UNIVERSITY OF DELAWARE
ENGINEERING

16TH ANNUAL

BIOMECHANICS RESEARCH SYMPOSIUM

APRIL 17, 2019

CENTER FOR BIOMECHANICAL ENGINEERING RESEARCH
201 Spencer Lab | Newark, Delaware 19716 | cber.udel.edu

Welcome students, faculty and friends!

The Center for Biomechanical Engineering Research (CBER) is pleased to host the 16th Biomechanics Research Symposium, an annual highlight for the biomechanics community at University of Delaware since 2004. Throughout the day, we will celebrate the outstanding achievements from our faculty and students, exchanging new ideas and sharing exciting data during the poster and podium presentations. Awards will be given to winners of best research.

I wish that you enjoy this year's keynote speech "Engineering solutions to optimize mobility after joint replacement," given by Dr. Jennifer Stevens-Lapsley, Professor and Director of the Physical Therapy program at the University of Colorado School of Medicine. Dr. Stevens-Lapsley is a Blue Hen alumnus, receiving her Master of Physical Therapy and PhD in Biomechanics and Human Movement from UD. Over the past two decades, Dr. Stevens-Lapsley has established a highly successful program aiming to improve care and rehabilitation for joint replacement patients. Her research highlights the importance of clinical and translational research, which has motived CBER to bring basic and translational researchers together during our annual symposium for years.

It takes many to make the symposium a success. First, I would like to thank Dr. X. Lucas Lu and Ms. Elaine Nelson who have overseen all the planning and organizing of the symposium during my sabbatical leave. We also acknowledge the time and effort from the Organizing and Student Committees and the contribution from all presenters, judges, and modulators. Last and not least, we like to thank Drs. Ajay Prasad and Thomas Buchanan for the financial support from the Mechanical Engineering Department and Delaware Rehabilitation Institute.

Please enjoy the symposium.

Liyun Wang

Professor, Center for Biomechanical Engineering Research Director

ACKNOWLEDGEMENTS

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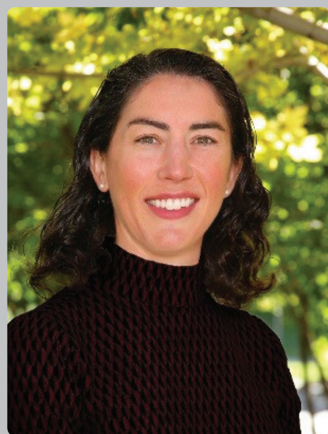
Resources for poster printing was provided by the Delaware Rehabilitation Institute/DRI, Thomas Buchanan, Director.

DELAWARE REHABILITATION INSTITUTE

Advancing the Science of Rehabilitation

Keynote Lecture



"Engineering solutions to optimize mobility after joint replacement "

Jennifer Stevens-Lapsley, MPT, Ph.D.
Professor
Director, Rehabilitation Science PhD Program
Physical Therapy Program
University of Colorado School of Medicine

ABSTRACT

Recent innovations in post-operative rehabilitation following total knee arthroplasty are expanding the boundaries of rehabilitation. Innovative analytic prediction tools have been engineered to anticipate patient recovery trajectories and individualize care, while reducing healthcare costs. But even with analytic tools, best practice for rehabilitation can be further tailored by using interventional strategies supported by evidence. The application of recent clinical trial findings will be described including the use of technology to address biomechanical asymmetries to improve function and preserve contralateral joint function.

BRIEF BIOGRAPHY

Dr. Stevens-Lapsley is a Professor and Director of the Rehabilitation Science PhD Program in the Physical Therapy Program at the University of Colorado Anschutz Medical Center. She is focused on identifying, integrating and advancing innovative evidence-based medicine solutions for older adult rehabilitation through highly effective research methods and partnerships. She has almost 20 years of clinical research experience in patients with osteoarthritis planning joint arthroplasty, and more recently, medically complex patient populations. Her research ranges from understanding the mechanisms of skeletal muscle dysfunction to studies of implementation of best rehabilitation practices in post-acute care settings. More specifically, her research includes the evaluation of care bundling strategies for joint arthroplasty, pragmatic interventions in medically complex patient populations, and health services research to understanding how rehabilitation services impact hospitalization rates and functional Dperformance. Her clinical research has resulted in numerous publications (100+), national and international speaking invitations, and awards such as the Jack Walker Manuscript award from the American Physical Therapy Association (APTA), and an Excellence in Research Award. Over the past decade, she has received over $14 million dollars to support her clinical research.

Dr. Stevens-Lapsley earned her PT degree at the University of Delaware, where she went on to complete a PhD in Biomechanics and Movement Science with a focus in Applied Physiology. She then completed post-doctoral training at the University of Florida.

Schedule of the Day

TIME	WHAT	WHERE
8:30AM	BREAKFAST & POSTER SET-UP	STAR CAMPUS- GLASS ATRIUM
9:00AM	WELCOME & INTRODUCTORY REMARKS	STAR CAMPUS- GLASS ATRIUM
9:10AM	KEYNOTE LECTURE: DR. JENNIFER STEVENS-LAPSLEY	STAR CAMPUS- GLASS ATRIUM
10:20AM	BREAK	
10:35AM	PODIUM SESSION 1	STAR CAMPUS- GLASS ATRIUM
11:35AM	LUNCH	
12:00PM	POSTER SESSION 1 (ODD #S)	STAR CAMPUS- MAIN CONCOURSE
1:00PM	POSTER SESSION 2 (EVEN #S)	STAR CAMPUS- MAIN CONCOURSE
2:00PM	BREAK	
2:15PM	PODIUM SESSION 2	STAR CAMPUS- GLASS ATRIUM
3:25PM	AWARDS SESSION	STAR CAMPUS- GLASS ATRIUM
3:45PM	ADJOURN	

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Sagar M. Doshi

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Mengxi Lv

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Denotes Podium #

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PODIUM PRESENTATIONS

Session 1

1 CARBON NANOMATERIAL-BASED NOVEL FUNCTIONAL GARMENTS FOR HUMAN MOTION ANALYSIS

Sagar M. Doshi, Kaleb Burch, Jill S. Higginson, Erik T. Thostenson

This research is focused on the development and validation of novel low-cost wearable technology that can be integrated to create functional fabrics and footwear. Typically, human motion is analyzed using instrumented treadmills and motion capture cameras. Their extremely high cost and complexity make them prohibitive for large scale use in the industry. Additionally, the motion data of the patient/subject can be monitored for a limited amount of time and not in their natural work/home environment. As a result, a critical need exists for low-cost, comfortable wearable technology for human motion analysis.

The sensing approach for the development of our wearable sensors is based on the formation of electrically conductive nanocomposite films of functionalized carbon nanotubes. The carbon nanotubes are deposited on a variety of common fabrics such as polyester, nylon, wool, and aramid. The electrically conductive nanocomposite coating is only ~500 nanometers thick and is chemically bonded to the fiber surface and shows piezoresistive electrical/mechanical coupling. The pressure sensor displays a large in-plane change in electrical conductivity with applied out-of-plane pressure. Preliminary experiments have been conducted by integrating these sensors into footwear with subjects walking on the split-belt treadmill. All the steps were detected by the sensors in the footwear and provided a reliable averaged peak force measurements at different walking speeds. For stretch sensing and joint motion detection, carbon nanotubes are deposited on knit fabrics and integrated into wearable sleeves. When integrated into an elbow sleeve, the sensors show a dramatic 3,250% change in resistance upon elbow flexion, demonstrating ultra-high sensitivity. These fabric based sensors have the potential to be used for biomechanics research, human-machine interaction, feedback control for assistive devices and rehabilitation related clinical applications.

2 STATIN USE IS ASSOCIATED WITH LOWER OCCURRENCE OF CLINICAL OSTEOARTHRITIS IN DELAWARE POPULATION

Mengxi Lv, Tiange Zhang, Michael Axe, Edward Ewen, Zugui Zhang, X. Lucas Lu

Statins are a class of drugs prescribed to over 40 million U.S. people to control the cholesterol levels. A few clinical studies on Europe population have revealed that the use of statin is associated with lower osteoarthritis (OA) occurrence than non-users. In contrast, a similar clinical study focusing on the US population generates conflicting results, indicating that statin use is associated with worsening physical function of knee joint for patients with confirmed knee OA. In this study, we investigated the impact of statin use on the symptomatic and radiological OA in the Delaware population using the patient database at Christiana Health Care System. In total, 53, 410 eligible patients were included, with 52% statin users and 5% total OA prevalence. The average age of the cohort is 56 ± 15 yrs. White population represents 54%. A majority of the patient (87%) were residents of Delaware. As results, statin use is associated with 39% reduction in OA occurrence according to the Cox regression model. Patients receiving statin treatment had lower OA rate (hazard ratio: 0.61) compared to the non-users. We further estimated the association between the statin use and occurrence of common musculoskeletal diseases. Statin use was significantly associated with lower occurrence of the muscle ligament disorder (Odds Ratio: 0.65), low back pain (OR: 0.80), limb pain (OR: 0.80), and joint pain (OR: 0.84). The correlation between statin use and lower OA occurrence could increase the prescription adherence of current statin users, especially those at a high risk of OA development due to joint injury histories. Repurposing of the statins could be a new pharmaceutical solution for PTOA prevention after joint injuries.

3 BRAIN MECHANICAL PROPERTIES AND BALANCE REACTIONS IN CHILDREN WITH CEREBRAL PALSY

G McIlvain, J Tracy, H Wright, J Crenshaw, CL Johnson; University of Delaware: Biomedical Engineering, Kinesiology and Applied Physiology, Physical Therapy

INTRODUCTION: Cerebral-palsy (CP) is caused by brain damage in utero and results in compromised coordination. Assessment of the neurological damage associated with this functional impairment has not been studied extensively. In this study, we use magnetic resonance elastography (MRE) to measure brain stiffness in children with CP and relate to measures of balance. MRE is an emerging technique which can sensitively assess microstructural brain health through *in vivo* measurements of viscoelastic shear stiffness.

