THE EFFECT OF ANKLE-FOOT ORTHOSIS ALIGNMENT ON ROLL-OVER SHAPE IN PATIENTS WITH LOWER LIMB RECONSTRUCTION

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INTRODUCTION

Injuries requiring limb reconstruction surgery often result in pain and plantar flexor weakness, for which ankle foot orthoses (AFOs) are commonly prescribed. The Intrepid Dynamic Exoskeletal Orthosis (IDEO) is a passive-dynamic AFO created to improve upon conventional AFO designs by utilizing energy storage and return [1]. However, an AFO may compromise how the foot rolls over the ground due to its semi-rigid footplate. Ankle-foot roll-over shape (ROS) is a biomechanical measure which characterizes how the center of pressure (COP) moves relative to the limb. The foot and shoe are viewed as a rocker with a single radius and the COP path relative to the limb is characterized from ipsilateral initial contact to contralateral initial contact [3]. Maintaining an optimal ROS is thought to increase the stability and efficiency of pathologic gait [3]. The ROS technique was initially developed to understand the relationship between device alignment and function [4]. Alignment has been shown to directly influence ROS in prosthetic devices, but its effect on ROS in AFOs is not well understood. The purpose of this study was to measure the effects of the sagittal plane alignment of the IDEO on ROS in patients with lower limb reconstructions.

METHODS

A total of nine male subjects with unilateral limb reconstruction (age 30±6, height 1.78±0.09 m, mass 87.2±9.7 kg) underwent gait analysis in a motion laboratory (marker data: 120 Hz, Motion Analysis Corp, analog data: 1200 Hz, AMTI, Inc.). Testing was performed with the IDEO aligned in 3 different conditions using a 3° wedge attached to the posterior strut (Fig 1): neutral (determined by orthotist based on pain-free range of motion), 3° more dorsiflexed, and 3° more plantarflexed.

Figure 1: The IDEO aligned in dorsiflexion (left) and plantarflexion (right) using a 3° wedge.

Each subject walked until their affected and unaffected limb each made full contact with a force plate 5 times. To determine ROS, the COP of the ground reaction force was calculated in Visual3D (C-Motion, Inc.), in the shank coordinate system. Ankle-foot ROS was initially calculated from contralateral heel strike to ipsilateral heel strike, then further cropped using only data from forward COP progression and normalized to height. A circle was fit to calculate the ROS radius. A 2-way repeated measures ANOVA (limb x alignment) was performed on the ROS radius values and ankle angle peaks. Paired t-test post-hoc analysis separated main effects (p<0.05).

RESULTS AND DISCUSSION

The 3° modifications in sagittal plane IDEO alignment significantly changed ankle alignment at the stance and swing phases throughout the gait cycle (p≤0.004 for all comparisons). However, these 3° changes in the alignment from the neutral position did not influence ROS radius in patients with lower limb reconstruction (p=0.455) (Fig 2-3). They also did not affect the ROS of the sound limb (p=0.800). There were no significant interactions (p=0.606).
The mean radii for ROS in the IDEO were found to be consistent with prior studies; Hansen et al. [6] found a range of median ROS radii to be between 0.12-0.28 in healthy controls. Despite the semi-rigid structure of the IDEO, and its impact on ankle biomechanics during walking [6], it did not affect ROS. This may indicate the IDEO maintains an appropriate rocker shape. In addition, the lack of differences between limbs indicates that the limited ankle range of motion permitted by the IDEO [6] did not negatively influence the ability of the intact limb to maintain near-normative ROS radius.

Prior research has studied the effects of other interventions on ROS, such as modifying heel height to change the sagittal plane ankle angle [6]. Similar to the alignment changes about the ankle in the present study, changes to ankle angle by systematically altering heel height also did not change ROS radii from their baseline control levels. The 6-degree range of changes in sagittal plane IDEO alignment were chosen because they were expected to be within the range different orthotists may choose when fitting a patient. Alignment alterations significantly affect the vertical displacement and overall alignment of the ROS (p<0.012). The results of this study indicate that, within this 6-degree range, these modifications to

alignment are not expected to negatively impact the rocker profile of the foot.

One limitation of this study is the lack of a no-IDEO condition, which would identify the acute effects of the IDEO on the rocker shape profile. Multiple subjects were unable to walk pain-free without the use of this assistive device and this condition was necessarily excluded from the study.

CONCLUSIONS

A 6-degree range of changes in the sagittal plane alignment of an AFO influenced the positions of the ROS relative to the leg, but not the radii in patients with lower limb reconstructions. ROS radii values were consistent with previously published literature from able-bodied individuals and did not differ from the unaffected limb. These results indicate that the ROS of the device effectively mimicked that of an intact limb during single limb stance.

REFERENCES


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