Thursday, May 20th			
Start Time (UTC)	**Finish Time (UTC)**	**Event**	**Presenter**
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Manzolini		HIP VARIANCE DECREASES IN PATIENTS WITH PERIPHERAL ARTERY DISEASE AS A RESULT OF SUPERVISED EXERCISE TRAINING: AN OPENSIM SIMULATION	Cody Anderson
Broer		INTER-LIMB COORDINATION IS IMPACTED BY AGE	Hannah Stogdill
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Lovelace		VARIABILITY ANALYSIS IN CYCLING TO IMPROVE BIKE FITTING	Daniele Albano
		Withdrawn	
Manzolini		STOCHASTIC RESONANCE AND HEAVINESS PERCEPTION OF AN OCCLUDED OBJECT	Alison Grunkemeyer
Gilbreth		PILOT-TESTING METHODS FOR ANALYZING THE EFFECT OF A PROSTHESIS-SIMULATING CRUTCH ON CONTRALATERAL LEG GROUND REACTION FORCE	Siena Senatore
Manzolini		WALKING IN A WIDTH-CHANGING VIRTUAL CORRIDOR AFFECTS GAIT VARIABILITY	Andreas Skiadopoulos
Thelan		GAZE PATTERNS DURING TREADMILL WALKING IN VIRTUAL REALITY	Isha Dhakal
Thelan		DEVELOPMENT AND VALIDATION OF A LOW-COST 3D PRINTED UPPER LIMB PROSTHETIC SIMULATOR	Chris Copeland
Lovelace		MOTOR UNIT DISCHARGE PATTERN AND SYNCHRONIZATION DURING BIMANUAL ISOMETRIC MUSCLE CONTRACTION	Yiyu "David" Wang
Thelan		KINEMATIC AND KINETIC ANALYSIS OF KNEE ARTHRODESIS- A CASE STUDY GUIDE TO CLINICAL DECISION-MAKING	Priyanka Aggarwal

Poster rooms shown in the right column above next to the poster title.

ANALYSIS OF MODERN ATHLETIC FOOTWEAR AND HUMAN BIOMECHANICS IN ENDURANCE RUNNERS, AND A PROPOSAL FOR A NEW HYPOTHESIS 'POTENTIAL STRESS LOADING THRESHOLD'

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Presentation Preference: **Podium**

INTRODUCTION

Running injuries continue to be a problem for runners every year. This study examines how improper footwear affects Running-Related Injuries (RRIs) and lower extremity pain. A survey was conducted comparing self-reported injury rates to age, activity levels, whether a participant had suffered an injury, and whether that injury had reoccurred. This data was compared to the respondent's footwear during the onset of injury and whether they had changed footwear post-injury.

Injury reoccurrence was found to be over twice as common in runners who did not alternate shoes with the onset of injury compared to those who did alternate their footwear. The results indicate a correlation between improper footwear and risk of injury. Based on the current research surrounding footwear and the data gathered from this experiment, a new idea known as the 'Potential Stress Loading Threshold' is proposed. This hypothesis suggests each component of the body can sustain a certain amount of cyclic stress before failure. This stress threshold is different for each body, and if the stress loading rate (SLR) can be contained beneath that threshold, injury will not occur.

METHODS

A survey was designed using Google Forms to determine the specific injury rate of respondents, and to determine if there is a correlation between injury and footwear used during activity. The responses confirming injury due to footwear are self-reported and not necessarily diagnosed clinically. Information was gathered about respondents' ages, training levels, footwear, whether an injury had occurred, and whether that injury had reoccurred. This data was compared to respondents' footwear during the onset of injury and whether the respondent had changed footwear post-injury. The survey was administered primarily via social media platforms and by respondent reposting and sharing. The survey was also sent to local physical therapy clinics, local collegiate and high school running teams, and running stores with the intent of both staff and customer completion. Survey responses required completion to be used in results.

RESULTS AND DISCUSSION

The results support the correlation between improper footwear and risk of injury. The percentage of respondents who had a reoccurring injury and switched shoes due to their injury was significantly lower than the percentage of respondents who had a reoccurring injury and did not switch shoes due to their injury (Figure 1). This concludes that had the participants who suffered an injury been utilizing proper footwear, their likelihood of injury would have decreased. Likewise, those who did not switch shoes due to their injury and had a reoccurring injury could potentially benefit from analyzing whether their footwear was a source of the issue.

Category	Injury reoccurred	Injury did not reoccur	Percentage of injury reoccurrence
Switched shoes due to injury	16	77	**17.20%**
Did not switch shoes due to injury	22	33	**40.00%**
Total	38	110	25.68%

Figure 1: Injury reoccurrence in runners who switched footwear post-injury

The Potential Stress Loading Threshold (PSLT) is the amount of stress a specific area of the body can endure before fatigue or failure. All human movement, especially running, produces forces that act on the body and compound if that movement is repeated. The number of cycles compared to the force applied to a specific component of the body must maintain a loading rate (red dot) lower than the threshold line (red line). If the stress loading rates can be contained beneath that component's threshold, injury will not occur (Figure 2).

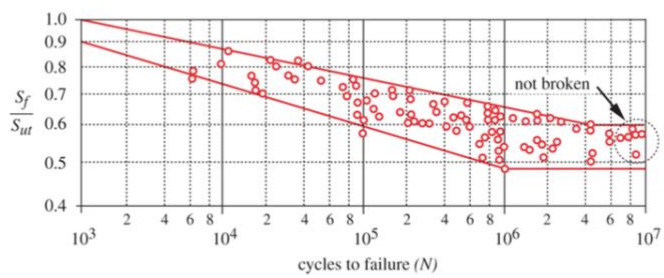

Figure 2: Wohler Strength Life or S-N Diagram [1]

CONCLUSIONS

The Potential Stress Loading Threshold hypothesis is proposed to replace the previous paradigms of pronation, cushioning, preferred movement path, comfort filter, and muscle tuning. Further investigation is needed to determine 1) how stress loading affects various components of the body, 2) the amount of stress each component can withstand, and 3) how to develop footwear that caters to each runner's specific biomechanical needs. More specific questions are also necessary to target sources of injury; therefore, further research is required.

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HIP VARIANCE DECREASES IN PATIENTS WITH PERIPHERAL ARTERY DISEASE AS A RESULT OF SUPERVISED EXERCISE TRAINING: AN OPENSIM SIMULATION

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INTRODUCTION

Peripheral Artery Disease (PAD) is characterized by the development of atherosclerotic plaques in the conduit arteries. A common manifestation of PAD is intermittent claudication, a cramping-like pain that arises in the muscles as a result of exercise and is only attenuated with rest. Current treatment options for PAD include revascularization surgeries and supervised exercise training (SET) [1]. While SET has been shown to produce favorable outcomes in PAD, gait is not fully restored [2], and it is possible that muscle activation changes as a result of SET may explain the remaining gait alterations.

METHODS

Kinematic data captured via a motion capture system, and kinetic data, captured via overground force plates, from patients with PAD (n=12), before and after a 6-month exercise intervention, were used as input for musculoskeletal modeling (OpenSim). Virtual models were scaled to match the anthropometry of the subjects before muscle parameters were derived. Muscle activation was analyzed across the stance phase of gait and the output from the computed muscle control tool was analyzed across subjects and conditions to determine how muscle activation changed as a result of supervised exercise training in PAD.