METHOD: 8 typically developing children (TD; 3M/5F; Age:5-12) and 10 children with CP (6M/4F; Age:5-12) completed an MRE scan session on a Siemens 3T Prisma scanner. MRE displacement data was used to create maps of viscoelastic shear stiffness (McGarry,2012). Balance reaction was measured by anteriorly and posteriorly perturbing subjects on a treadmill at increasing accelerations until the subject took a step to recover balance, the single-step-threshold (SST)(Crenshaw,2014). Spearman-rank correlation compared whole-brain stiffness with anterior and posterior SST. Voxel-wise correlations were performed after co-registering each stiffness map.

RESULTS: In the CP-group, whole-brain stiffness significantly correlates with posterior-SST (r=0.793;p=0.011) and approaches significance for anterior-SST (r=0.635;p=0.066). A stiffer brain was associated with larger SST accelerations, indicative of greater balance performance. A voxel-wise analysis revealed specific regions which correlated with balance reaction, including the precentral gyrus and the cingulate gyrus.

CONCLUSION: In this study, we have shown that brain stiffness in children with CP relates to impaired balance function, we have identified significant clusters that include major motor areas. Notably, the CP group comprised those children of the highest function levels, yet a significant structure-function relationship was still observed, highlighting the sensitivity of brain stiffness to tissue health.

4 NON-INVASIVE MRI ASSESSMENT OF MENISCUS AND CARTILAGE CHANGES IN A LARGE ANIMAL MODEL OF MENISCUS INJURY

Kyle D. Meadows (1), Sonia Bansal (2,3), John M. Peloquin (1), Liane M. Miller (2,3), Jay M. Patel (2,3), Kamiel S. Saleh (2), Michael W. Hast (2), Miltiadis H. Zgonis (2,3), Robert L. Mauck (2,3), Dawn M. Elliott (1)

(1) University of Delaware, (2) University of Pennsylvania, (3) CMC VA Medical Center

The link between meniscus injury and OA risk is well-known in humans and has been established in small animal models, but the incremental progression of meniscus changes and the inter-relationship between cartilage and meniscus degeneration over time remain unknown. The purpose of this study was to establish this link between MRI measurements (T_2 time and gagCEST) and tissue properties using our established large animal model. Minipigs underwent bilateral arthorscopic surgery in which each of the two medial menisci received one of the following interventions: sham (arthroscopy without meniscus incision), DMM (destabilized medial meniscus, transected anterior attachment), vertical longitudinal tear, or radial tear (n=3/treatment). After 1 month, in the meniscus tear region, T_2 time was higher with a radial tear ($p<0.06$); gagCEST was higher after DMM ($p<.05$) and lower after radial tear ($p<0.06$). In the cartilage, T_2 time was higher after DMM ($p<0.05$) and after radial tear ($p<0.05$). There was a significant correlation of cartilage T_2 time with both contact pressure from TekScan and cartilage indentation modulus ($p<0.05$). This study demonstrated that non-invasive MR assessment of knee joint health can reveal degenerative changes in meniscus and cartilage resulting from injury in a large animal model. Meniscus tears increased joint loading (confirmed by TekScan) leading to cartilage degeneration that was detectable via MRI. The non-invasive assessments confirmed invasive measurements, providing an important advance to allow longitudinal study of joint changes following different meniscus injuries.

Denotes Podium #

5 MEDIAL COMPARTMENT UNDERLOADING 3 MONTHS AFTER ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION IS ASSOCIATED WITH LOWER TIBIOFEMORAL CARTILAGE GLYCOSAMINOGLYCAN CONTENT 24-MONTHS AFTER SURGERY

Jack R. Williams[1], Kelsey Neal[1], Jacob J. Capin[2,3], Ashutosh Khandha[2,4], Lynn Snyder-Mackler[2,3,4], Thomas S. Buchanan[1,2,4]

[1]Mechanical Engineering, [2]Biomechanics & Movement Science, [3]Physical Therapy, [4]Biomedical Engineering

INTRODUCTION: Osteoarthritis (OA) development after anterior cruciate ligament reconstruction (ACLR) is a well-documented phenomenon. Loading alterations early after surgery have been linked to the development of OA. Early OA is characterized by the loss of glycosaminoglycans (GAG) within cartilage. This study examined the relationship between medial compartment knee joint loading 3 months after ACLR with GAG content 24 months after ACLR.

METHODS: 12 subjects (4 women, 24.4 ± 9.6 years) were tested during overground walking 3 months after unilateral ACLR. Peak medial compartment force (pMCF) was computed in the involved (injured) and uninvovled (noninjured) limbs. GAG content in these same 12 subjects was determined 24 months post ACLR using a quantiative magnetic resonance technique callled GagCEST.

RESULTS AND DISCUSSION: A significant positive correlation between loading at 3 months and cartilage's 24-month GAG content was found within select regions of the involved limb. In particular, it was found that those who underloaded their involved limb at 03 months, compared to the uninvolved, had lower GAG content within that limb at 24 months. These results, while preliminary, suggest that involved limb underloading early after ACLR may be linked to later signs of early OA development.

PODIUM PRESENTATIONS

Session 2

1 QUADRICEPS STRENGTH DOES NOT MODIFY GAIT MECHANICS AFTER ACL RECONSTRUCTION, REHABILITATION, AND RETURN TO SPORT TRAINING

Elanna Arhos, Jacob Capin, Ashutosh Khanda, Thomas Buchanan, Lynn Snyder-Mackler

Individuals after anterior cruciate ligament reconstruction (ACLR) walk using aberrant mechanics (e.g., smaller involved knee flexion angles and moments and medial tibiofemoral joint under-loading) linked to early development of osteoarthritis (OA). Quadriceps strength is linked to pre-operative gait asymmetries and post-operative function, and is included in return-to-sport (RTS) criteria. Evidence linking quadriceps strength with gait biomechanics is limited to pre-operative and early rehabilitation time points. A critical time to evaluate the relationship between quadriceps strength and gait mechanics is after ACLR, rehabilitation, and RTS training when athletes are returning to sport. We analyzed biomechanical and functional data from 77 participants after ACLR, post-operative rehabilitation, and RTS training. Our key variables of interest included: quadriceps strength, peak knee flexion (PKF) angle, internal knee extensor moment at PKF, sagittal plane knee excursion at weight acceptance and mid-stance, quadriceps muscle force at PKF, and peak medial compartment contact force. Quadriceps strength was measured using an electromechanical dynamometer during a maximal voluntary isometric contraction. Participants completed over-ground gait analysis at a self-selected speed consistent across trials. Data were processed using Visual 3D, and knee kinetics were calculated via inverse dynamics. A validated, patient-specific electromyography (EMG) driven musculoskeletal model was used to estimate qaudriceps muscle forces and joint contact forces bilaterally from EMG data. We found no significant or meaningful correlations between quadriceps strength and our biomechanical gait variables after RTS training. Our findings indicate that among those at RTS who are well-rehabilitated, quadriceps strength is not related to gait asymmetries. These results suggest clinical interventions are insufficient at targeting gait. Post-operative rehabilitation should include gait specific components to address these lingering biomechanical deficits.

2 NOVEL FABRIC-BASED FORCE SENSORS FOR CONTINUOUS OVERGROUND GAIT ANALYSIS

Kaleb Burch[1], Sagar Doshi[1], Erik Thostenson[1], Jill Higginson[1]

[1]Mechanical Engineering, University of Delaware

Characterization of gait is a major focus in biomechanics research. A key parameter used to evaluate gait is vertical ground reaction force, which is typically measured by force plates in a research lab. Force-sensing footwear, such as the fabric-based sensors used in this study, can enhance gait analysis by enabling data collections outside of a lab setting.This study aims to validate the use of these sensors for evaluation of gait in clinical and research settings.

Two sensors were placed on a left-footed sandal, one on the hindfoot and the other on the forefoot. Kinetic data was collected from a subject walking on an instrumented treadmill with the sandals. The subject performed a calibration test and two trials each at three different walking speeds (0.5 m/s, 1 m/s, and 1.5 m/s). Outcome measures included peak force accuracy, detection of steps, and detection of heel-strike and toe-off. Sensor force readings were combined and peak forces were averaged across the first 10 steps of each trial. All outcome measures were compared against the treadmill.

All steps were detected by both sensors. The sensors provided reliable 10-step averaged peak force measurements across all three walking speeds (Slow: 1-3% error, Medium: 3-10% error, Fast: 1-6% error).

These results indicate that the sensors can reliably measure ground reaction forces over multiple gait cycles and detect gait events. The accuracy of this sensor over many steps is promising for applications such as clinical monitoring of how patients load injured limbs and for the expansion of research beyond a lab setting.

3 IS A CHANGE IN PHYSICAL ACTIVITY ASSOCIATED WITH A CHANGE IN HEALTH-RELATED QUALITY OF LIFE AFTER TOTAL KNEE REPLACEMENT?

Christiansen, MB, Thoma LM, Master H, Voinier DM, Macri E, White DK

University of Delaware, Department of Physical Therapy, Biomechanics and Movement Science Program

BACKGROUND: Little is known about this relationship between physical activity (PA) and health-related quality of life (HRQoL) in people after total knee replacement (TKR), who often elect to have surgery due to decline in HRQoL. The purpose of this study was to examine the association of a change PA before and after TKR with a change in HRQoL.

METHODS: We used data from the Osteoarthritis Initiative (OAI) and included participants who had a TKR after enrolling. The exposure was change in PA at least 1-year before or after TKR. We quantified PA using Physical Activity Scale for the Older (PASE) categories as Low PA ≤ 94, Moderate PA 95-146, High PA 147-206, Very High PA ≥ 207. We classified participants as Increased/ Maintained PA or Decreased PA. Our primary outcome was a change in HRQoL before TKR to after TKR which was quantified using 12-item Short Form Survey Physical Component Summary (PCS). We dichotomized PCS scores using a difference of 2; < -2 Decline HRQoL and ≥ -2 Maintained HRQoL. We calculated odds ratios and 95% confidence intervals (95%CI) stratified by older and younger adults and adjusted for potential confounders.

