.

References:

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EFFECTS OF A SINGLE SESSION OF NEUROMUSCULAR ELECTRICAL STIMULATION TO THE TIBIALIS ANTERIOR ON BALANCE CONTROL

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Introduction: Lower leg strength, which is important for balance control, declines with aging, contributing to impaired balance and fall risk. Weakness in tibialis anterior (TA) is associated with poorer performance, specifically during challenging balance tasks. Exercise-based interventions can improve muscle strength and balance; however, adherence, accessibility, and time demands may limit their effectiveness, especially in older adults. Neuromuscular electrical stimulation (NMES) offers an alternative approach by eliciting muscle contractions that can enhance muscle strength and balance [1,2]. However, benefits are typically observed following multiple NMES sessions (4-12 weeks), and acute effects are not well established [3,4]. Exploring single session effects will address the above limitations of multi-session and exercise-based programs.

Aim: This study explores the effects of a single session of NMES to TA on dorsiflexion strength and static and dynamic balance performance in healthy young adults.

Methods: NMES will be compared to sensory level stimulation via transcutaneous electrical nerve stimulation (TENS) and no stimulation (CONTROL). Stimulation is applied to the dominant limb. Using a pre-post design with block randomization by sex, participants are assigned to NMES, TENS, or CONTROL groups (target: n=45). Strength and balance tests (performed on dominant limb) include isometric dorsiflexion strength and rate of force development, single leg stance (SLS; number of errors), and the modified star excursion balance test (mSEBT; reach distance). For balance tasks, anterior-posterior (AP) and medial-lateral (ML) centre of pressure (CoP) range, total path length, and velocity measures will also be calculated from force plate data (Fs: 2000Hz). Muscle activity during the balance tests for TA, gastrocnemius, soleus, and gluteus medius will be expressed as a percentage of their maximum voluntary isometric contraction.

Expected Results: It is hypothesized that NMES compared to TENS and CONTROL will 1) increase TA strength and rate of force development, 2) improve SLS performance (i.e., fewer errors; increased ankle muscle activity, reduced hip muscle activity; decreased AP and ML COP range, total path length and velocity; all evidence of tighter static balance control), and 3) improve mSEBT performance (i.e., increased reach distances; increased TA activity; increased AP and ML COP range and total path length but decreased velocity; all evidence for improved dynamic balance control). Outcomes may help inform future research and clinical applications using NMES over a single session to improve strength and balance. Additionally, it is expected that the TENS group will demonstrate improvements in balance performance as well, although less than those of the NMES group but greater than those in the CONTROL group.

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