RESULTS AND DISCUSSION

In our sample of patients with PAD, SET did not result in significant increases in muscle force extrema. However, SET did result in a significant reduction in the variance of hip muscle force (Figure 1). Interestingly, our results indicate that the reduction in hip variance was mostly caused by the 1/3 of subjects (n=4) who reported attenuation of ischemic thigh pain on the San Diego Claudication Questionnaire (SDCQ) after SET (Figure 2). Specifically, the muscle groups that experienced the greatest reductions in variance were the hip abductors, hip external rotators, hip extensors, hip flexors, and hip internal rotators.

CONCLUSIONS

This study demonstrated that a subset of patients with PAD experienced a reduction in hip variance as a result of SET. This subset was identified as those who experienced an attenuation of ischemic thigh pain as reported in the SDCQ. Additionally, this study has demonstrated that the OpenSim simulator may be a valuable tool for estimating potential intervention outcomes in PAD.

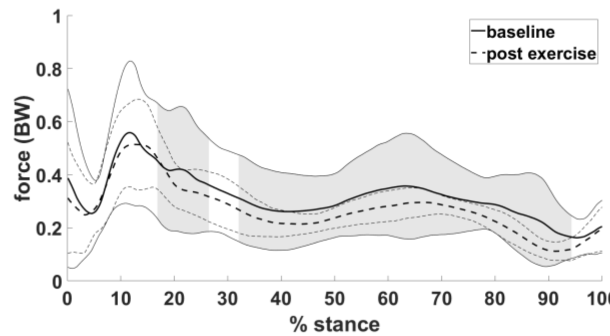

Figure 1: Hip external-rotator force (group, n=12). The gray regions indicate a significant change in group variance (p<0.05).

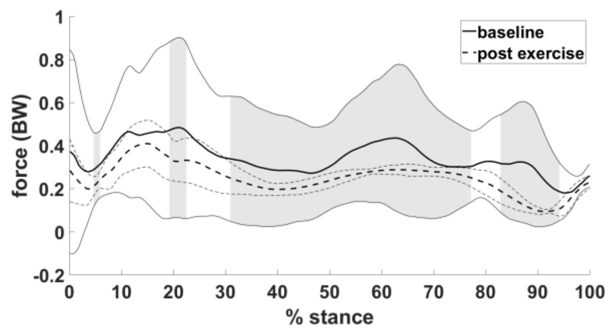

Figure 2: Hip external-rotator force (no-pain, n=4). The gray regions indicate a significant change in group variance (p<0.05).

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ACKNOWLEDGEMENTS

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INTER-LIMB COORDINATION IS IMPACTED BY AGE

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Presentation Preference: [**Poster**]

INTRODUCTION

Inter-limb coordination is the relationship between limbs or body segments during movement. In order for the body to perform effectively and efficiently on a daily basis, the limbs or segments should demonstrate optimal coordination between each other. Walking is an imperative movement in any person's daily life that requires substantial inter-limb coordination. The lack of synchrony between limbs while walking can not only lead to failure in performing daily tasks, but also an increased risk of falling which can result in serious injury. While many studies have focused on how specific gait patterns are affected by aging, no study has shown how inter-limb coordination during gait is affected by age. It has been shown that aging can trigger deterioration in sensory systems like vision, proprioception, and the vestibular systems. This means that people will be required to adapt to tasks and environment differently based on their age. Therefore, we hypothesize that with age, the duration of inter-limb coordination will decrease. Specifically, cross recurrence quantification analysis (cRQA) and cross sample entropy (cSE) will be used to quantify the duration of coordination [1] and synchrony between the limb [2] respectively. Therefore, the duration of coordination is hypothesized to be in the order: healthy young > healthy middle > healthy old, and the synchrony between the limbs will be: healthy young< healthy middle< healthy old.

METHODS

For the study, 35 healthy individuals were put into three groups: young (20 to 40 years of age), middle (41 to 60 years of age) and older (61 years of age and above) adults. The participants performed a 5-minute walk on a treadmill (Figure 1) at their preferred walking speed (PWS). The first 200 steps will be taken from each measurement and averaged. For cRQA and cSE, data will be down-sampled to 10 Hz, and first two minutes of data will be analyzed. All data will be processed using Matlab (Mathworks, Natick, MA).

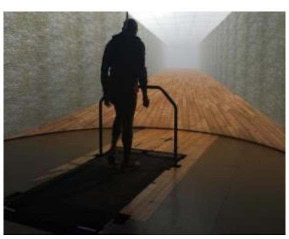

Figure 1: *Participant walking on a treadmill.*

In order to analyze the inter-limb coordination, markers were positioned on heels of the left and right legs. Their movement in anterior posterior direction was analyzed using cRQA. The plot that cRQA creates, provides a visual representation of the inter-limb coordination between the two legs. Recurrence rate was set to 2.5%. Main variables from cRQA includes mean diagonal length, percent determinism, entropy of diagonal length, radius, embedding dimension. The cSE measure assesses the inter-limb coordination by measuring the synchrony between the two legs.

RESULTS AND DISCUSSION

Based on the visual inspection (Figure 2) from our preliminary analysis, older aged adults and young adults have lower mean diagonal length, while middle age adults have higher mean diagonal length (mean ± SD). Assuming that healthy young adults have healthy optimal duration of inter-limb coordination, with progression of age, in the middle age group, sensory deterioration begins to take effect on inter-limb coordination dynamics, causing them to have higher duration of coordination. With further aging (at the old age group), adaptive changes begin to show effects on inter-limb coordination such that the mean line length of cRQA reduces. The knowledge gained from this study may be important to develop proper rehabilitation techniques because it can be applied to the rehabilitation of different pathologies. Current rehabilitation techniques are generally applied to all populations regardless of age.

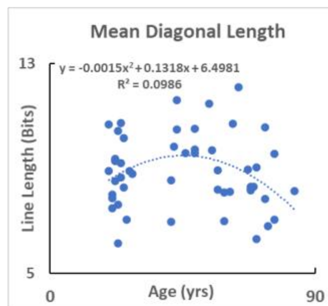

Figure 2. *Inter- limb coordination across age.*

CONCLUSIONS

In this study, we examined how inter-limb coordination dynamics changed across age. We observed that the duration of inter-limb coordination varied across ages in an inverted-U shaped pattern. We will continue with our study to determine conclusively if our observations are statistically significant. Our study is expected to provide new insights into healthy aging,

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ACKNOWLEDGEMENTS

This study was supported by the COBRE grant (1P20GM109090-01) from NIGMS/NIH, a NASA EPSCoR Research grant (80NSSC18M0076) and an AHA AIREA award (18AIREA33960251). In addition, intramural GRACA and FUSE grants from the UNO also provided support.

ASSOCIATION OF PRE-OPERATIVE SQUAT SYMMETRY AND POST-OPERATIVE KNEE FUNCTION IN PATIENTS AFTER ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

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Presentation Preference: [**Poster**]

INTRODUCTION

Patient-reported outcomes at 6 months after anterior cruciate ligament reconstruction (ACLR) are associated with hop test symmetry and return to pre-injury level of sports at 1-year post-ACLR. [1,2] Identifying preoperative relationships to postoperative subjective knee function can help clinicians modify patients' treatment plans to improve long-term outcomes. It is unknown if limb loading symmetry patterns during squats before ACLR relate to postoperative subjective knee function. The aim of this analysis was to evaluate the association between knee flexion moment symmetry during bilateral bodyweight squatting before ACLR and two patient-reported outcome measures at 6 months post-ACLR.