RESULTS: Of the 421 participants who had a TKR, 220 participants had complete data. Older adults who Increased/Maintained PA had 71% (0.29-0.82) less risk of a Decline in HRQoL compared to those who Decreased PA. Change in PA was not associated with HRQoL in younger adults.

CONCLUSION: Increasing/Maintaining PA after TKR may protect against a decline in HRQoL in older adults.

4 CORRELATIONS BETWEEN MECHANICAL PROPERTIES OF THE ADOLESCENT BRAIN AND RISK-TAKING BEHAVIORS

RClements, GMcIlvain, CJohnson

INTRODUCTION: Adolescence is characterized by an increase in risk-taking behaviors. In a 2006 study, Galvan et al. used fMRI to determine that early development of the accumbens relative to the orbitofrontal cortex can result in higher levels of risk-taking behavior. Magnetic resonance elastography (MRE) measures brain mechanical properties through mechanical palpation and MRI imaging to analyze the microstructural health of regions of the brain. MRE has only just begun to be used in adolescents, and has not yet been used to analyze risk taking behavior. This work aims to address this gap in literature by providing *in vivo* measurements of the damping ratios of the accumbens and prefrontal cortex in the adolescent brain which can be used to predict risk-taking behavior.

METHODS: A sample of N=43 healthy, adolescent children (22/21 M/F; ages 12-14) completed an MRE scan session on a Siemens 3T Prisma MRI Scanner. Participants also completed the Balloon Analogue Risk Test (BART), in which they were presented with a digital balloon and offered the chance to earn money by pumping the balloon. The more that the participant pumped the balloon, the greater the risk that the balloon exploded and all earnings were lost.

RESULTS: There is a significant correlation ($p<0.05$) between the differences in the damping ratios of the accumbens and prefrontal cortex and total points earned in the BART. Specifically, the difference in the left accumbens and the frontal orbital cortex ($p=0.0072$) and the left accumbens and the frontal operculum cortex ($p=0.0051$) showed the highest correlation with total points.

CONCLUSIONS: These results correspond with the 2006 study by Galvant et al. and provide further insight into properties of the adolescent brain that can cause an increase in risk-taking behaviors.

5 DEVELOPMENTAL DIFFERENCES IN PREFRONTAL CORTEX ACTIVATION IN THE TOWER OF HANOI TASK

Kimberly Milla[1], Elham Bakhshipour[1], Amanda Plumb[2], Reza Koiler[1], Nancy Getchell[1]

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Our group has characterized hemodynamic activity in the prefrontal cortex (PFC) during the Tower of Hanoi task (ToH) in adults, however to our knowledge this has not been investigated in children. We examined PFC activity in typically developing (TD) children using functional Near-Infrared spectroscopy (fNIRS) as they solved ToH puzzles. Two conditions were presented to participants; the first condition utilized a traditional 3D model requiring manual manipulation. The second condition used a 2D computerized model that presented equivalent executive function demands yet with diminished motor requirements. Our aim was to further understand the PFC role in these two ToH conditions in children. Nineteen TD children (5F/14M, $\bar{x}$ = 10.9 ± 2.2 y.o) solved puzzles in 2 blocks of 3, 1-minute epochs. Participants had a mean MABC-2 percentile of 55.9 and 44.2 for the manual dexterity subcategory. Paired, two-sample t-test for means was utilized to analyze data. Results showed significantly lower changes in oxygenated hemoglobin, ΔHbO, in block 2 (B2) with respect to block 1 (B1), $p = 0.047$. Furthermore, significantly lower ΔHbO was seen in B2 when participants began the protocol with the 3D condition (3D/B1), $p = 0.026$, unlike participants that began the protocol with the 2D condition (2D/B1), $p > 0.05$. Lastly, no significant differences in ΔHbO were found between 3D and 2D conditions, contrary to findings in adults. In conclusion, this study supports evidence in adults where learning and performance benefited the most by introducing the most complex condition first, followed by the simpler condition. This knowledge about developmental differences in PFC activation will guide future research to discern the possible areas of impairment on the perception-cognition-action continuum in specific developmental disabilities, such as DCD.

POSTER PRESENTATIONS

Cells Tissue Biomechanics

1 TENDON MULTISCALE MECHANICS ALTERED BY BATH OSMOLARITY

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Phosphate buffered saline (PBS) is a common choice for bathing solution in mechanical testing of biological tissue; however, PBS causes increased hydration and decreased modulus in tendon and other tissues. The PBS bath also increases collagen fibril diameter and interfibrillar spacing. It remains unknown how PBS may alter tendon multiscale mechanical behavior and damage. Rat tail tendons were tested in 0.15M PBS (n=8) or 8% SPEG (n=7). Testing included ramping each sample to 6% grip strain (baseline), holding for a 15-min relaxation, unloading to initial length for 40-min, then loading to failure (diagnostic). Tissue-level parameters included transition point, inflection point, and linear region modulus. Microscale parameters were measured using confocal images and included microscale strain and sliding. At baseline, SPEG had a higher modulus compared to PBS, and no difference in transition and inflection point. At diagnostic, the modulus decreased compared to baseline for both SPEG and PBS, providing evidence that damage had occurred, however the modulus was no longer different between the two groups. At diagnostic, the transition strain was higher in SPEG compared to PBS. At diagnostic, inflection point strain increased for both groups compared to baseline, but there was no difference between SPEG and PBS. The microscale strain in SPEG was higher than PBS throughout loading, and lower than PBS after unloading and during recovery. Microscale sliding was not different between SPEG and PBS, and both only partially recovered. This study shows that osmolarity of bath solution is important in tendon mechanical testing and affects microscale loading and mechanical damage. Future mechanical testing should consider using a bath solution with an osmolarity that maintains fresh tissue water content.

2 BRAIN AND HIPPOCAMPAL VISCOELASTIC PROPERTIES IN HEALTHY AGING

Peyton Delgorio, Faria Sanjana, Lucy Hiscox,
Joshua Hobson, Christopher Martens, and
Curtis Johnson

During normal aging, the brain experiences volumetric atrophy due to tissue degeneration. Assessment of the viscoelastic mechanical properties of the global brain (GB) as well as the hippocampus (HCe), an important structure in memory processing, may provide additional metrics for measuring brain tissue integrity throughout the healthy aging process. The aim of this study was to determine how healthy aging affects both the GB and HCe viscoelastic properties. Based on previous work, we hypothesized a decrease in volume and shear stiffness and an increase in damping ratio (DR).

Mechanical property and volume measurements were performed using a noninvasive imaging technique called magnetic resonance elastography (MRE). 15 healthy participants (age range: 22-69y; mean: 41±15y) were scanned on a 3T Siemens Prisma MRI scanner using a 64-channel head coil. Vibrations required for MRE were generated at 50 Hz using a commercial external pneumatic driver (Resoundant). The imaging protocol included a structural T1-weighted MPRAGE (magnetization-prepared rapidly-acquired gradient echo) sequence at a 0.9x0.9x0.9mm^3 resolution and a whole brain spiral MRE acquisition at a 1.25x1.25x1.25mm^3 resolution. Linear regression was used to statistically analyze the data.

GB stiffness significantly correlated with age (F=5.45, r^2=0.295, p<0.05), showing a -0.007kPa decrease in GB stiffness per increasing year. HCe DR (F=0.651, r^2=0.048) and volume (F=0.568, r^2=0.042) did not significantly correlate with age, but there was a 0.001 increase in HCe DR measures and a -0.009cm^3 loss in HCe volume per increasing year. These results support our hypothesis that stiffness of the brain decreases with normal aging. Future studies will include analyzing correlations with memory performance and MRE property values in a larger sample.

3 COMPARISON OF BOUNDARY LUBRICANTS ON THE TRIBOLOGICAL REHYDRATION OF ARTICULAR CARTILAGE

Margot S. Farnham[1], David L. Burris[2], Christopher Price[1,2] ([1]UD BME, [2]UD MechE)

Articular cartilage maintains exceptionally low friction and withstands repeated articulations without incurring wear. To sustain physiologically-consistent fluid load support and low friction responses *ex vivo*, our lab uses the convergent stationary contact area (cSCA) configuration, where large diameter explants are compressed to ~0.25MPa (~body-weight compression) and reciprocally slid at 80mm/s (~walking speed). The cSCA allows for long-term testing without inducing damage by providing the environment necessary for strain recovery during sliding (i.e. tribological rehydration). Previous cSCA experiments have used a bathing solution of phosphate buffered saline (PBS); however, the addition of boundary lubricants found *in vivo* (synovial fluid (SF), hyaluronic acid (HA)), or used in explant culture (bovine serum albumin (BSA), culture media) has not been investigated. The *goal of this study was to assess the effect of boundary lubricants on tribomechanical outcomes in the cSCA*. We also wanted to determine if low-viscosity lubricants (PBS, culture media) are suitable for *ex vivo* tribology studies, or if higher viscosity lubricants are required to produce physiological 'safe' frictional responses. Bovine cartilage explants were extracted from previously frozen knees, allowed to free-swell in PBS, and put through a tribological rehydration characterization protocol (30min sedentary compression + 30min reciprocal sliding) to establish baseline PBS behavior. Explants then free-swelled in PBS and were tested a second time, with lubricant (SF, PBS+HA (5mg/mL), PBS+BSA (3% w/v), or culture media) added to the contact just prior to sliding. Finally, explants free-swelled in lubricant and were tested a third time. The *higher-viscosity lubricants (SF, HA) significantly increased tribological rehydration* during sliding in the second test ($p=0.011, 0.011$), indicating that applying lubricant just prior to sliding is sufficient for improving tribological outcomes. Additionally, end-of-sliding (equilibrium) friction significantly decreased for these lubricants in the third test ($p = 0.033, 0.009$). These results suggest that high-viscosity lubricants *enhance* articular cartilage lubrication *ex vivo* but are not necessary for maintaining physiologically-consistent tribomechanical behavior in the cSCA.

