Uneven Walkway Design for Orthotic Gait Research

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INTRODUCTION

Ambulation outside often includes walking over uneven terrain. Paradoxically, most research on human gait has been over level surfaces. New research is now being performed to address this shortfall (Thies, 2005; Wade, 2007).

The trajectory of the body's center of mass (CoM) is carefully controlled and has a direct effect on energetic cost of locomotion (Simoneau, 2010). Uneven terrain should disrupt CoM movement yet, before this research may be undertaken, validation and standardization of an uneven walkway needs to be accomplished.

The purpose of this research was to define the design and performance of a replicable uneven walkway. Disruption of CoM movement during ambulation over even, i.e. level ground to uneven terrain would determine walkway performance. Our hypothesis states that the uneven terrain would: 1) increase CoM displacement in the transverse and sagittal planes and 2) an AFO would exacerbate these displacements.

METHOD

Subjects: One non-pathological subject (111 kg, 182 cm, 22 yrs) out of five recruited, has completed this study approved by the Alabama State University Internal Review Board.

Apparatus: A custom molded solid AFO made of poly-propylene was worn by the subject during the AFO testing. Ambulation over the uneven terrain occurred on an 8'x32" walkway with 3"x1" 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.

Procedures: A single subject walked eight times at a self-selected speed on even and uneven terrain, with and without an AFO. Each subject had retroreflective markers placed on anatomical landmarks on the upper extremities, lower extremities, head, and torso in accordance with Vicon PlugInGait (Vicon Motion Systems, Oxford, UK). An eight camera motion capture system (Vicon Motion Systems, Oxford, UK) recorded limb kinematics at 100 Hz.

Data Analysis: Vicon Nexus 1.8.4 calculated CoM movement based on a limb segment model (Gutierrez-Farewik, 2006). Displacement of the CoM in the sagittal plane was defined as the difference in the lowest and highest peaks of these waves in the vertical and medial/lateral axis, i.e. sagittal and transverse planes. Mean displacement and standard deviations were used to compare conditions. The limited number of subjects that have completed this study currently limit additional statistical analysis.

RESULTS

CoM displacement (mm) increased when ambulating on the uneven walkway compared to even walkway, 50 ± 1 to 89 ± 12 without an AFO, and 52 ± 5 to 88 ± 11 wearing an AFO in the sagittal plane. Similar results were demonstrated in the transverse plane, 47 ± 6 to 68 ± 8 without an AFO, and 59 ± 11 to 77 ± 23 wearing an AFO.

DISCUSSION

The data identified that the walkway does increase CoM displacement in both conditions. Despite being non-pathological, the subject was still unable to maintain a smooth gait. This is interesting considering the body's necessity to control CoM displacement for energy conservation (Simoneau, 2010). This data suggest more detailed studies may be required to further test the amount of deviation caused by the walkway.

CONCLUSION

The design of this uneven walkway was effective at disrupting CoM movement in healthy subjects walking with and without an AFO. Future work should investigate the effect of prosthetic components and/or orthotic interventions on locomotion energetic cost in pathological populations.

CLINICAL APPLICATIONS

This walkway could be used to simulate uneven terrain when training patients to ambulate with their new prosthetic components or orthoses.

REFERENCES

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