THE EFFECT OF MULTIAXIAL FOOT STIFFNESS WITH PROSTHETIC EMULATORS OVER UNEVEN TERRAIN

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INTRODUCTION

Individuals that have undergone trans-tibial amputations encounter serious dilemmas when navigating over uneven terrain. The combination of an altered motor system in conjunction with the non-rigid residuum/socket interface results in two pathways leading to impaired stability. This work focuses on using a prosthetic emulator to test prosthetic feet in isolation of the residuum/socket interface.

Increases in the displacement of whole body center of mass (CoM) indicate increased energy expenditure (Kuo, 2010). A decrease in the CoM height is indicative of compensation for gait instability (Curtz, 2010). These outcomes provide a way to evaluate the performance of multi-axial prosthetic foot stiffness over uneven terrain.

The purpose of this study was to determine the effect of multi-axial foot stiffness on COM height and displacement and utilize this information in strengthening evidence-based clinical practice.

METHOD

Subjects: One (of seven recruited) male (92.5 kg, 172.72 cm, 33 yrs) non-amputee utilizing bilateral prosthetic emulator ankle foot orthoses(AFO's) completed this pilot study approved by the Alabama State University Internal Review Board.

Apparatus: Ambulation over the uneven terrain occurred on an uneven walkway with blocks specifically placed in a sequential pattern. The center of each block was spaced 8" apart from each other with 4" around the perimeter. A mat was placed over the uneven walkway reducing visual feedback and a harness system was used for safe ambulation over the uneven walkway. An eight camera motion capture system (Vicon Motion Systems, Oxford, UK) recorded limb kinematics at 100 Hz.

Procedures: A single subject walked 10 times at 100 steps/min on even and uneven terrain with varying multi-axial ankle stiffness (Endolite Multi-flex foot set to soft, typical, and firm via ankle snubber selection).

Data Analysis: Vicon Nexus 1.8.4 calculated CoM movement. Mean displacement of the CoM in the sagittal plane was defined as the difference between low and high peaks in CoM movement. Mean displacement and mean CoM height was used to compare conditions.

RESULTS

The uneven walkway decreased gait stability as evidenced through lower CoM height regardless of ankle stiffness. The height decrease was most pronounced for the soft ankle stiffness with relative parity between the typical and firm ankles (Figure 1). There was decreased CoM displacement observed on uneven terrain for soft ankles (Figure 2).

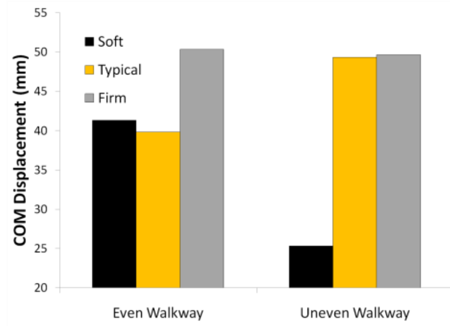

Figure 1: Mean CoM displacement

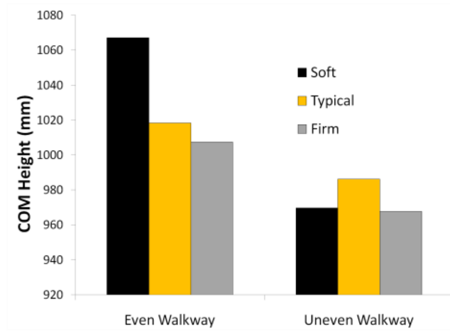

Figure 2: Mean CoM height

DISCUSSION

CoM height suggests the uneven surface resulted in reduction in stability for the subject. CoM displacement data is inconclusive regarding energy expenditure with this first of seven subjects.

CONCLUSION

CoM height data suggests while using prosthetic emulators, subjects' stability differences broadly resemble those of people with amputation. These pilot results indicate prosthetic emulator AFO's may be useful tools for research. However, more subjects are needed before conclusions may be drawn about the utility of variable stiffness multi-axial components.

CLINICAL APPLICATIONS

More research with prosthetic emulators will demonstrate which, if any, of the variable stiffness ankle components are most suitable to ensure the stability and safety of prosthetic users.

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