4 EXAMINING SOURCES OF NOISE IN MAGNETIC RESONANCE ELASTOGRAPHY (MRE)

AJ Hannum, G McIlvain, and CL Johnson; Biomedical Engineering, University of Delaware

Magnetic resonance elastography (MRE) is a phase-contrast MRI technology that creates mechanical property maps of the brain *in vivo* through induced vibration. Signal noise often degrades quality of reconstructed images and is a limiting factor in developing higher resolution images. Several different factors have been proposed to contribute to signal noise in MRE including head motion and the cardiac cycle.[1] To identify MRE signal noise, EPI scans were taken of human subjects with 25 replicate time points in each data set. Data sets included: (1) both the motion encoding gradient (MEG) and MRE vibration off to evaluate image noise, (2) the MEG on and vibration off to evaluate physiological noise, and (3) both the MEG and vibration on to evaluate vibrational noise. To analyze the data, the differences from the median image values were calculated at each data point. In order to assess head motion signal noise, the subject's head was packed tightly with small pillows to reduce motion during scanning. It was observed that this packing reduced the level of signal noise in the image during vibration. In a separate assessment, a human subject wore a pulse oximeter device to determine if the peak of the cardiac cycle aligning with the MEG contributed to more signal noise.[2] A cross correlation was performed between the recorded cardiac cycle of the test subject and signal noise with the MEG. The ability to understand and evaluate sources of noise will allow for the continuation and improvement of MRE as a tool for brain health.

REFERENCES: [1] Chaze et al., ISMRM, 2016;
[2] O'Halloran et al., MRM, 2012.

5 PUBERTY AND MECHANICAL PROPERTIES OF THE ADOLESCENT BRAIN

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INTRODUCTION: While the mechanical properties of the adult brain are heavily studied (Hiscox, 2016), there is a lack in understanding of the development of adolescent brain tissue during puberty. Through magnetic resonance elastography (MRE), the stiffness of the adolescent brain can be measured to identify regions that develop during adolescence. Adolescent brain mechanical properties have been seen to differ from that of the adult brain and certain developmental disabilites, such as cerebral palsy, affect brain stiffness.

METHODS: The data used in this study was collected in a previous study (McIlvain, 2016) where MRE scans were taken of 41 participants aged 12-14 using a Siemens 3T Trio MRI scanner. Pubertal development was assessed through both adolescent and parent self-reported developmental meausures, saliva testosterone and estradiol levels, and hair testosterone levels. The z-score was taken across these development conditions to obtain one value of puberty for each subject. Subjects were split into 'high pubertal development' and 'low pubertal development' groups. Results were analyzed for age and puberty z-score.

RESULTS: Pubertal development significantly correlated with the damping ratio of the brain tissue in the right cerebrum (p=0.0149) and right frontal lobe (p=0.0026). Age significantly correlated with the stiffness of the left occipital lobe (p=0.0466), right amygdala (p=0.0299), right cerebrum (p=0.0375), right pallidum (p=0.0169), and right thalamus (p=0.0325). Pubertal development with age as a covariet correlated with the damping ratio of the right frontal lobe (p=0.0048).

CONCLUSIONS: MRE of adolescent brain tissue has identified brain regions that develop during puberty. These findings of typical brain tissue development during puberty can be applied to study abnormal pubertal development

6 SEDENTARY TIME RELATES TO WORSENING KNEE CARTILAGE DAMAGE OVER TWO YEARS: THE MOST STUDY

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Knee cartilage requires mechanical loading (i.e., walking) to remain healthy. When cartilage is deprived of loading (i.e., sitting), it loses water and experiences friction. Thus, people who are sedentary may experience cartilage damage. We examined how sedentary time relates to worsening cartilage damage in people with/at risk for knee osteoarthritis. We separately analyzed people with fewer vs. more steps/day because we suspected the effects of sedentary time are different between these groups.

We used MOST data. Participants' steps/day were collected for 7 days at baseline. We stratified our sample by median steps/day and identified tertiles of sedentary time. The Low tertile was the reference group for each stratum. Participants had knee MRIs obtained at baseline and two years. Cartilage morphology was scored using WORMS over two years. Our outcome was worsening cartilage damage, defined as any increase in cartilage WORMS. We used logistic regression to calculate risk ratios and 95% confidence intervals, adjusting for potential confounders.

We included 951 participants. Participants who walked <7000 steps/day with high sedentary time had 1.53 (95%CI [1.03-2.28]) and 1.78 [0.96-3.29] times the risk for worsening medial tibiofemoral and lateral patellofemoral cartilage damage, respectively, compared to the reference group. Participants who walked ≥7000 steps/day with high sedentary time had 2.15 [1.16-4.00] times the risk of lateral patellofemoral cartilage damage compared to the reference group.

More sedentary time, coupled with fewer steps walked per day, may be detrimental for medial TF and lateral PF knee cartilage. Walking more steps per day did not reduce the risk of lateral PF cartilage damage.

7 COMPARISON OF INVOLVED AND UNINVOLVED LIMB T2 VALUES 24 MONTHS AFTER ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

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[1]Mechanical Engineering, [2]Biomechanics & Movement Science, [3]Physical Therapy, [4]Biomedical Engineering *Introduction: There is a well-established relationship between anterior cruciate ligament reconstruction*

(ACLR) and the premature development of osteoarthritis (OA). Transverse relaxation (T2) time, a quantitative magnetic resonance imaging (qMRI) variable, can quantify the degradation of the cartilage's collagen matrix, an early sign of OA development. A higher T2 relaxation time is indicative of collagen matrix degradation. As part of a longitudinal study we examined T2 values in the involved (injured) and uninvolved (noninjured) limbs 24 months post ACLR.

METHODS: 16 subjects (7 female, age: 23.6 ± 8.7 years) were examined 24 months after unilateral ACLR. Each subject underwent a supine bilateral knee MRI (3T, Siemens) using a sagittal T2 mapping sequence. For both the medial and lateral tibiofemoral compartments cartilage T2 values were determined for 6 regions of interest (ROIs) corresponding to the primary load bearing regions of the knee during gait.

RESULTS AND DISCUSSION: For all regions the involved limb had a higher T2 value than the uninvolved limb in both tibiofemoral compartments. Two regions in the medial compartment and one in the lateral compartment had significant positive differences between limbs (involved-uninvovled). Higher T2 values are indicative of collagen matrix degredation, a sign of early OA. Higher involved limb T2 values at 24 months, when compared to uninvolved limb T2 values, may indicate that the early onset of OA is occurring within this cohort.

8 PERLECAN DEFICIENCY IMPAIRS THE INTRACELLULAR CALCIUM SIGNALING IN MECHANICALLY LOADED BONE AND OSTEOCYTES

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Perlecan is found within the pericellular matrix of osteocytes and can serve as a critical component of osteocytes' mechanosensing tethers. Deficiency in perlecan is associated with profound musculoskeletal disorders, such as the Schwartz-Jampel syndrome with reduced stature and skeletal abnormalities. In this study, we aimed to test *the hypothesis* that perlecan deficiency impairs the intracellular calcium signaling pathway in mechanically loaded bone and the encased osteocytes. We performed RNA sequencing analysis on 19-week-old perlecan deficient mice (Hypo) and WT controls subjected to tibial loading for 7 days on the left tibia, and identified the downregulation of calcium signaling pathway, with 4-8 fold decrease in the transcripts of the L-type calcium channel (*Cacna1s*), ER Ca^{2+} releasing receptor (RYR), ER Ca^{2+} refilling pump (SERCA), and some downstream genes (*Mylk2; Mylk4; Tnnc2; Phkg1*). This was further confirmed by our in situ calcium imaging study. Perlecan deficient mice showed more than 58% lower responding rate, fewer number of peaks and lower percentage of multiple responding peaks. The dynamic measures of the first peaks in Hypo, relative to WT, showed a trend of lower magnitude, longer arising time, and longer relaxation time. Pooling all the peaks together, similar differences were observed in Hypo relative to WT in the peak magnitude and relaxation time, but no change in arising time. These results support our hypothesis and elucidate the mechanisms underlying the attenuated anabolic response to loading in Hypo.

9 CK2.3, A MIMETIC PEPTIDE OF BMPRIA, IS A POTENTIAL ACTIVATOR OF OSTEOBLAST DIFFERENTIATION AND ACTIVITY

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Osteoporosis, often referred to as OP, is a disease that is characterized by low bone mineral density. This decrease in bone mineral density leaves the bone more fragile and porous. This fragility in bone is due to an imbalance between the bone forming cells, osteoblasts, and the bone reabsorbing cells, osteoclasts. With the bone being more fragile, OP patients are more susceptible to fractures and the risk of fracturing a bone increases with age. Approximately 1 in 2 women and 1 in 4 men over the age of 50 will break a bone due to OP and an estimated 20% of those who suffer hip fractures die within a year due to complications.

Despite the ever-constant presence of osteoporosis, mortality rates for this disease remain unchanged, demonstrating the ineffectiveness of current treatments on the market. Our lab has designed a novel peptide, CK2.3, which increases bone mineral density and the expression of Alkaline Phosphatase (ALP) and Osteocalcin (OC) *in vivo*. The peptide works by blocking the enzyme casein kinase 2 (CK2). CK2 is a regulatory protein in the BMP2 signaling pathway that interacts with more than 300 substrates. ALP and OC are not only well-known biochemical markers for osteoblasts but are also crucial proteins that effect the bone remodeling cycle. Retired breeders of female C57BL/6J mice were obtained from the Jackson Laboratory (Bar Harbor, ME). At 6 months of age, female mice) were injected in the tail vein once a day for five consecutive days with CK2.3 at, 0.76 μg/kg (low), 2.3 μg/kg (medium), and 6.9 μg/ kg (high) per mouse, or 50μl of PBS as a vehicle control. At one week, two weeks, and four weeks after the initial injection, mice were sacrificed, and femurs were isolated. Immunofluorescent images of femur slices were quantified for each week. One week and two weeks after the initial injection did not show a significant difference in the expression of ALP and OC. Four weeks after the initial injection showed a significant increase in the expression of ALP and OC in a dosage dependent manner.