METHODS

This preliminary analysis included participants within an ongoing, observational study who completed testing before ACLR and 6 months after ACLR (n=23; 10 females, 13 males; age: 20.1±5.1 years). Exclusion criteria included concomitant injury to other knee ligaments requiring surgical treatment, baseline cartilage damage, planned meniscectomy, or previous injury or surgery to either knee.

Preoperatively, participants performed 3 sets of 5 bilateral squats at self-selected speed using a reliable retroreflective marker set placed on the trunk and lower extremities. Kinetic and kinematic data were collected using an 8-camera motion capture system (120 Hz) and two embedded force plates (1080 Hz). Participants also performed 3 trials of quadriceps maximum voluntary isometric contraction at 90° knee flexion. Peak torque was measured using an isokinetic dynamometer.

At 6 months post-ACLR, participants completed electronic versions of the Global Rating Scale (GRS), which asks patients about their current knee function, and the Knee injury and Osteoarthritis Outcome Score (KOOS). The KOOS has 5 subscales (Pain, Symptoms, Activities of Daily Living, Sport/Recreation, Quality of Life) and has been validated for use in patients with ACL injury [3]. Both the KOOS and GRS are scored from 0-100 with higher scores indicating better knee function.

Separate multiple linear regression models were used to assess the relationship between peak external knee flexion moment (PKFM) limb symmetry index (LSI) and each patient-reported outcome, including GRS and 4 KOOS subscales. The sport/recreation subscale was not included in this analysis because it is not relevant at this timepoint. Each model was controlled for sex, concomitant meniscus repair, and baseline isometric quadriceps strength LSI based on their known relationships with self-reported outcomes. [4,5]

RESULTS AND DISCUSSION

Descriptive statistics for all continuous variables are shown in Table 1. In this sample, the model for the association between preoperative PKFM LSI during squatting and 6-month GRS was significant after controlling for sex, concomitant meniscus repair, and baseline isometric quadriceps strength LSI ($p=0.033$; $R^2=0.424$). Preoperative PKFM LSI explained an additional 18.0% of the variance in 6-month GRS ($\beta=-2.374$, $p=0.029$). In this model, baseline isometric quadriceps strength symmetry was also a significant predictor ($\beta=2.180$, $p=0.043$). PKFM LSI was not associated with any of the KOOS subscales at 6 months post-ACLR (all $p>0.05$).

CONCLUSIONS

The results of this analysis suggest that patients with greater asymmetry in PKFM during squatting preoperatively had better self-reported knee function at 6 months post-ACLR. Based on these results, it is evident that there may be a discrepancy in objective function and patient perception of function, but how this relationship changes over time requires more investigation.

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Table 1. Descriptive statistics for all continuous variables. *LSI=limb symmetry index; PKFM=peak external knee flexion moment; KOOS=Knee injury and Osteoarthritis Outcome Score.*

Time Point	Variable	Mean±SD
Preoperative	Isometric Quadriceps Strength LSI (%)	80.1±16.5
	PKFM LSI (%)	71.9±23.4
6 months post-ACLR	Global Rating Scale (GRS) (%)	75±15
	KOOS Pain (%)	92.1±8.2
	KOOS Symptoms (%)	87.6±7.2
	KOOS Activities of Daily Living (%)	96.5±6.5
	KOOS Quality of Life (%)	59.5±16.6

Variability analysis in cycling to improve bike fitting

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Presentation Preference: [**Poster**]

INTRODUCTION

Bike fitting is the procedure that serves to identify the optimal riding position for the cyclist both in terms of comfort and performance. To date, although there are several parameters to consider, there is no consensus among bike fitters on which parameters to focus on [1]. The analysis of human movement variability could provide further information on how the two systems, human and bicycle, work together, based on some studies carried out on amputee patients [2] it seems that using the largest Lyapunov exponent (LyE) as a variability index it is possible to quantify the degree of stability and predictability of a system. For this reason, we have chosen to apply the LyE calculation to three different bike setups to understand if it is possible to determine an optimal one.

METHODS

One participant (male; age: 31yrs; height: 1.82 m; mass: 80 kg) was recruited for the present study. Subject signed informed consent before the study. After warming up for 5 minutes on a spin bike, the subject pedalled for 6 minutes at the self-chosen cadence. Three different setups were used by only modifying the height of the saddle, the vertical distance between the bottom bracket and the centre of the saddle (setup1 = 0.82m; setup2 = 0.79m; setup3 = 0.77m). The subject was asked to assign a preference value from 0 to 5 relating to comfort for each setup. The displacement of a reflective marker positioned on S1 was captured by a 6-camera optoelectronic system (BTS Bioengineering) with a sampling rate of 60hz. The LyE for the displacement in the anteroposterior (AP), mid-lateral (ML) and vertical (V) were computed in MatLab (The MathWorks). The correlation between LyE value and saddle height and between LyE value and preference expressed by the subject was calculated. A one-way ANOVA was performed on the data, with $p = 0.05$.

RESULTS AND DISCUSSION

Setup1 shows the lowest LyE values in all directions, setup2 shows the highest value in the AP direction, while an intermediate value in the ML and V direction. Setup3 instead shows an intermediate value in the AP direction, but the highest in the ML and V directions. This result, interpreted with respect to the theory of optimal variability [3], could indicate that an excessive saddle height reduces the complexity of the system compared to an optimal level. The data show a good correlation of the LyE value in the V and ML direction both with the saddle height ($r = -0.7$; $r = -0.8$) and with the preference ($r = 0.6$; $r = 0.7$). ANOVA shows significant differences only in the ML direction, in particular between setup1 and setup2 ($p = 0.047$) and between setup1 and setup3 ($p = 0.025$). Considering the difference in saddle height between the different setups and the preference value indicated (setup1= 3; setup2= 5; setup3= 4), these results agree with the fact that the difference in height between setups 2 and 3 is smaller as well as the difference in the preference expressed.

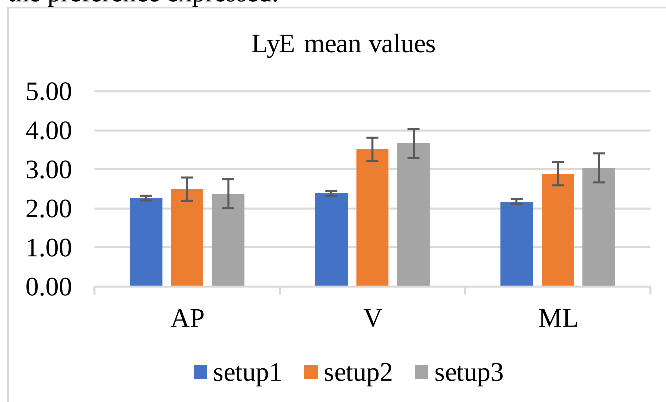

Figure 1 *LyE mean values for 3 setups in AP, V, ML direction.*

CONCLUSIONS

It seems that the LyE values in the ML direction could identify an excessive saddle height compared to the optimal one. However, as this is a case study it is necessary to repeat the measurements on a larger sample to confirm the results. The information provided by a variability analysis could integrate that obtained through a conventional analysis to improve bike fitting.

