DEVELOPMENT OF A VISUAL BIOFEEDBACK SYSTEM FOR CENTER OF PRESSURE MODIFICATION DURING GAIT

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INTRODUCTION

Visual biofeedback has been utilized for mobility modification in various impaired populations for a considerable amount of time [1-4]. With the advent of new technologies capable of both collecting and portraying physiological information in real time, new techniques for mobility modification are now available. Center of pressure (COP) , defined as the centroid of all external forces acting on the plantar surface of the foot, it is a direct combination of kinetic and kinematic variables making it an intriguing function to investigate within mobility modification [5]. In order to evaluate this claim, we have developed a system to visually show COP trajectory in the transverse plane of the foot along with target locations for heel strike and toe off location. **The overall goal of this project is to modify COP during gait as a method to alter functional mobility in healthy adults in order to further understand and develop rehabilitation techniques and strategies.**

We hypothesize that:

1.) All healthy walkers will be able to volitionally modify and maintain an altered COP trajectory when provided visual biofeedback and
2.) Shifting the COP trajectory medially and laterally will decrease/ increase frontal plane ankle moments, respectively, while anterior and posterior shifts will increase and decrease sagittal plane ankle moments, respectively .

METHODS

In this feasibility study, one adult subject walked at 1.25 m/s on a split belt instrumented treadmill (Bertec, Columbus, OH) while motion capture (Vicon Nexus, Denver, CO) data of the lower extremities was collected.

Utilizing a software development kit capable of connecting motion capture and ground reaction force data with computation software (MathWorks, Natick, MA) we provided a visual/graphical representation of the COP trajectory in real-time to the walking subject through the use of a custom Matlab code. Using the subject's normal/neutral COP trajectory as the basis, we graphically provided a target toe off location which was shifted medially, laterally, posteriorly and anteriorly along the length of the foot.

In the extended study with no fewer than 12 healthy subjects, we will also use electromyography (EMG) to understand specific ankle muscle compensations (tibialis anterior, gastrocnemius and soleus) caused by the modified COP. Finally, using indirect calorimetry, the metabolic energy expenditure required to maintain each modified COP trajectory will be collected.

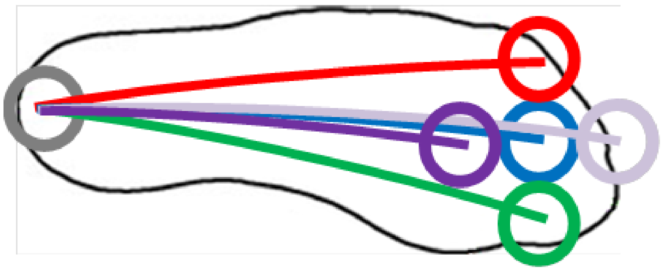

Figure 1: Graphical depiction of output from custom Matlab code. Purple represents neutral toe off location alongside four potential shifted targets (**red**, **green**, **purple**, and **light grey** target locations for shifts laterally, medially, posteriorly and anteriorly, respectively).

RESULTS AND DISCUSSION

This proof of concept study demonstrated the general ability of an individual to modify their toe off location along the foot's x-axis (medial/lateral) shown in **Figure 2**. These results represent the average COP trajectory over 20 consecutive steps for one healthy adult male walking at 1.25 m/s.

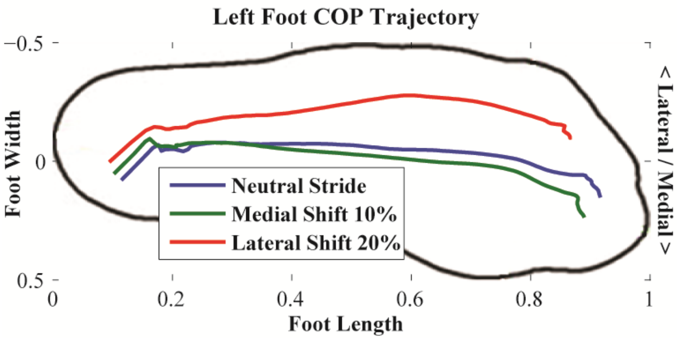

Figure 2: Transverse plane view of COP trajectory while provided no biofeedback/neutral walking (**Blue**), toe off shifted 10% of foot width medially (**Green**) and toe off shifted 20% of foot width laterally (**Red**). Axes normalized to foot width and foot length, respectively.

Mechanics data shown below in **Figure 3** provided some key insight into the underlying effects caused by modifying the COP trajectory. The most prominent alterations occurred with the 20% lateral shift of the toe off while the 10% medial shift generated largely similar mechanical outcomes in both the sagittal and frontal planes.

The lateral shift had implications in the sagittal plane (decreased dorsiflexion angle contributing to a reduction in moment magnitude during stance phase and, thus, reduced peak power during push-off). Frontal plane kinematics showed an approximately 10 degree offset throughout the entire gait cycle towards ankle inversion that had substantial effects on the frontal plane moment (~150% increase). Power generation, while visibly affected, had peak magnitudes of only ~3% of those seen in the sagittal plane.

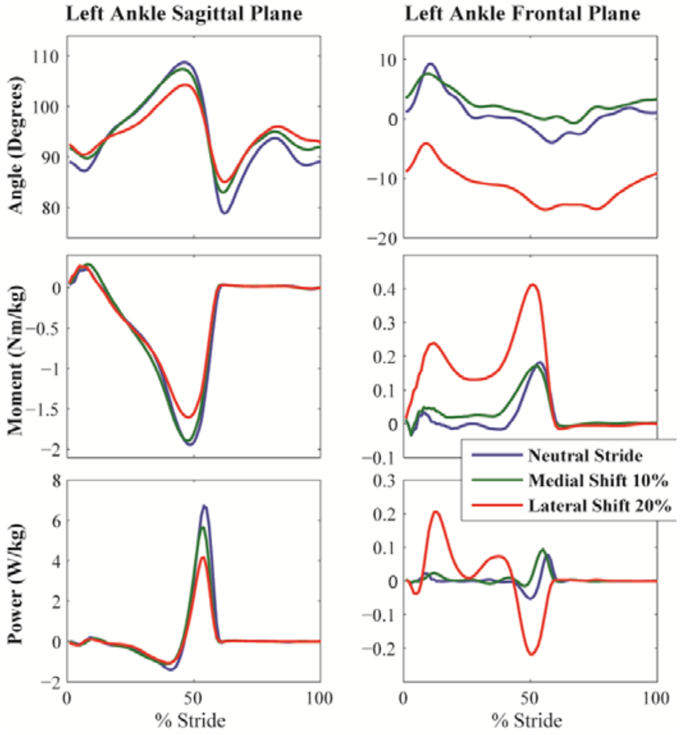

Figure 3: Sagittal and frontal plane mechanics for the left ankle joint while provided no biofeedback/neutral walking (**Blue**), toe off shifted 10% of foot width medially (**Green**) and toe off shifted 20% of foot width laterally (**Red**).

Ultimately, this pilot study and data has demonstrated the capacity of healthy walkers to modify their COP trajectory via our biofeedback application. We will continue validating the approach through further data collection including evaluation of compensations at more proximal joints (i.e. knee and hip) and also new parameters including EMG and metabolic expenditure.

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