10 THE EFFECTS OF MECHANICAL LOADING ON BONE METASTASES IN AN SYNGENETIC MOUSE MODEL WITH INTACT IMMUNE SYSTEM

Shubo Wang, Shaopeng Pei, Jerahme Martinez, Liyun Wang

Bone metastsis occurs in 70% breast cancer survivors. Physical activity has been shown to reduce the recurrence rate and improve the quality of life of breast cancer patients. In a recent study, mechanical loading was shown to inhibit the development of overt osteolytic bone metastases in a SCID mouse xenograft of human breast cancer. However, the mechanism has not been fully addressed. To investigate the effects of mechanical loading in a mouse model with intact immune system, we chose a mouse breast cancer cell line Py8119 and injected the cancer cells to both tibiae of C57B/L6 mice. Axial tibial compression was applied to the left limb and the other limb was used as a contralateral control. The progression of bone metastasis was monitored by weekly in vivo micro CT scanning up to 5 weeks. The Py8119 cell line is very aggressive and as low as 5,000 cells can form osteolytic bone metastases within 3-5 weeks. The present study shows that tibial compression induced bone formation in the loaded tibia indicated by microCT images and measurements during the first two weeks. However, the overall progression of osteolytic lesion was not slowed down in loaded tibia as compared with non-loaded tibia, which indicates limited protection from mechanical loading. Overt tumor burden formed in loaded tibiae and nonloaded tibiae without a significant difference. Furthermore, bone perforations developed earlier in loaded tibia with higher hazard rate. In this study we showed that the anabolic effects of mechanical loading were unable to inhibit the growth of Py8119 cells in bone. Futher work is needed to understand the effects of mechancial stimuli on the Py8119 cells in bone marrow cavity.

11 DECREASED RESPONSIVENESS TO BMP2 OBSERVED IN CELLS EXTRACTED FROM OSTEOPOROTIC PATIENTS

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Osteoporosis is a bone disease that is characterized by low bone density, which ultimately increases the occurrences of fractures or breaks. In a normal, healthy individual there is a balance between osteoblasts, bone forming cells, and osteoclasts, bone resorbing cells. Therapeutics on the market focus on either decreasing osteoclast activity or increasing osteoblast activity. BMP2 is a crucial growth factor in bone development and is known to induce osteoblast and osteoclast differentiation. BMP2 has also been approved for spinal infusion in the anterior lumbar in order to promote bone growth and healing. This suggests BMP2 could be a therapeutic for osteoporosis. However, long term use increases the risk of fracture by increasing osteoclast activity. To further study BMP2, human femoral heads were collected from Christiana Care Hospital in Newark, Delaware from patients undergoing hip arthroplasty surgery. The patients were diagnosed with either osteoporosis or osteoarthritis. Cells were extracted from the collected femoral heads and grown. The cells were treated with BMP2, and a mineralization assay (Von Kossa) was conducted in order to measure cellular mineralization activity. The treatment of BMP2 did not induce mineralization within the osteoporotic population. This is significant because the lack of mineralization response upon BMP2 stimulation has never been investigated in cells extracted from osteoporotic patients. This indicates that the BMP pathway is disrupted in patients diagnosed with osteoporosis and is a great potential target for therapeutic intervention.

12 A POSSIBLE TREATMENT FOR OSTEOPOROSIS, THE ACCUMULATION OF THE NOVEL MIMETIC PEPTIDE CK2.3 IN TRABECULAR BONE OF MICE

Ryan Wood , John Nguyen, Lora Schell

Osteoporosis is a disease characterized by reduced bone mineral density, which causes bone weakness. This fragility results from an imbalance between osteoclasts, bone absorbing cells, and osteoblasts, bone building cells. This skewed ratio can be caused by osteoclasts being either overnumerous or overactive. The condition is incredibly common, especially in the elderly; one in five men over age 50 and one in three women over age 50 will experience osteoporotic fractures, fractures which can be fatal in older victims. Despite various treatments for osteoporosis, mortality rates for the affliction have remained constant over the past few decades, showing that modern treatments are ineffective. Bone morphogenetic proteins (BMPs) are growth factors involved in bone formation. Casein Kinase 2 (CK2) is a regulatory protein that is capable of interacting with more than 300 substrates. Blocking the CK2 BMPRIa complex has resulted in increased bone mineralization in vitro and in vivo, while also suppressing osteoclastogenesis in vitro. The peptide CK2.3 was designed to CK2.3 block the enzyme CK2 from binding to BMPRIa. CK2.3 has been shown to increase bone mineral density by reducing osteoclastogenesis. The half-life of CK2.3 in the marrow cavity of trabecular bone in 6-month-old, retired breeder, female mice was observed, as too long a half-life could make the peptide dangerous, and therefore an ineffective treatment. Peptide concentration at different time intervals was investigated using quantified immunofluorescence analysis. Peptide concentration was at its maximum two weeks post injection and was decreasing by the fourth week, though the peptide appears to still be stable at four weeks.

Notes

POSTER PRESENTATIONS

Clinical Biomechanics

13 KNEE ADDUCTION MOMENTS AND CONTRALATERAL OSTEOARTHRITIS PROGRESSION AFTER UNILATERAL TOTAL KNEE ARTHROPLASTY

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INTRODUCTION: After unilateral total knee arthroplasty (TKA), many patients develop worsening pain and osteoarthritis (OA) progression in the contralateral knee. It is possible that asymmetrical loading, characterized by greater adduction moments in the contralateral knee, is a causative factor in the high incidence of contralateral TKA. The purpose of this study was to 1) determine the incidence of contralateral radiographic knee OA progression after unilateral TKA, and 2) determine if knee adduction moments in the contralateral knee are higher in those who have contralateral OA progression.

METHODS: Individuals who underwent unilateral TKA participated in a gait analysis within two years of surgery. Pre-operative and follow-up radiographs were used to quantify the severity of contralateral knee OA using the Kellgren-Lawrence (KL) score. Individuals were classified as either contralateral OA progressors or non-progressors based on changes in KL score. Independent t-tests were used to compare demographics and biomechanics between groups.

RESULTS: Of the 41 individuals who participated, 56% had OA progression in the contralateral knee by follow-up. The average time between baseline and follow-up was 7.8 (2.4) years. There were no significant differences in average knee adduction moment of the contralateral knee between groups (progressors -0.233 (0.113) Nm/kg; non-progressors -0.274 (0.132)), p=0.291. There were no significant differences for subject demographics between groups.

CONCLUSIONS: It is possible that the mechanisms result in rapid contralateral OA progression are different than primary knee OA progression. Future studies that explore biomechanical and other physiological factors are warranted. Future studies should quantify radiographic changes by the loss of joint space, and record data for other risk factors, such as physical activity.

14 UNDERSTANDING THE UNDERLYING MECHANISMS OF A MANUAL DEXTERITY ASSESSMENT USING FUNCTIONAL NEAR INFRARED SPECTROSCOPY

Elham Bakhshipour, Reza Koiler, Kimberly Milla Ceja, Nancy Getchell

The Purdue pegboard Test (PPT) is a valid and reliable tool widely used to evaluate manual dexterity in a broad diversity of clinical populations. This test includes four sub-tests: preferred, non-preferred, both hands (moving pegs into board) and assembly (assembling washers and collars). PPT is sensitive not only to fine motor skill, but also to cognitive planning and working memory. To date, despite the developments in neuroimaging technologies, the neural mechanisms underlying each sub-test have not been investigated. The aim of this study was to characterize the neural mechanisms of each individual sub-test in an ecologically valid manner. Unlike fMRI and EEG, functional near infrared spectroscopy (fNIRS) is a non-invasive neuroimaging technique that can capture blood oxygen-level dependent (BOLD) activity while an individual move in a relatively unrestrained manner. For this study, healthy adults (18-35yrs) performed PPT while fNIRS data was collected in a randomized block design for 3 sets from the Prefrontal Cortex (PFC). A one-way ANOVA was conducted to compare BOLD activity between conditions. Our results indicate that there was a significant difference between tasks (p=0.03). Post hoc analysis showed a significant difference between conditions based on task complexity, with the assembly task showing greater HbO. There was a significant difference in the average BOLD activity between the assembly and all other conditions (p<0.01).

These results indicate that sub-tests differ in neural demands and task complexity impacts overall neural activity in the PFC. This suggests that the assembly task may provide a more sensitive measure to examine both motor and executive (dys)function in neurodevelopmental disorders such as DCD and ADHD.

15 PERSONALIZED HIGH ANKLE BRACING FOR INJURED ATHLETES IN CONTACT SPORTS

Kiki Bink, Riley Curtin, Andrew Reynolds, Rachel Swamy, Brandon DeSantis, Martha Hall, Sarah Rooney

The goal of this project is to design a way to minimize internal and external rotation of the proximal ankle joint during activity among athletes with high ankle sprains in order to reduce pain, joint instability, and recovery time. The ineffectiveness of current high ankle sprain braces and the high cost of custom orthotics poses a problem for athletes seeking an enhanced recovery process and an accelerated return to sport.

The brace that our team developed in the previous semester (Fall '18) provides a custom fit to the user without the casting process and excessive cost associated with custom orthotics. This prototype utilizes an ergonomic footplate designed in SolidWorks and 3D printed with NinjaTek Cheetah filament, a strong yet flexible material. The footplate is hinged at the ankle joint and is secured to a circumferential orthoplast support with removable steel rivets. Once the orthoplast is formed to the anatomy of the user's lower leg and inserted into a neoprene pocket lining, it is tightened to the lower leg with a ratcheting buckle strap.