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Table 1 *Table shows correlation between saddle height and LyE and between preference and LyE.*

	LyE_AP	**LyE_V**	**LyE_ML**
Saddle height (r)	-0.2	-0.7	-0.8
Preference (r)	0.3	0.6	0.7

NEURAL ACTIVITY IS SIMILAR DURING FINGER TAPPING WITH PERIODIC, RANDOM OR FRACTAL METRONOMES

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Presentation Preference: **Poster**

INTRODUCTION

Neural activity peaks in amplitude similar to the frequency of metronomes when motor synchronization is associated with periodic rhythms. Neural activity is also known to show patterns of fractal fluctuations which are non-periodic rhythms, but it is unknown how neural activity synchronizes with fractal metronomes. Here, we make the hypothesis that synchronization of neural activity with fractal metronomes will result in lower amplitude activity at mean frequency, due to a wider distribution of beat intervals around the mean frequency in fractal rhythms.

METHODS

Healthy young adults (n = 20) seated in a chair with arm rest and dimly lit room were fitted with electroencephalogram (EEG) to monitor neural activity throughout the collection. Participants were asked to tap their dominant index finger on a pressure sensitive pad with least possible movement in rest of body and consistent posture. They were given synchronized finger tapping tasks while listening to types of metronomes through a loudspeaker.

Peaks of metronomic clicks were used to calculate α-DFA exponent and obtain inter-beat intervals (IBIs) and finger taps were used for inter-tap intervals (ITI). Cortical data between 1.5 to 2.5 Hz in electrodes from midline frontal and occipital, Fz and Oz, respectively, was compared based on the frequency present in the metronomes. Amplitudes associated with each frequency were normalized using z-score. One-way ANOVA were used to determine significance between the conditions for each electrode ($p<0.05$).

RESULTS AND DISCUSSION

There was no significant difference between conditions of frontal and occipital cortical recordings, but large inter-individual variations were evident. Peak amplitude of neural activity was observed near 2Hz. Clear visible peaks of amplitude were lacking in some participants, especially during non-periodic metronomes (fractal and random) which may be due to other cortical processes or unwanted interference in recordings. It may imply the presence of discreet mechanism in different lobes underlying motor synchronization. Non-parametric assessment is to be used in further examination in order to obtain goodness of fit between metronomes and cortical recordings. Our study contributes to the current understanding of perception of day-to-day rhythms in human brain and its effect on motor synchronization.

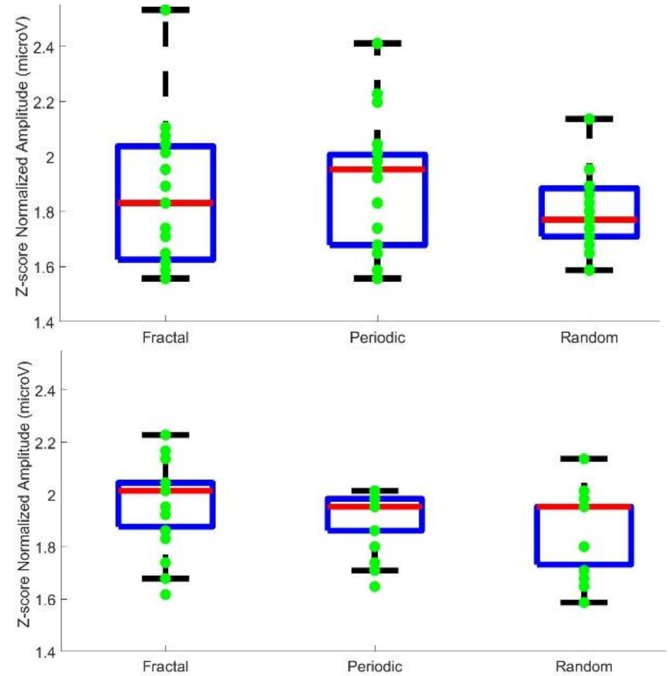

Figure 1: Normalized peak amplitude frequencies of frontal (top) and occipital (bottom) electrodes during motor synchronization with types of metronomes. Quartiles, median and range of data were indicated with Box and Whisker plots. Green dots indicate each individual value in the data. Large individual differences between frontal and occipital electrodes are displayed between 1.5 to 2.5 Hz peak amplitude frequencies. Peak amplitude is slightly higher (non-significant difference) with Periodic metronome for the frontal electrode (Top middle plot). The occurrence of peak amplitude frequency by participants in one condition was unrelated to the occurrence of peak amplitude frequency in other conditions.

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Stochastic Resonance and Heaviness Perception of an Occluded Object

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Introduction

Heaviness perception is the ability to use haptic feedback from effortful touch to determine the weight of a wielded object [1]. The perception of an object being wielded does not rely solely on the object's mass, but muscular effort as well. When an object is wielded, torques and moments of inertia are produced. The inertia tensor contains those moments and provides information about how mass is distributed in a rigid body. The corresponding eigenvalues and eigenvectors of the inertia tensor have been related to an object's perceived magnitudes (e.g., weight) and directions (e.g., orientation with respect to hand), respectively (**Figure 1a)**[2]. The inertia tensor can be visualized as an ellipsoid, as seen in **Figure 1b**, which is produced in effect from the constraints related to the position of the limb. In this study, we will manipulate the eigenvectors associated with an object in relation to the limb.

Recent studies have also provided evidence that adding noise to a weak stimulus can enhance a person's ability to detect it [2]. Introducing a subthreshold (vibrational) stimulus embedded with noise may, in some cases, improve sensations gained from limb movements [1]. We hypothesize that adding vibrotactile noise of various forms will improve accuracy in perceiving heaviness of a wielded object (**Figure 2)**.

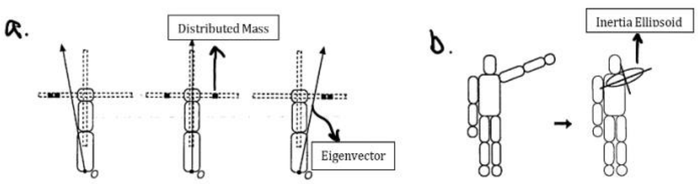

Figure 1: (a) Effect of varying mass loads on eigenvectors. (b) Inertia ellipsoid of upper limb.

Methods

Ten adults (18-45 years of age) will be seated for the duration of the trial with a BM3C tactor fastened to the humerus of the subject as seen in **Figure 2**. Subjects will wield an occluded object with varying masses. Vibrational stimuli will be introduced via the tactor with different signals of colored noise, or signals produced by stochastic processes varying in power spectral slope. Noise (3) × mass (6) combinations will be presented. Each condition of noise and mass will be introduced randomly. Subjects will rate the heaviness of the object by stating their perceived proportion of mass added on a scale of 1-10.

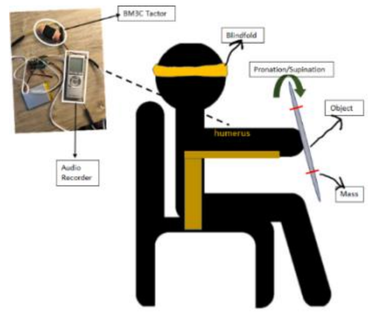

Figure 2. Proposed experimental set up. The participant will be blindfolded to ensure proper occlusion of the wielded object. The BM3C tactor will be fastened to the humerus where vibrational stimuli embedded with a noise signal will be applied.

