

Friday May 21st			
Start Time (UTC)	Finish Time (UTC)	Event	Presenter
5:30pm	6:15pm	Promising Graduate Student Award Podiums	
5:30pm		CASE STUDY: A RHYTHM STORED, LOST, AND REMOVED FROM BRAIN ACTIVITY	Ryan Meidinger
5:45pm		A NOVEL BIOMECHANICAL MODEL TO DISCRIMINATE BETWEEN FALLS & NON-FALLS IN UNCONSTRAINED DOUBLE-LIMB SLIPS	Abderrahman Ouattas
6:00pm		IS THE DISSIPATIVE ENERGETIC BEHAVIOR OF THE HUMAN HEEL ASSOCIATED WITH THERMAL CHANGES?	Nikolaos Papachatzis

CASE STUDY: A RHYTHM STORED, LOST, AND REMOVED FROM BRAIN ACTIVITY

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Presentation Preference: [Podium]

INTRODUCTION

Moving in time with external events is crucial for many activities, e.g., playing sports or music. Timing movement with an external event appears to require synchronization of brain activity with the frequency of the events¹, measured with steady-state evoked potentials (SSEPs). A synchronization-continuation task can reveal components of motor timing, like the ability to synchronize with (synchronization) and reproduce (continuation) a rhythm of external events. It is unknown what is required to reproduce rhythms but is believed to require memory that needs to be stored, retrieved, and may decay over time. In rhythmic working memory tasks, SSEPs have been useful to predict and understand the storage and retrieval of prior events. The ability to reproduce a rhythm of external events, is made increasingly variable by events that occur at rates faster or slower than the individuals preferred pace², suggesting decay, inaccurate retrieval, and/or a lack of storage of a memory. Retrieval and storage can be measured with greater SSEPs and decay can be measured with reductions in SSEPs over time. It is our hypothesis that in synchronization-continuation tasks steady-state evoked potentials will be highest at the beginning of (retrieval) and gradually degrade throughout continuation (decay).

METHODS

A total of 30 healthy young adults will be recruited to participate in the current study and some of the data from one participant will be presented in this abstract. The participant was sat in a comfortable chair, with their right index finger rested on a pressure sensitive pad and fitted with a 128-channel electroencephalogram (EEG) net. The participant then performed three, four-minute self-paced finger tapping conditions. The self-paced tapping conditions were used to calculate preferred, fast (preferred/2), and slow (preferred*2) intervals for the metronomes. The fast and slow intervals were within the range of tempos that a person of this age range should be able to synchronize finger tapping. There were three lengths of synchronization (30, 60, and 120 sec) to determine the effect on continuation performance. The 30 second synchronization conditions are presented in this abstract. After all synchronization-continuation tasks there was a recorded five-minute period of silent rest. Data from the EEG were processed with EEGLAB to remove movement artifacts and perform time-frequency analysis (wavelet transform, 3 cycles). From the time-frequency analysis heat maps of the participants Fz (mid-frontal) electrode are presented in the results.

RESULTS AND DISCUSSION

We have currently collected six participants with 24 left to collect, so no major conclusion can be made from the current participant's data. This participants results may suggest that the highest amplitude and longest synchronization of neural activity with the metronome is present with the fast conditions but in rest this is not continued, it was removed or

desynchronized. The synchronization of brain activity in Figure 1 appears to be increased through most of continuation performance suggesting that this information was held and possibly retrieved in what could be memory of the rhythm with decay over time, then removed during rest. Although the synchronization of brain activity was not as prominent in preferred and slow conditions, they lack the desynchronization present with the fast condition. It is possible that all these metronomes are remembered but the memory mechanisms are not carried into the future in the same fashion nor stored to at the same amplitude. The different neural representations may also be due to different networks and frequency bands impacted by the metronome rates.

A major goal of this work is to determine if the development of these SSEPs over the trial relate to the ability to reproduce a metronome and uncover the effect of metronome rate. Further analysis will also determine the impact of concepts from dynamics systems research (i.e. anticipation) on neural synchronization.

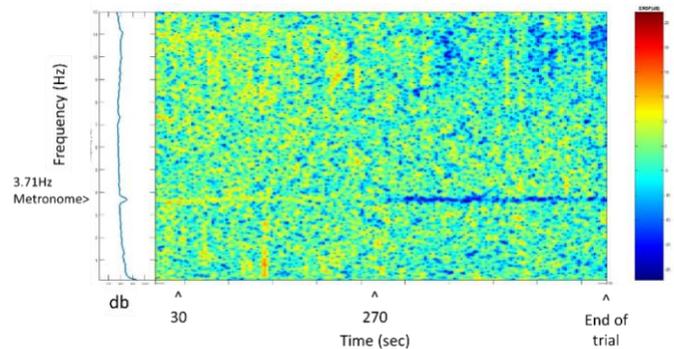


Figure 1: Time frequency analysis of the 30-second fast synchronization-continuation task. On the left side extending from the y-axis, the power spectrum of the entire trial. The x-axis (bottom) is in time but only includes the major time points of the trial. On the right, a heat axis that describes the color associated with increased or decreased amplitude at a time (x-axis) and frequency (y-axis) within the heat map. This participants EEG presented phases of clear synchronization during the metronome presentation, a gradual decay, and desynchronization during the period of rest at the metronome frequency and others higher frequencies. These results were not replicated with the preferred or slow metronome conditions, suggesting differing mechanisms used in the different conditions.