The brace needs improvements to be a feasible product that UD Athletics can utilize. The improvements that I'm working on this semester are:

1. Incorporation of 3D body scanning technology in the design of the footplate to offer completely customizable orthotic.
2. Optimizing the hinging mechanism to ensure strength/durability over time.
3. Investigating the use of a more low-profile ratcheting strap.
4. Incorporation of compression sleeve in the design.

The goal for the end of the semester is to have designed an improved prototype and created a plan for UD Athletics to be able to design custom ankle braces for injured athletes.

16 IMPAIRMENTS IN SENSORY REWEIGHTING FOLLOWING HIGH REPETITIVE HEAD IMPACT EXPOSURE

Jaclyn B. Caccese, Fernando Vanderlinde dos Santos, John J. Jeka, KAAP Department

The potentially detrimental effects of repetitive head impact (RHI) exposure have become recognized as a major public health issue. The purpose of this study was to compare sensory reweighting between individuals who report high-RHI exposure and those who report low-RHI exposure. Thirty participants completed a validated, self-reported questionnaire to estimate RHI exposure over the previous year, and were divided into low-, medium-, and high-RHI groups. Sensory reweighting was compared between low- (N=10, 4 males, 22.9±3.0years, 170.5±7.7cm, 70.0±12.14kg, 7±9 RHI) and high-RHI groups (N=10, 5 males, 20.0±1.1years, 170.4±7.4cm, 69.6±13.4kg, 273±161 RHI). To evaluate sensory reweighting, we simultaneously perturbed upright stance with visual (i.e. a moving visual scene at 0.2Hz), vestibular (i.e. a ±1mA bilateral monopolar galvanic vestibular stimulus (GVS) at 0.36Hz), and proprioceptive stimulation (i.e. an 80Hz vibratory stimulus to their bilateral Achilles tendons at 0.28Hz). The visual stimulus was presented at different amplitudes (i.e. 0.2m, 0.8m in the anterior-posterior (AP) direction) to measure the leg-segment AP displacement change in gain to vision, an intramodal effect, and in gain to GVS and vibration, both intermodal effects. A repeated-measures ANOVA was used to compare sensory reweighting between groups. There were group differences for gain to GVS (i.e. condition X group effect; F=5.068, p=0.004), whereby the high-RHI group did not reweight gain to GVS across conditions, and gain to vision (F=3.397, p=0.024), whereby the high-RHI group had higher gains than the low-RHI group in the 0.2m visual stimulus condition. There were no group differences for gain to vibration (F=0.045, p=0.834). These results suggest that individuals exposed to high RHI exposure may have impairments in vestibular and visual reweighting.

17 A VALIDATION OF MARGIN OF STABILITY CALCULATIONS RELATIVE TO PELVIC ORIENTATION DURING GAIT

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The minimum lateral margin of stability (*Min Lat* MoS) during walking is a measure of dynamic stability, accounting for the whole-body center of mass position *and* velocity relative to the edge of the base of support. Previous studies have demonstrated that lateral stability is altered in populations at risk of falling. The lateral MoS is typically calculated relative to an intended walking trajectory. A disadvantage of this approach is that it assumes that individuals adhere to a linear path, with deviations potentially mischaracterized as instability. Calculating MoS relative to pelvic orientation, however, would not require this assumption, and it would also evaluate stability with respect to lower-extremity anatomy. The purpose of this study was to describe and validate the approach of calculating the *Min Lat MoS* relative to the pelvic orientation. Using motion capture analysis, the right and left *Min Lat MoS* was determined for unimpaired adults as they walked along a straight path and a curved path, the latter path representing an exaggerated deviation in straight-line walking. For the traditional MoS calculation, stability was quantified assuming a straight walking trajectory. For the pelvic-oriented MoS, the *Min Lat MoS* was evaluated along the mediolateral axis of the pelvis. In straight-line walking, the pelvic-oriented MoS was smaller, yet more variable than the typical calculation. For curved-path walking, the pelvic-oriented MoS was different and less variable than that calculated in the global coordinates. These results confirm that the two methods produce different *Min Lat MoS*. We have validated the use of a pelvic-oriented *MoS* calculations when the walking direction is altered, unknown, or variable.

18 ALTERED RUNNING MECHANICS RELATED TO KINESIOPHOBIA IN RUNNERS WITH ACHILLES TENDINOPATHY

Patrick Corrigan and Karin Grävare Silbernagel

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Introduction: Aberrant loading while running may partially explain re-injury rates for patients with Achilles tendinopathy. Yet, it is unknown if loading patterns change during a run and if clinical measures relate to these changes. Therefore, we aimed to determine if Achilles tendon loading patterns change during a 30-minute steady-state run in patients with Achilles tendinopathy and explore the relationships between changes in loading and patient symptoms, kinesiophobia, and calf muscle endurance.

Methods: 12 runners with Achilles tendinopathy were included (age:44±11y; height:171±10cm; mass:70±12kg; VISA-A score:71±10; current mileage:40±29km/wk). Participants ran on an instrumented treadmill for 30 minutes at their endurance pace (2.9±0.3m/s). After a 6-minute familiarization, marker trajectories and ground reaction forces were sampled in the 7th and 29th minute. Sagittal plane ankle joint angles, moments, and powers were calculated and a musculoskeletal model estimated Achilles tendon loading. Two weeks before the biomechanical evaluation, a clinical evaluation was completed. Symptom severity, kinesiophobia and calf muscle endurance were measured with algometry and hopping pain, the Tampa Scale for Kinesiophobia (TSK), and the heel-rise endurance test.

Results: On the injured side, peak concentric ankle power decreased (p=0.02), but there were no changes in peak plantarflexion moment, peak eccentric ankle power, or Achilles tendon loading (p=0.12-0.65). No changes occurred on the uninjured side (p=0.17-0.90). TSK scores related to changes in Achilles tendon impulse, peak concentric ankle power, and peak plantarflexion moment (r=-0.66- -0.60; p=0.02-0.04), indicating that patients with greater kinesiophobia unloaded their injured tendon during the run.

Conclusions: Ankle joint concentric power reduces during a 30-minute steady-state run in patients with Achilles tendinopathy. Additionally, changes in Achilles tendon loading are associated with kinesiophobia.

19 LOWER EXTREMITY ENERGY ABSORPTION DURING A 90° CUTTING TASK PRE-POST FIFA11+

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Non-contact ACL injuries among women's soccer players frequently occur during a cut, and may be the result of poor neuromuscular control. The 11+ is a warm-up program designed to promote neuromuscular control, proper biomechanical technique, and soft landings during plyometric exercises.

Energy absorption in the lower extremity during a 90° unilateral cut was assessed in collegiate female soccer players pre and postseason using a 6 degree-of-freedom power analysis. Intervention team players completed the 11+ during the season, control team players completed their typical warm-up. Two-way repeated measures ANOVAs were used to determine the relationship between 11+ participation and energy absorption.

Intervention team participants did not demonstrate differences in energy absorption following participation in the 11+ for a single soccer season. Although the 11+ addresses biomechanical technique, it may not change energy absorption during a sport-specific 90° cut.

20 TRAINING PROPULSION: LOCOMOTOR ADAPTATION TO ACCELERATIONS OF THE TRAILING LIMB.

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Many stroke survivors suffer from hemiparesis, a condition that results in impaired walking ability. Walking ability is commonly assessed by walking speed, which is dependent on propulsive force both in healthy and stroke populations. Propulsive force is determined by two factors: ankle moment and the posture of the trailing limb during push-off. Recent work has used robotic assistance strategies to modulate propulsive force with some success. However, robotic strategies are limited by their high cost and the technical difficulty of fitting and operating robotic devices with stroke survivors in a clinical setting.

We present a new paradigm for goal-oriented gait training that utilizes a split belt treadmill to train both components of propulsive force generation, achieved by accelerating the treadmill belt of the trailing limb during push off. Belt accelerations require subjects to produce greater propulsive force to maintain their position on the treadmill and increases trailing limb angle through increased velocity of the accelerated limb.

We hypothesized that accelerations would cause locomotor adaptation that would result in measurable after effects in the form of increased propulsive force generation. We tested our protocol on healthy subjects at two levels of belt accelerations. Our results show that 79% of subjects significantly increased propulsive force generation, and that larger accelerations translated to larger, more persistent behavioral gains.

21 RECOVERY OF PATIENTS WITH ACHILLES TENDINOPATHY OVER 1 YEAR

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INTRODUCTION: Most treatment studies for Achilles tendinopathy include 12-week interventions. However, there is no study evaluating the natural corollary of injury for these patients. The purpose of this investigation is to describe the outcomes of patients with Achilles tendinopathy over 1-year without controlling treatment and to compare patient characteristics between those who have and have not recovered at 1-year.

MATERIALS AND METHODS: 100 patients (57M, mean(SD) age of 54(15) years) with Achilles tendinopathy were followed over 1-year (0-, 2-, 4-, 6- and 12-months). Patient reported outcomes were used to evaluate patient symptoms, with VISA-A score≤90/100 indicating full recovery. Age, sex, TSK scores, and FAOS-QOL scores were compared between recovered (R) and unrecovered (U) patients at 1-year.

RESULTS: Mean(SD) VISA-A scores were 54(23), 62(23), 67(22), 71(22), and 74(21) at baseline, 2-, 4-, 6-, and 12-months, respectively. FAOS-QOL scores were 45(18), 56(21), 63(1), 65(20), and 70(22) at baseline, 2-, 4-, 6-, and 12-months, respectively. At 2-months, 10% of patients had fully recovered, an additional 13% at 4-months, 8% at 6-months, and 15% at 12-months. In total, 32% patients recovered in 12-months. FAOS-QOL scores were higher (R:85(18), U:63(20), $p<0.001$) and TSK scores were lower (R:31(7), U:35(6), $p=0.01$) in the recovered group. There were no differences in age or sex ($p>0.05$).

CONCLUSION: Our findings demonstrate that 8-15% of patients experience recovery at each time point based on VISA-A scores. At 12 months, those who have not recovered displayed significantly higher TSK scores and lower FAOS-QOL scores.

