The Effect of Dorsiflexion Resistance on Ankle and Knee Joint Joint Kinematics Quantified with an Instrumented Ankle-Foot Orthosis During Treadmill Walking

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INTRODUCTION

Dorsiflexion assist ankle foot orthoses (AFO's) are among the most common AFO's prescribed and are primarily designed to provide toe clearance during the swing phase portion of the gait cycle. While the dorsiflexion assist targets the control of swing phase ankle foot motion, the dorsiflexion assist mechanism may inherently also resist plantar flexion and dorsiflexion during stance phase. Therefore, in an attempt to control the ankle and foot during swing, an undesirable perturbation during stance phase motion may result. Philosophically, orthoses should be designed to control only those motions required to achieve the biomechanical objective yet permit normal motion for optimal function. Although some orthotists may be cognizant of such limitations with dorsiflexion assist AFO's and the perturbations that they may induce during walking, there are limited studies that quantify the effect ankle motion resistance may have on walking. Knowledge of the effect dorsiflexion and/or plantar flexion resistance has ankle and knee joint motion may be helpful for improving treatment outcomes and predicting functional performance in AFO users that have assist/resist control mechanisms. We hypothesized that if dorsiflexion resistance is applied to the ankle foot in normal healthy subjects that the range of ankle dorsiflexion would decrease compared to free ankle motion without dorsiflexion resistance during walking. To test our hypothesis we designed an experimental instrumented AFO capable of providing dorsiflexion resistance during stance phase and could also measure ankle dorsiflexion, the dorsiflexion resist force and also sense foot contact at the heel and forefoot. In addition a custom designed knee angle goniometer and an instrumented shoe for the opposite foot with sole sensors were also developed for the study.

METHODS

Three levels of dorsiflexion-resist force were applied to the ankle using multiple bungee cords. The three conditions were AFO with no orthotic constraint (control), AFO with three bungee cords attached, and AFO with five bungee cords attached, respectively, providing 0 Nm, 27 Nm, and 40 Nm of maximum dorsiflexion-resist moment applied about the ankle. The peak ankle dorsiflexion angles in the late stance phase were measured and averaged over 5 consecutive steps taken with the ipsilateral leg for each condition as subject walked at their self-selected speed (1.1 m/s.). At the time of this abstract submission only one subject's data had been processed.

RESULTS

The findings indicate that as the level of dorsiflexion-resist load applied to the ankle increased, the mean peak ankle dorsiflexion in the late stance phase decreased (Fig. 1). The mean peak dorsiflexion angles were **13.56º** ± 1.63º, **11.16º** ± 0.96º, and **8.23º**± 1.20º, respectively, for the control, three bungee cords, and five bungee cords conditions. Compared to unconstrained ankle, the conditions with three and five bungee cords demonstrated 18% and 39% decrease in the mean peak dorsiflexion range in the late stance, respectively.

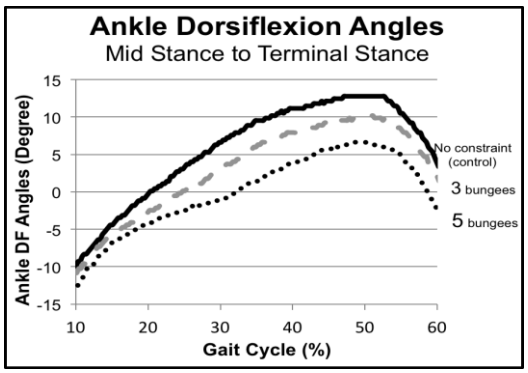

Figure 1. Dorsiflexion resistance with 3 bungees (dash line) and 5 bungees (dotted line) decreased ankle dorsiflexion compared to the control (i.e., free motion) (solid line)

DISCUSSION/CONCLUSIONS

The results of this study suggests that altering stiffness of an AFO influences gait kinematics; thus, clinicians should be cognizant of the imposed gait abnormalities an AFO could cause for patients due to undesirable orthotic joint constraints, thereby

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compromising the functional performance and outcome of the orthosis.