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A Novel Biomechanical Model to Discriminate Between Falls & Non-Falls in Unconstrained Double-Limb Slips

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Presentation Preference: [Podium, Doctoral Student]

INTRODUCTION

More than 25% of older population fall each year in the US [1]. Slips alone account for 25% of overall falls [2]. Slip induced falls are task-specific, and successful fall recovery is dependent upon the condition and the environment. Recent data indicates that slipping feet travel in a variety of directions [3], and pose diverse challenges to supporting body weight and maintaining an upright trunk. However, we lack the data necessary to guide interventions on recovery from diverse double-limb slip related loss of balance, due to the heavily focused literature on single limb slips at heel strike. Preliminary data collected from a larger study [4] showed unconstrained and diverse feet velocities relative to the center of mass (CoM) velocity during double-limb slips. We hypothesize that falls from double-limb unconstrained slips can be predicted by a combination of feet positions and velocities relative to CoM velocities.

METHODS

Three young adults (26.66 ± 2.62 years; 78.57 ± 11.35 kg, 1.69 ± 0.08 m) participated in the study. Participants completed 3 sessions of 12 double limb slips each within one week (36 slips in total), that were triggered using an in-lab built Wearable Apparatus for Slip Perturbations (WASP) [3-4]. The WASP induced slips to both limbs simultaneously while participants walked at a fixed gait speed of 1.3 ± 0.1 m/s on a 10 m walkway. Falls were identified if participants applied more than 30% of body weight to the harness, which was measured using a load cell [5]. Full body kinematics were recorded using a 17-camera motion capture system (Motion Analysis Corp., Santa Rosa, CA) and sampled at 100 Hz.

All data were analyzed from slip onset until both feet reached a velocity of 0, and was referred to as the slipping timeline. Right and left feet velocities relative to the CoM were extracted at the frame when each foot velocity is least similar to the CoM velocity within the slipping timeline. Such specific timepoint was chosen to quantify the maximum asynchronicity of the base of support relative to the CoM between falls and non-falls. To test our hypothesis, we used feet velocities and directions relative to the CoM velocities and directions as inputs to a logistic regression classification model trained through machine learning to discriminate trials in which the subject fell from non-falling trials. Custom Visual3D (C-Motion Inc., Germantown, MD, USA) pipelines were used for data analysis. Custom MATLAB codes (MathWorks, Natick, MA) were used for statistical analysis, and significance level will be set at 0.05.

RESULTS AND DISCUSSION

In the experimental data analyzed thus far, there have been 4 falls, and 12 recoveries. Using unconstrained slips to both feet simultaneously, slipping feet had substantial ML slipping speeds that ranged from 10% to 222% of the AP component. In the AP direction, contralateral slipping limbs always slipped in

the same direction relative to the CoM (Figure 1). However, in the ML direction, the slipping feet travelled in the opposite direction 75% of the time (Figure 1).

The logistic regression model based on these ML slipping feet

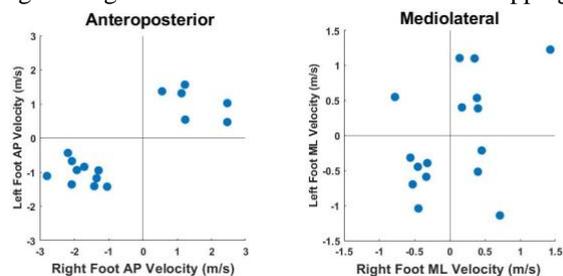


Figure 1: AP & ML Feet velocities relative to the CoM.

speeds and directions (medial or lateral to the CoM) relative to the CoM correctly predicted all falls and recovery trials with a deviance, a measure of the unexplained variance in the modeled data, of 0.5 (Figure 2). Not adding direction to the ML feet velocities predicted only 2 of the 4 trials and all 12 recoveries. On the other hand, using only the AP feet speeds (model deviance 17.8) and directions (model deviance 17.3) relative to the CoM failed to predict any of the falling and recovery trials.

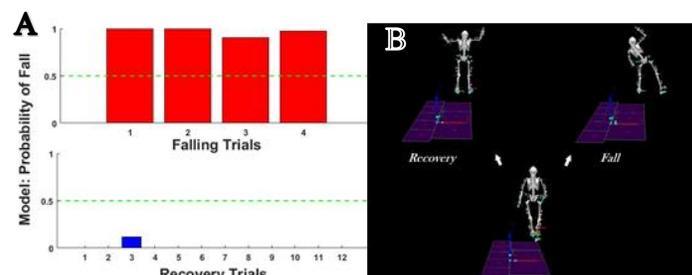


Figure 2: A. Logistic Regression Model using ML feet speeds and directions. B. Demonstration of a fall & a recovery.