22 CHARACTERIZING DISTAL FOOT STIFFNESS AS WALKING SPEED INCREASES

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Walking is a critical motor ability, providing for societal participation. Illness or injury can impair walking ability. Orthotic devices are frequently used as treatment with ankle-foot orthoses being most common[2]. In typical gait, during late stance, the distal foot deforms under load, and has been found to absorb lower limb power[3]. This power loss can be minimized using a rigid footplate with a toe rocker[4], indicating that energetics in the ankle-foot complex can be manipulated by controlling foot deformation. We theorize that we can harness distal foot energetics by manipulating foot stiffness using a deformable foot orthosis to store and return energy. In order to do this, the stiffness of the distal foot first needs to be characterized across a range of walking speeds, which was the purpose of the current study. We hypothesized that, in typical gait, as walking speed increased, the distal foot stiffness would increase. Motion capture from nine subjects walking at four scaled speeds (0.4, 0.6, 0.8, 1.0 stature/second) were analyzed. From these data, the moment about the second metatarsal head and foot-to-floor angle were calculated and graphed against each other (y-axis: moment, x-axis: angle) from heel-rise to toe-off. Distal foot stiffness was calculated as the slope of the line of best fit for the linear portion of the moment-angle curve, defined as from when the change in slope after heel-rise was first less than 0.05 to the maximum moment. As such, distal foot stiffness was defined according to the formula $k=M/\theta$, where k is distal foot stiffness, M is moment about the second metatarsal head and θ is foot-to-floor angle. On average, the data showed that as walking speed increased, stiffness increased.

23 RETURN-TO-SPORT TRAINING DOES NOT IMPROVE GAIT SYMMETRY REGARDLESS OF MECHANISM OF INJURY IN FEMALE ATHLETES AFTER ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

Naoaki Ito, Jacob J. Capin, Ashutosh Khandha, Kurt Manal, Thomas S. Buchanan, Lynn Snyder-Mackler

INTRODUCTION: Gait asymmetries such as tibiofemoral underloading are associated with early onset osteoarthritis (OA) after anterior cruciate ligament reconstruction (ACLR). Women are more likely than men to develop OA and sustain non-contact ACL injuries. Return-to-sport (RTS) training improves outcomes after ACLR. However, the influence of RTS training on gait mechanics in those who sustain non-contact versus contact injuries is unknown. The purpose of this study was to investigate the effect of RTS training on gait mechanics in female athletes grouped by mechanism of injury (MOI).

METHODS: 29 female athletes (19 non-contact/10 contact) received 10 session of RTS training consisting of strength, agility, and plyometric exercises after ACLR and rehabilitation. Gait kinetics, kinematics, and joint contact forces were calculated before and after training. Variables of interest were peak medial compartment contact force (pMCCF), total contact force (pTCF), knee flexion moment (pKFM), knee flexion angle (pKFA), and knee adduction moment.

STATISTICS: 2×2×2 (time by limb by MOI) ANOVA.

RESULTS: There were time×limb interaction effects for pMCCF ($p=0.026$) and pTCF ($p=0.034$), characterized by lesser involved versus uninvolved limb loading after training. However, interlimb differences did not exceed the minimum detectable change. Main effects of limb for pTCF ($p=0.012$), pKFM ($p=0.006$) and pKFA ($p<0.001$) were observed; all values were lower in the involved limb.

DISCUSSION: Our results suggest that RTS training does not improve gait symmetry regardless of MOI in female athletes. With the exception of the non-contact group at pre-training, female athletes walked with lower joint loading, moments, and angles in their involved limb. Future studies should consider interventions to target gait asymmetry in female athletes regardless of MOI.

24 UNDERSTANDING HANDWRITING PAUSES IN THE DETAILED ASSESSMENT OF SPEED OF HANDWRITING TEST USING FNIRS

Reza Koiler, Elham Bakhshipour, Kimberly Milla, Mandy Plumb, Nancy Getchell

Writing is one of the most complex cognitive and motor tasks in humans. Previous research has shown a significant difference in the location and percentage of pauses between typically developing children and children with DCD. However, it has yet to be determined if longer pauses in DCD children are due to higher cognitive processing demands, fatigue, movement difficulties or some combination of these. To investigate, we administered two subtests (Copy Best (CB) and Copy Fast (CF)) of Detailed Assessment of Speed of Handwriting (DASH) assessment. Seven Healthy college students between the ages of 18-22 completed DASH with scores ranging from 31st – 98th percentile, all indicating no difficulties with handwriting speed. Then the subset of copying a sentence containing all letters of alphabet was explored further while functional near infrared spectroscopy (fNIRS) was used to collect brain oxygen-level-dependent (BOLD) from the prefrontal cortex (PFC). Order of tasks were randomized and each task lasted for 1 minute with rest periods jittered between 12-18 seconds before and after each task. Pauses were defined as pen lifts from the tablet and were categorized as short (30-250 ms) or long (251-2000 ms). CB had significantly higher BOLD activity ($p<0.05$) as well as significantly more frequent, longer pauses than the CF. Also, a significant difference between tasks in frequency of pauses existed with a greater frequency of longer pauses in CB ($p<0.003$) and greater frequency of shorter pauses in CF ($p<0.03$). Our results suggest that CB has a higher cognitive workload than CF, resulting in greater BOLD changes and longer pauses. Future analysis will focus on children with DCD and ADHD to characterize the nature of pauses in these clinical populations.

25 EFFECT OF LOAD CARRIAGE ON NATURAL ANKLE QUASI-STIFFNESS

Corey Koller, BIOMS Program; Joseph Glutting, School of Education; Elisa Arch, KAAP Department

Dismounted soldiers often carry loads exceeding 30-40% of bodyweight (BW). Carrying heavy loads has shown to increase propulsion force during gait, which the plantar flexor (PF) muscles primarily contribute to. In stance, the PF muscles eccentrically then concentrically contract, aiding in the storage and return of mechanical energy. Natural ankle quasi-stiffness (NAS) can quantify the ankle joint's control of shank forward rotation, which is mainly driven by the PF muscles. The spring-like bending stiffness of ankle-foot orthotics can potentially replicate NAS by providing the resistance needed to control shank's forward rotation and store mechanical energy. Thus, the bending stiffness of these devices can potentially be used to augment function of healthy individuals. However, to optimally design such devices, we need to first understand how tasks like load carriage affect NAS. Therefore, the purpose of this study was to determine the effect load carriage has on NAS in college-aged healthy individuals. We hypothesized that as load carried increases, NAS will also increase. Twelve college-aged healthy individuals underwent an instrumented gait analysis while walking over ground at 0.8 statures/second under three load carriage conditions: no external load, weighted vest with 10% BW, and weight vest with 20% BW. NAS was calculated as the slope of the line of best fit on the moment-angle graph over stance-phase dorsiflexion. Data were analyzed using a multilevel linear model. Results showed that the participants' NAS was significantly less on their non-dominant limb than their dominant limb ($P = 0.009$). Additionally, NAS was significantly greater while carrying 20% BW compared to carrying no load ($P = 0.001$). Future works will investigate other soldier tasks, such as running, and compare these results with a military population.

26 DOES WALKING AT HIGHER INTENSITIES INCREASE OR DECREASE THE RISK OF TOTAL KNEE ARTHROPLASTY?

Hiral Master, Louise Thoma, Meredith Christensen, Dana Mathews, Daniel White.

There is conflicting evidence whether walking more is associated with risk for total knee arthroplasty (TKA) in knee osteoarthritis (OA). One reason for inconsistent findings is that walking can occur at different intensities (leisurely stroll vs. brisk walk). However, little is known about the association of walking intensity with the risk of TKA. Given we have 24 hours/day, the purpose of this study was to examine to what extent replacing time non-walking with walking at different intensities was assoicated with the risk of TKA.

We used publicly available data from the Osteoarthritis Initiative. Our exposure, time spent in different walking intensities was measured using accelerometer at baseline and was quantified by step cadence. We defined <1 step/min as non-walking, 1-49 steps/min as very-light, 50-100 steps/min as light, and >100 steps/min as moderate-to-vigorous intensities of walking. Our outcome, time to TKA was quantified in months from the baseline visit date to TKA date if received in the subsequent five years. Participants without TKA at the 5-year follow-up or lost to follow-up were censored. To examined effects of replacing time non-walking with walking at different intensities with the risk of TKA over five years, we calculated hazard ratios and 95% confidence interval using isotemporal substitution within a Cox regression.

We found, replacing 5 minutes of non-walking time with 5 minutes of walking at moderate-to-vigorous intensity **reduced** the risk of TKA. However, replacing 5 minutes of non-walking time with walking at very-light or light intensity had **no effect** on the risk of TKA. Healthcare professionals may consider encouraging their patients with knee OA to go for brisk walk for at least 5 minutes/day.

 All researchers are from the University of Delaware, Newark, DE, USA unless otherwise noted.

27 THREE DIMENSIONAL SIMULATIONS OF ATHEROSCLEROSIS BY MORPHOELASTICITY

Navid Mohammad Mirzaei, Dr. Pak-Wing Fok

Atherosclerosis is a disease considered to be one of the leading causes of death. This phenomenon can be described as a combination of mechanical deformation of the vessel wall along with the cell and chemical dynamics that happen inside of it. We consider the vessel wall as a growing hyperelastic material with three layers. To describe tissue growth we use morphoelasticity as the mathematical framework. To include the stiffening effect of collagen fibers we employ a Holzapfel-Gasser-Ogden anisotropic strain energy function. In addition, we explore the distribution of oxidized lipids, macrophages, oxygen and necrotic cells in the intima at each growth step via a system of PDEs. All numerical simulations are carried out via the finite element method on the FENICS framework. Altogether, this allows us to observe intimal thickening as a result of vessel growth along with histological changes within the wall such as the development of necrotic zones.