Expected Results and Discussion

We expect that the embedded pink noise signal will produce the highest level of accuracy regarding heaviness perception compared to the alternative condition as seen in the projected outcomes in **Figure 3**.

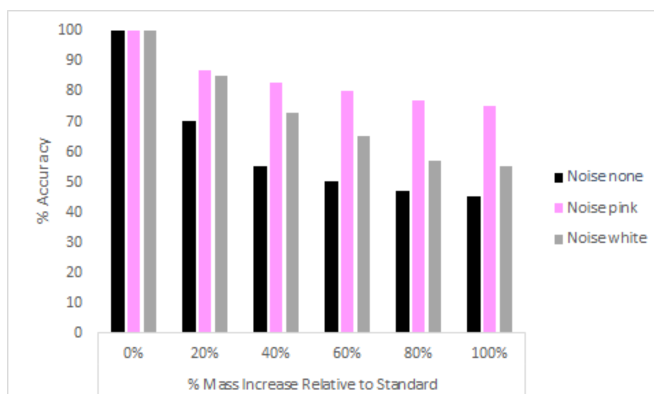

Figure 3: Expected outcomes of accuracy for given incremental masses with respective embedded noise signals for proposed experimental design.

Conclusions

Introducing a noise as a subthreshold vibration is hypothesized to improve the heaviness accuracy of a given wielded object. Pink noise is expected to display the highest level of accuracy considering the exploratory patterns conveying fractal properties the subjects will exert. These fractal properties are common in most biological systems, therefore producing a more accurate identification of weight.

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PILOT-TESTING METHODS FOR ANALYZING THE EFFECT OF A PROSTHESIS-SIMULATING CRUTCH ON CONTRALATERAL LEG GROUND REACTION FORCE

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Presentation Preference: **Poster**

INTRODUCTION

About one million adults in the US live with a lower limb amputation [1]. Despite remarkable advances in research on passive and active prostheses [2], there are less expected side effects, such as increased pain and osteoarthritis in the intact limb [3,4]. When designing assistive devices for amputees, instead of only optimizing the prostheses, we will focus on the optimization of footwear as shoe parameters, such as cushioning, can affect ground reaction forces [5]. Additionally, modern prostheses have multiple settings that can be individualized (pylon height and stiffness).

Our specific aim is to pilot test various methods of altering the use of a prosthesis simulator on one leg and analyzing the effects on ground reaction force. The longer-term goal from this preliminary work is to develop algorithms that allow us to optimize shoe parameters of hardness and pylon height simultaneously.

METHODS

As a preliminary step toward testing the effects of altering prosthesis and footwear in amputees, we pilot tested the effect of a prosthesis-simulating crutch (Figure 1). We conducted a protocol with four conditions and analyzed the effect on ground reaction force on both legs.

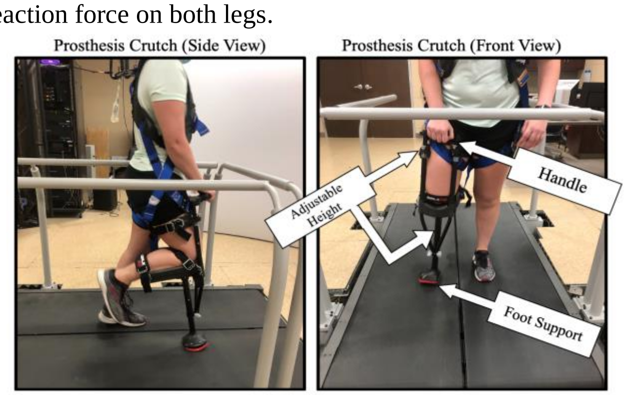

Figure 1: The prosthesis crutch intended to simulate walking with a prosthesis

The participant was required to walk without the prosthesis crutch, with the prosthesis crutch, with the handle set at a higher height and without the use of the handle entirely. The first two conditions help analyze the ground reaction force, and the other two conditions evaluate the functionality of the prosthesis crutch. We recorded the ground reaction force from a Bertec Split-belt treadmill. The data was processed by plotting the normalized stride through heel detection and filtering.

RESULTS AND DISCUSSION

As expected, walking with the prosthesis crutch drastically alters the ground reaction force. Additionally, wearing the prosthesis crutch leads to changes in the ground reaction force on the opposite leg (Figure 2). This suggests that optimizing prosthesis parameters could allow for minimizing intact leg loading for individuals who wear a prosthesis. Research related to prosthesis push-off has found similar results related to knee intact loading [6].

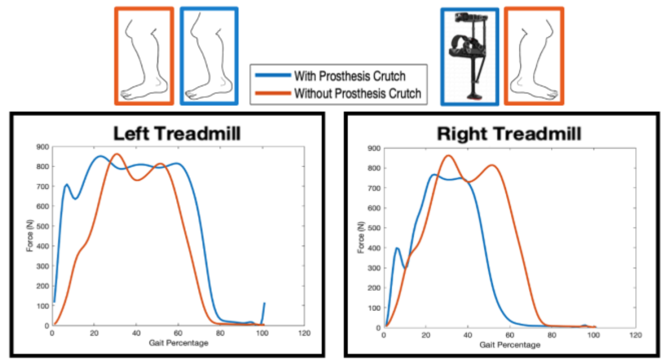

Figure 2: The mean of the normalized ground reaction force for walking with (blue) and without (orange) the prosthesis crutch

There are also interesting, unexpected effects of the prosthesis crutch. The prosthesis crutch does not seem to alter the peak value of the ground reaction force but rather the loading rate toward the initial impact peak (Figure 2). The non-prosthesis wearing side also seems to make longer contact with the ground than the-prosthesis side and without it entirely.

In future experiments, we will pilot-test different shoe parameters like pylon height and stiffness and analyze their effect on ground reaction force. Our overall goal is to create a human-in-the-loop optimization algorithm that allows us to optimize shoe parameters to reduce intact knee loading.

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WALKING IN A WIDTH-CHANGING VIRTUAL CORRIDOR AFFECTS GAIT VARIABILITY

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INTRODUCTION

Mediolateral visual perturbations during treadmill walking impact gait variability. However, this effect was shown for randomly or discretely changing visual perturbations and remains unknown for continuously changing visual perturbations [1,2]. The purpose of this study was to investigate whether continuous changes in the width of a virtual corridor could affect gait variability during treadmill walking.

METHODS

Nine healthy adults (26±5 years; height: 168±14 cm; body mass: 69±21 kg) performed three 6-min treadmill walking conditions while kinematics was acquired. The conditions were the following: one with a fixed-width corridor (1.91 m) presented as the Control condition, and two with different width sizes of the corridor where the width of the corridors was expanding and then narrowing sinusoidally during each condition (Figure 1). The step width and step length time series from all participants/conditions was identified from the kinematics and was evaluated using i) the standard deviation to identify changes in the amount of variability, and ii) the fractal scaling exponent estimated with detrended fluctuation analysis to identify changes in the temporal structure of variability. We implemented a shuffle surrogate test to identify if the variability of the time series has a deterministic origin. We used random permutations of the original data to statistically differentiate time series from uncorrelated noise [3]. We compared the variability measures among width-changing virtual corridor conditions using a linear mixed effects model with width-changing virtual corridor condition as a fixed effect and the blocking factor (participant) as a random effect. For comparing fixed effects, we used Tukey's multiple comparison test. Significance level was set at α=0.05.