CONCLUSIONS

Unconstrained double-limb slips produced more diverse ML feet velocities relative to the CoM compared to AP. The logistic regression model using ML feet velocities relative to the CoM predicted all falls and recoveries and outperformed the AP velocities, indicating ML movements during slipping may be more susceptible to deviations than AP movements within the recovery process of falls.

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Is the dissipative energetic behavior of the human heel associated with thermal changes?

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Presentation Preference: [Please indicate **Podium**]

INTRODUCTION

During human walking, the leading limb collides with the ground and performs negative work¹. It is now well established that a large portion of this collision work is performed by the foot, in particular the heel^{2,3}. Energy absorption (or dissipation) maybe be beneficial as a protective mechanism to minimize trauma or injuries⁴. However, it is currently unclear where the foot's energy goes or how the body absorbs or dissipates this energy. One possibility is that the heels' energy is dissipated as heat. The laws of thermodynamics state that the dissipated energy may increase the heels' thermal energy (i.e., increase temperature), which could potentially explain the increases in heel temperature during walking⁵. Currently, it is unclear whether the heel's mechanical energy can induce thermodynamic responses. Understanding the relationship between biomechanics and temperature regulation may be valuable for improving diagnoses for foot complications, such as the formation of diabetic foot ulcers that are thought to arise due to impaired ability to dissipate heat⁶.

Here, we used walking with added mass to increase negative work done by the heel³ and investigated its effect on thermodynamic responses. We hypothesized that the heel's temperature would increase when walking with added mass. We also hypothesized that the increase in temperature is related to the increase in energy absorbed (i.e. negative work), and energy dissipated (i.e. net negative work) by the heel.

METHODS

A total of 20 healthy young adults (5 females, 15 males; age: 24.4±2.8 yrs; height: 1.74.61±0.07 m; mass: 83.6±21.2 kg; means± s.d.) walked over-ground on force plates and for 10 minutes on a treadmill (both at 1.25 m/s). Participants carried (via weight vest) three different levels of symmetrical loads: 0%; no added body mass, 15%, and 30% of their body mass. The over-ground walking conditions were used to collect foot mechanics data (kinematic & kinetic), whereas the treadmill conditions were used to measure the foot temperature data. We quantified the mechanical power and work done by the foot using a unified-deformable analysis⁷. To isolate the heel contribution, we computed the work when the center-of-pressure was underneath the heel segment during the early stance phase^{3,8}. An estimate of the total work over the 10 minutes of treadmill walking was calculated by multiplying the average work per step measured in over-ground trials by the number of steps taken in 10 minutes of treadmill walking. Temperature measurements were taken immediately before and after each treadmill condition at the bottom of the right foot, including the heel pad. We computed the change in temperature of the heel before and after each walking condition. To determine the effect of the added mass on the dependent variables, a one-factor repeated-measures ANOVA was used.

When a significant main effect was found, a Bonferroni post hoc analysis was conducted for pair-wise comparisons. To examine the relationship between changes in foot temperature (before and after walking) and foot energy dissipation, a linear mixed models test will be used. The significance level was set to $\alpha = 0.05$ for all the statistical tests.

RESULTS AND DISCUSSION

Our hypotheses were not supported as there was no significant increase in heel temperature between added mass walking conditions ($p=0.138$, Figure 1, Right side), despite an increase in the magnitude of negative work ($p=0.003$, Figure 2, Left side). Neither the negative nor the net work of the heel was associated with the increase in heel temperature ($p=0.535$ & $p=0.661$ respectively).

This is likely related to agile temperature control by the healthy function of the vascular system (e.g., blood flow & tissue oxygenation) of the normal leg and the excellent control of the shear forces by the plantar structures of the foot. It is possible that in different disease states the ability of the vascular and musculoskeletal systems to control the temperature in the foot is significantly decreased therefore producing a closer association between negative work and heat dissipation in the working foot. Future studies are needed to further uncover the mechanisms of temperature responses, which may lead to novel insights for understanding the causes of foot complications such as diabetic ulcers⁶.

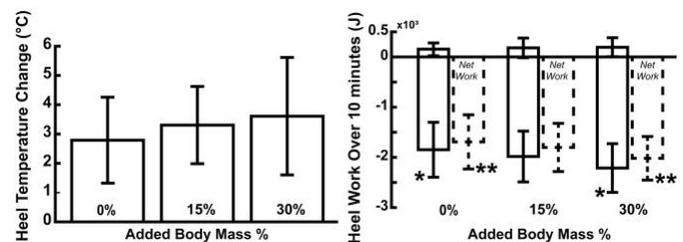


Figure 1: (Left side) The heel's temperature increased after 10min. of walking but there was no significant effect of added mass on change in temperature ($p=0.138$). **(Right side)** The added mass significantly increased the magnitude of heel's negative ($p=0.002$) and net ($p=0.003$) work over 10 minutes of treadmill walking, but not the positive work ($p=0.265$). The asterisks indicate significance (*: negative work; **: net work) ($N=20$).

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