28 MODELLING NON-LINEAR NATURAL ANKLE QUASI-STIFFNESS ACROSS MULTIPLE WALKING & RUNNING SPEEDS

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In human gait, the ankle is commonly modelled as a linear rotational spring that stores and returns energy throughout stance. However, this model ignores the higher-order damping effects of the physiological ankle joint. More accurate characterizations of these nonlinear phenomena may help optimize future orthotic and prosthetic devices. In this study, ankle moment vs. angle curves from healthy individuals were analysed at different walking and running speeds. Linear, quadratic, and cubic curves were fit to multiple portions of stance, and nonlinear regressions reduced average squared residuals between the model curve and measured data. Seven young, healthy adult human subjects walked and ran over ground at six speeds which represent slow, moderate, and fast walking and running speeds. A 3D motion capture camera system collected 3D kinematic data and three force plates collected ground reaction force data. Subject-specific models were built, and joint mechanics were computed using Visual 3D software. Ankle moment vs. ankle angle curves during stance were divided into multiple regions: 1) Impact (foot strike to peak dorsiflexion (DF) moment, walking only), 2) Loading (max DF moment to peak plantar flexion (PF) moment), and 3) Push Off (peak PF moment to toe off). Linear, quadratic, and cubic least-square curve fits were performed on a trial-by-trial basis for each part of stance (Figure 1). The average residual squared [(measured data – curve fit)^2 across all data points] was computed for each trial, and the average of all trials per condition is reported. Average squared residuals decreased with every increase in order of the regression model.

29 PLANTAR FLEXOR RECRUITMENT DURING WALKING WITH REAL-TIME ADAPTIVE AND FIXED SPEED TREADMILL CONTROLLERS

Kayla M. Pariser, Nicole T. Ray, Jill S. Higginson

Mechanical Engineering, University of Delaware

Individuals tend to walk at a faster self-selected (ss) speed on a real-time adaptive treadmill versus a fixed speed treadmill, but it is unclear why. This study analyzed how the gastrocnemius (GAS) and soleus (SOL) function is altered by a real-time adaptive control to promote faster ss walking speeds for healthy adults. The primary function of the GAS is swing initiation while the SOL propels the trunk forward. Five participants walked at their ss speeds on an instrumented split-belt treadmill in its fixed and real-time adaptive control modes and kinematic (100 Hz) and kinetic data (2000 Hz) was collected. Subject-specific inverse dynamics simulations were generated for three gait cycles for each treadmill control, for a total of six for each subject. The motions were applied to a musculoskeletal model with 23 degrees of freedom and 92 musculotendon actuators. The model was scaled by the participants' dimensions and residual reduction analysis and computed muscle control were run to compute GAS and SOL muscle force and activation. For all participants with the adaptive treadmill, peak GAS force was less, and peak SOL force was greater than with the fixed speed control. Muscle moment arms and ankle torque did not differ between treadmill controls. This trend is believed to be primarily due to the change in treadmill control and not the difference in ss walking speed as one subject chose the same ss speed for both treadmill control modes. Our results indicate that less energy may be required for swing initiation with more energy needed for trunk propulsion on the adaptive treadmill, suggesting that the adaptive control may assist with swing initiation in gait training rehabilitation.

30 COMBINED EFFECTS OF USER-DRIVEN TREADMILL CONTROL AND FUNCTIONAL ELECTRICAL STIMULATION FOR POSTSTROKE REHABILITATION

Nicole Ray[1], Darcy Reisman[2], Jill Higginson1

[1]Mechanical Engineering, [2]Physical Therapy

INTRODUCTION: Faster walking speeds are a key outcome of poststroke rehabilitation and functional electrical stimulation (FES) of the paretic ankle muscles during gait training can increase walking speeds. FES is typically applied during fixed speed treadmill walking when participants are unable to use their augmented forward propulsion to instantaneously increase their walking speeds. Therefore, we will determine the response of stroke survivors to FES while using real-time adaptive, user-driven treadmill control.

METHODS: 14 individuals poststroke (38±29 mo., 8 M, 64±9 years, 1.74±0.12 m, 85.62±17.59 kg) performed walking trials on an instrumented, split-belt treadmill in a random order:

1. Fixed-speed control (FS) at self-selected (SS) speed
2. FSTM at fastest comfortable (FAST) speed
3. User-driven control (UDTM) at SS speed with FES
4. UDTM at FAST speeds with FES

Paired t-tests (α=0.05) were used to assess differences in walking speed and anterior ground reaction forces (AGRF) between conditions.

RESULTS AND DISCUSSION: Participants selected faster SS and FAST speeds on the UDTM with FES than the FSTM (SS: Δ=0.15 m/s, p=0.001|| FAST: Δ=0.12 m/s, p=0.001). There were meaningful increases in peak AGRF values for both limbs during SS walking on the UDTM with FES compared to FSTM (NP: Δ=2.3% BW, p=0.025|| P: Δ=1.4% BW, p=0.049), which was expected with faster walking speeds. However, there were no differences in peak AGRF values for the FAST walking conditions despite faster walking speeds for UDTM with FES (NP: Δ=0.67% BW, p=0.307|| P: Δ=0.14% BW, p=0.073). Both controllers require the same AGRF to run at a given speed, so the UDTM with FES allows users to instantly select speeds that fully utilize their propulsive forces and may augment functional gains after rehabilitation.

31 EFFECTS OF FES-ASSISTED CYCLING ON CHILDREN WITH CEREBRAL PALSY

Ashwini Sansare, Ahad Behboodi, James Alesi, Henry Wright, Samuel C.K. Lee

Recumbent cycling has been proposed as potential means of exercise for those lacking balance and coordination necessary for upright exercises. However, muscle spasticity and cocontraction in children with cerebral palsy (CP) makes it difficult to attain cycling cadence and intensity required for achieving aerobic and therapeutic benefits. Functional electrical stimulation (FES) can be used in such patients to help elicit more appropriately timed, stronger muscle contractions.

AIM: To assess the effects of FES-assisted recumbent cycling on peak VO_2 (pVO2), cadence and muscle activation patterns in five individuals with CP

METHODS: Five subjects with CP, Gross Motor Function Classification System (GMFCS) level II-IV, trained on a recumbent tricycle-based FES system for 30 minutes, thrice a week for eight weeks. FES was applied to bilateral quadriceps muscles in coordination with cycling crank angle. The pre- and post-intervention assessments include: surface EMG data collected from the rectus femoris, gluteus maximus, vastus lateralis (VL), biceps femoris (BF), gastrocnemius and tibialis anterior while the subject cycled without FES assistance at their fastest possible speed; peak VO_2 was measured during a separate stress test on the same recumbent cycle.

RESULTS: Higher GMFCS levels were associated with higher gains in pVO_2. The subjects reported mean increase of eighty six percent in cycling cadence. Center of Mass (CoM) of the activation pattern for the overlapping curves of the respective agonist-antagonist pair demonstrated a shift away from each other, implying a decrease in the muscle co-contraction. Bilateral knee muscles show the largest positive shift in CoM, with medium effects sizes.

CONCLUSION: These results suggest that FES-assisted cycling can reduce muscle co-contraction, improve pVO_2 and cadence, thus helping patients attain therapeutic training intensities.

32 PATIENTS WITH PATELLAR TENDINOPATHY COMPENSATE WITH THE PLANTAR FLEXORS TO OFFLOAD THE PATELLAR TENDON

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PURPOSE: Patellar tendinopathy is a chronic, painful injury of the patellar tendon, most common in jumping athletes. Symptomatic athletes have significantly better jump performance than healthy, matched controls in bilateral jumping tasks. However, it is unknown if side-to-side differences exist in unilateral functional tests. Therefore, the purpose of this study was to determine if side-to-side differences exist in lower extremity function in individuals with unilateral patellar tendinopathy.

MATERIALS/METHODS: 8 (3 F) subjects with a diagnosis of unilateral patellar tendinopathy were recruited.

Symptom severity was assessed using the Victorian Institute of Sport Assessment – Patella (VISA-P) questionnaire. Participants performed the heel rise endurance test, a single-leg counter-movement jump (CMJ), and a single-leg drop CMJ to evaluate lower extremity function. Paired t-tests were used to compare repetitions and maximum height from the heel rise test and average jump height from the CMJ and drop CMJ between the symptomatic and asymptomatic limbs. Effect sizes (Cohen's d) were calculated for comparisons.

RESULTS: Subjects had a mean±SD age of 26±9 years, height of 69±5 in, weight of 169±34 lbs, and VISA-P score of 58±16 points. Subjects performed more heel rise repetitions on their symptomatic limb and the effect size was large (Symptomatic: 28±6 reps, Asymptomatic: 25±5 reps, $p = 0.045$, Cohen's $d = 0.86$). There were no differences in heel rise height, CMJ height, or drop CMJ height between limbs ($p>0.05$).

CONCLUSIONS: Individuals with unilateral patellar tendinopathy have greater performance on the symptomatic limb in the heel rise test but no differences in jump performance between limbs. This suggests that these patients may be compensating with the plantar flexors to decrease load on the patellar tendon.

Schedule of the Day

TIME	WHAT	WHERE
8:30AM	BREAKFAST & POSTER SET-UP	STAR CAMPUS- GLASS ATRIUM
9:00AM	WELCOME & INTRODUCTORY REMARKS	STAR CAMPUS- GLASS ATRIUM
9:10AM	KEYNOTE LECTURE: DR. JENNIFER STEVENS-LAPSLEY	STAR CAMPUS- GLASS ATRIUM
10:20AM	BREAK	
10:35AM	PODIUM SESSION 1	STAR CAMPUS- GLASS ATRIUM
11:35AM	LUNCH	
12:00PM	POSTER SESSION 1 (ODD #S)	STAR CAMPUS- MAIN CONCOURSE
1:00PM	POSTER SESSION 2 (EVEN #S)	STAR CAMPUS- MAIN CONCOURSE
2:00PM	BREAK	
2:15PM	PODIUM SESSION 2	STAR CAMPUS- GLASS ATRIUM
3:25PM	AWARDS SESSION	STAR CAMPUS- GLASS ATRIUM
3:45PM	ADJOURN	

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