RESULTS AND DISCUSSION

The standard deviation of the step width time series significantly increased in the Wide condition (2.06±0.50 cm) as compared to the Narrow (1.87±0.37 cm) condition (p=0.015). The fractal scaling exponent of the step width time series significantly decreased (p<0.001) for the Wide condition (0.68±0.09) as compared to the Narrow condition (0.79±0.09); and significantly increased (p=0.03) for the Narrow condition as compared to the Control condition (0.73±0.11). The results of the surrogate tests indicated presence of deterministic characteristics (i.e., long-range correlations) in the step width and step length time series for each width-changing virtual corridor (Figure 2). Overall, our findings demonstrated that continuous change in the width of the virtual walking path affect step width variability in healthy young adults. When the virtual corridor was expanding in a wider fashion, the amount of step width variability increased, and its temporal structure became less persistent. Our results suggest that the gradual transition from a wide to a narrow visual field may reweight visual information (from motion) as a function of corridors' width. As a result, step width variability during walking could be modulated continuously through visual information.

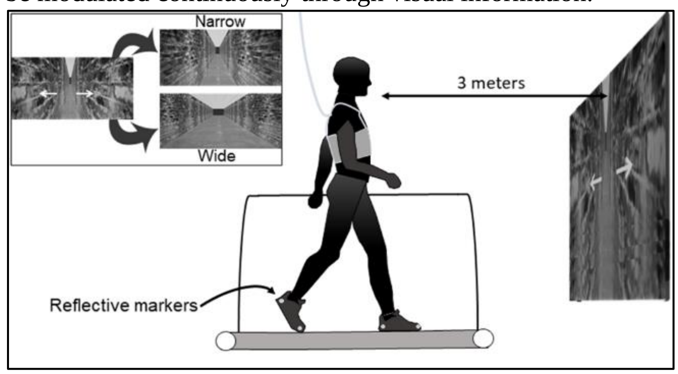

Figure 1: Experimental setup showing our width-changing virtual corridor with the Narrow condition (altering between 0.38 m and 1.14 m; left top) and the Wide condition (altering between 0.38 m and 2.67 m; left bottom) identified.

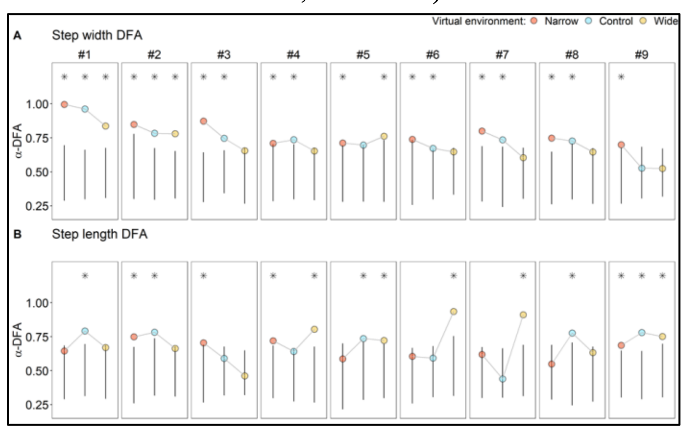

Figure 2: Shuffle surrogate tests of step width (A) and step length (B) time series of each participant (#1 to #9) using α-DFA as discriminating statistic. Colored dots represent the observed α-DFA values for each width-changing virtual corridor (Narrow, Control, Wide). The vertical lines represent the range of the surrogate α-DFA values. Asterisks show when the observed α-DFA values are greater than the second greatest surrogate, indicating a statistically significant difference from uncorrelated 'white' noise (p≤0.005).

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GAZE PATTERNS DURING TREADMILL WALKING IN VIRTUAL REALITY

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INTRODUCTION

Balance control during gait is affected by a wide range of sensorimotor feedback systems including vision, proprioception, and the vestibular system. [1] Maintenance of balance and stability are the foundational components of many static and dynamic movements that individuals perform every day. In healthy individuals, all sensory systems will work together to allow the brain to receive feedback in regard to the environment and respond to different sensory inputs as they are walking. However, in individuals that have impairment in one of these areas, it can be very difficult to maintain balance or walk. Vision plays a vital role in being able to walk and maintain balance. It allows for us to avoid obstacles, control our stride, and navigate where we are going. [2] In our previous study, we showed that vision plays an important role in controlling balance during walking. This was shown by vision having similar effects to support surface perturbations on medio-lateral stability. However, this result was assumed since we did not have a measure of visual perception/response. With eye tacking, it is possible to answer this question conclusively. Our second question is how visual perceptual decisions are made in a dynamic environment, i.e., how acute is our awareness of the visual environment as we interact with it during walking. We use Tobii eye tracking glasses (Tobii, Danderyd, Sweden) to examine gaze control in participants during a visual symmetry task that tests an individual's ability to perceive shifts in their environment. Gaze tracking helps us see how well the participant is responding to the stimuli, if the gaze is concentrated in one place, we can tell that the task is easier for the participant since they are responding well to the stimuli. If the gaze is all over the place, we can tell that the task is harder, and they are not responding well to the stimuli. For our research study, we are looking at how the gaze will differ when participants are walking on an oscillatory platform with visual stimuli having different origins of optic flow.

METHODS

We will be collecting data from healthy young individuals between the ages of 19 –35. The walking test will be completed on a Computer Assisted Rehabilitation Environment (CAREN) that is a treadmill on a platform that has six degrees of freedom, which means that the platform can be moved in six directions while the treadmill is on. As they are walking on the platform, they will also be wearing eye tracking glasses that allow for gaze tracking while completing the dynamic visual acuity test (DVAT). The participants will walk at three different speeds, (slow, preferred, and fast) at three different oscillations (0°, ±5°, ±10°) a Computer Assisted Rehabilitation Environment (CAREN). For this research we will be looking into four different conditions, (1) Baseline – normal AP optic flow (OF) and normal AP treadmill movement, (2) OF – oscillating OF with normal AP treadmill movement, (3) Static – no OF with normal AP treadmill movement, (4) Platform – normal AP OF with oscillating platform. As participants are walking on the platform, they will also be wearing eye tracking glasses that allow for gaze tracking. The DVAT tests an individual's ability to adapt to and perceive horizontal shifts in their environment. We use this to determine the perception threshold in degrees.

RESULTS

We anticipate the results of our study to indicate that when there is a shift from baseline conditions, to platform and optic flow, gaze control will be reduced. Individuals may not be able to control their gaze as they would during the baseline due to the need to adjust to atypical varying stimuli, creating a more unstable condition.

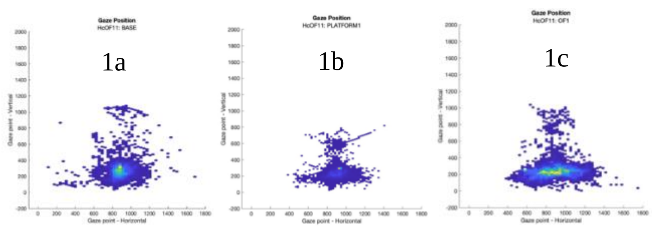

Figure 1: This figure shows three different trails for a participant. The yellow/orange shows a concentration of gaze, meaning that the participant's gaze was focused there for most of the trial, and the dark blue indicates where the gaze not as concentrated. Preliminary analysis of the balance study shows shifts in gaze matching the oscillations of the visual feedback in the baseline condition. (Fig 1a). In platform oscillations, gaze patterns don't show distinct regions of concentration (Fig 1b). And in the optic flow condition, we see that shifts in gaze again matches the oscillations of the visual feedback (Fig 1c).

CONCLUSION

We anticipate our gaze results will demonstrate more conclusively the effects of visual feedback on balance control during gait on stable and unstable support surfaces. In addition, we will have a better assessment method for determining dynamic visual acuity.

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DEVELOPMENT AND VALIDATION OF A LOW-COST 3D PRINTED UPPER LIMB PROSTHETIC SIMULATOR

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Presentation Preference: Poster

INTRODUCTION

It is estimated that 35-58% of children with an upper limb reduction (ULR) reject their prosthesis [1]. Prosthetic simulators are devices used to aid individuals with ULR with familiarizing with their prosthetic limb by using their non-affected limb. The literature surrounding these tools have examined kinematic and functional results of variability of practice and training paradigms [2,3]. If these simulators can emulate the ULR neural responses, investigation of these responses with a larger pool of typically developing (TD) participants may further inform prosthetic rehabilitation. Thus, the purpose of this study was to collect preliminary data examining the effects of prosthetic simulators on brain activation. The hypotheses of the present study were that TD children using a prosthetic simulator would exhibit lower activation in the motor areas of the cortex, similar to neural activation patterns seen in children with upper limb reductions who are novice prosthetic users.

METHODS

The study was approved by the UNMC Institutional Review Board. The ULR group consisted of 2 girls and 3 boys, with a mean age of 8.76 ± 3.37 years, who reported to be right-handed. An age- and sex-matched (mean age: 8.96 ± 3.23) group of right-handed TD children were also recruited. An assent was explained by the corresponding author and signed by the children and their parents.

Changes in brain activation were observed using functional near-infrared spectroscopy (fNIRS), which measures the blood oxygen levels, or hemodynamic responses within the superficial cortex. Responses in the contralateral primary motor cortex (M1), supplementary motor area (SMA), and primary somatosensory cortex (S1) were recorded for three one-minute trials of the Box and Block test with one minute of rest between trials. The ULR group performed the task with their prosthesis, while the age and sex-matched TD group used their non-preferred hand, with and without a prosthetic simulator.

RESULTS AND DISCUSSION

The results of the present study serve as preliminary data to guide future studies. Individual paired analysis was also performed. Means of the region activations can be found in Figures 1 and 2. Independent t-tests highlighted significantly less activation in the M1 ($p = 0.002$) and SMA ($p < 0.001$) of the ULR group. No significant difference was detected in S1. When observing the effect of the simulator in TD participants, dependent t-tests revealed significantly less SMA activation ($p = 0.043$) and significantly higher S1 activation ($p = 0.002$) when using the prosthetic simulator.

The reduced ULR M1 and SMA activation may be a product of diminished motor areas corresponding to the affected limb. The increased SMA activity in TD participants could reflect increased motor planning challenges introduced by the fingers. Finally, the prosthetic simulator may allow for emulation of the ULR S1 during motor tasks, as no difference was observed between groups, which may be due to increased proprioceptive or visual demands.

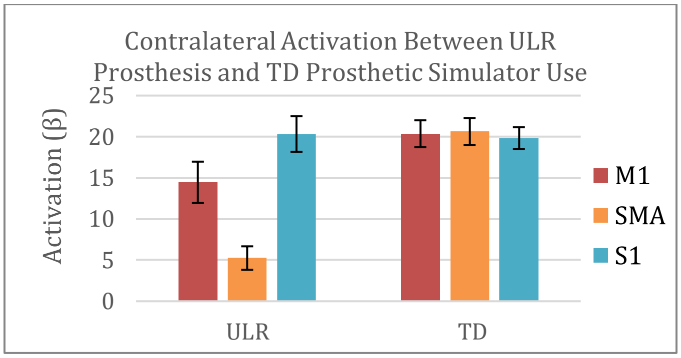

Figure 1: Differences in activation between groups. ULR participants had markedly lower SMA activation during the BB task.

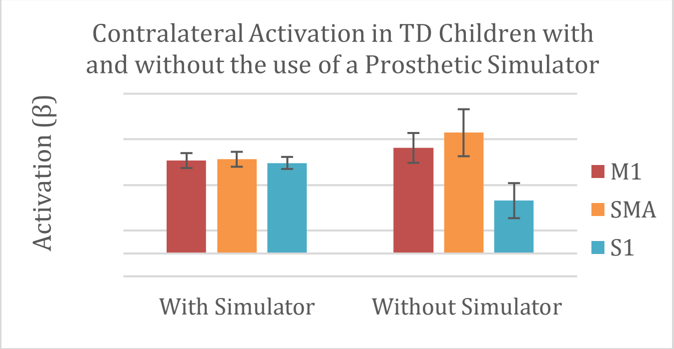

Figure 2: Changes in activation induced by the prosthetic simulator. S1 activation was significantly increased with use of the simulator.

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MOTOR UNIT DISCHARGE PATTERN AND SYNCHRONIZATION DURING BIMANUAL ISOMETRIC MUSCLE CONTRACTION

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INTRODUCTION

Distinct neural processes contribute to unilateral and bilateral movements (Swinnen 2002; Rokni et al. 2003). However, it remains largely unknown whether motor unit (MU) recruitment strategy differs between unilateral and bilateral isometric force generation.

METHODS

Subjects. Thirteen healthy subjects participated in the study.

Method. Using advanced electromyography (EMG) sensor arrays and MU decomposition techniques, we examined a substantial population of MUs during unilateral and bilateral low-force matching tasks. The common synaptic input to motor neurons was assessed in the frequency domain with coherence analysis. The low frequency oscillations of motor unit spike trains were analyzed by the first principal component of the low-pass filtered spike trains [first common component (FCC)].

RESULTS AND DISCUSSION

Motor Units. MU firing rate decreased during bilateral compared with unilateral contractions. MU action potential duration was greater and MU amplitude remained unchanged during bilateral compared with unilateral contractions.

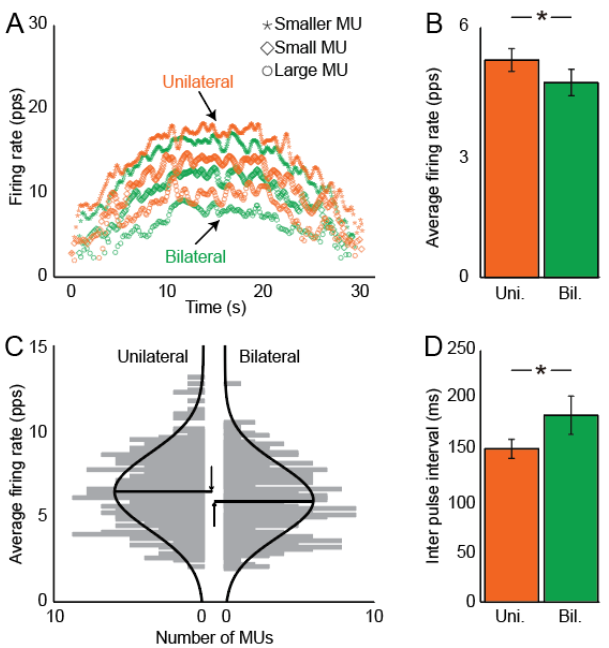

Figure 1: Mean MU firing rate and inter pulse interval for the FDI muscle during unilateral and bilateral contractions.

Common synaptic input to MUs. The strength of common drive was reduced in the delta (0.5-5Hz), but not alpha (5-13 Hz) and beta (13-30 Hz) bands, during bilateral compared with unilateral contractions.

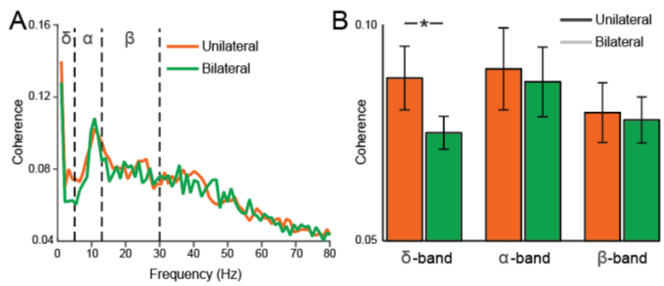

Figure 2: Coherence between spike trains of motor neurons for the FDI muscle during unilateral and bilateral contractions.

MUs vs. force. Principal component analysis indicated that the coefficients of variation (CV) of the low-frequency oscillations of MU firing rate correlated with the CV of force output during unilateral and bilateral contractions.

CONCLUSIONS

The mechanisms of synaptic input to MU for unilateral and bilateral force control remains poorly understood. Here, we demonstrated that MU discharge rate and the strength of common drive in the delta band decreased while MU action potential duration increased during bilateral compared with unilateral contraction. We suggest that neural strategies of MU recruitment differs between unilateral and bilateral isometric contractions.

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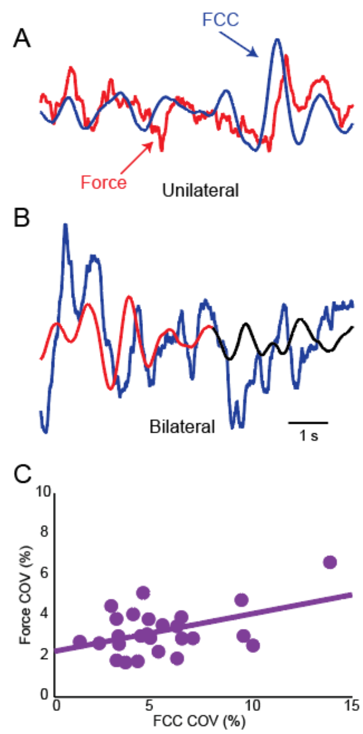

Figure 3: First common component (FCC) and force during unilateral and bilateral contractions.

KINEMATIC AND KINETIC ANALYSIS OF KNEE ARTHRODESIS- A CASE STUDY GUIDE TO CLINICAL DECISION-MAKING

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Presentation Preference: [**Poster**]

INTRODUCTION

Knee arthrodesis is an option that gives a stable, painless joint but walking with a fixed knee can cause gait deviations and make activities of daily living difficult [1]. Since the arthrodesed knee may not be restored to how the joint functions in a normal gait pattern, this case study aims to find key points for a realistic gait and functional rehabilitation program.

METHODS

A 65-year-old male underwent left knee arthrodesis due to a post-traumatic knee flexion deformity, repeated infections and loss of knee extensor mechanism. This was followed by physiotherapy and a 2-cm shoe-raise under left foot on full-weight bearing. Even after 18 months of surgery, patient used a walker, showed excessive trunk flexion (Figure 1) and right foot lag. Physical examination revealed tightness of bilateral hip flexors, and weakness of bilateral trunk extensors (2-/5), bilateral hip extensors (3-/5) and left hip abductors (2-/5). A kinematic (500 Hz) and kinetic (1000 Hz) gait analysis (SMART DX-7000, BTS Bioengineering, Milan, Italy) was done to guide further rehabilitation. A conventional gait model with Helen Hayes 18-marker protocol was used [2]. Joint centres were identified by anthropometric data and regression equations. After consent, the patient walked at a self-selected walking speed, with and without shoe raise in the same session, till clean forces were obtained for both left and right leg.

RESULTS AND DISCUSSION

Post shoe-raise, the spatial-temporal parameters still revealed asymmetry. The left leg's single-limb-support phase (SLS) increased minimally (to 17% of the gait cycle) and lacked hip extension in late stance. Thus, the right step length remained negative (lag) with its stance phase >80% of the gait cycle. Cadence improved but the mean velocity (0.2 m/s) was low, which is comparable with walker-assisted studies [3]. The left kinematics showed correction (Figure 2) in early stance phase after shoe-raise (no pelvic drop and near-neutral ankle) to stop limb lengthening. But in late stance and swing phase, the left side pelvis still rose (blue arrow) suggesting ground clearance strategy. A change to heel-only-raise [4] and left ankle dorsi-flexor strengthening may assist this clearance. Also, preliminary findings showed high average trunk flexion (about 29 degrees - pelvis reference), sustained bilateral hip flexion (Figure 3), a net internal hip extensor moment instead of flexor and absent second peak on left vertical GRF (Figure 4). These suggest shifting of GRF vector anterior to the hip and lack of stabilizing forces (hip and knee extensor), especially in late stance on the left leg, possibly needing a lumbo-pelvic stability program and a less supportive device like crutches to reduce trunk flexion, make gait more efficient and re-align GRF vector posterior to hip.

Figure 1: The patient in right stance phase

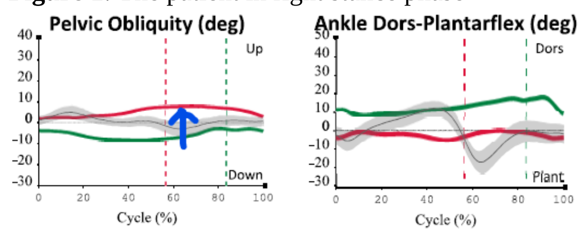

Figure 2: Pelvis (coronal plane) and ankle (sagittal plane) compensation post-raise

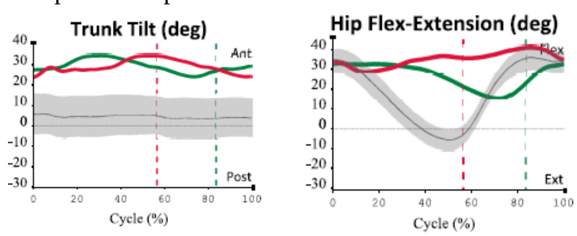

Figure 3: Trunk tilt and Hip flex-extension (sagittal plane)

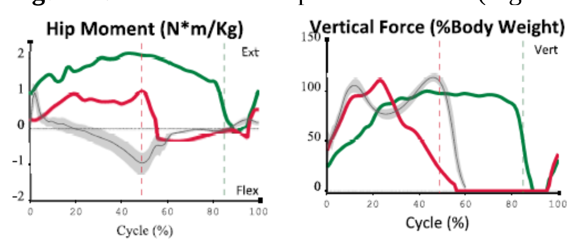

Figure 4: Hip internal moment (sagittal plane) and vertical GRF (Ground reaction force) post-raise

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