Effect of ankle-foot orthosis plantarflexion resistance on lower-limb kinematics and kinetics in patients with stroke

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INTRODUCTION

Patients with stroke are generally provided with an ankle-foot orthosis (AFO). AFOs can assist their mobility through improvement in tempo-spatial, kinematic and kinetic parameters of gait. AFO's plantarflexion resistance resists movement of the ankle joint toward a plantarflexion direction and plays an important role at initial contact in stance and during swing in hemiplegic gait. Therefore, an AFO whose plantarflexion resistance is appropriately tuned could benefit the patients (Yamamoto et al., 2011). Previous studies suggested that plantarflexion resistance would affect ankle and knee joint kinematics (Kobayashi et al., 2011; Kobayashi et al., 2013). However, its effect on the kinetics has not been systematically studied. The aim of this study was to investigate the effect of AFO plantarflexion resistance on ankle and knee joint kinematics and kinetics by systematically changing the plantarflexion resistance of an articulated AFO.

METHOD

Subjects: Ten subjects with chronic stroke (2 females/8 males) participated in this study. Their mean age was 56 (11) years old and mean time since stroke was 6 (3) years.

Apparatus: A custom articulated AFO with plantarflexion resistance adjustable joints was developed and its resistance was quantified by an AFO mechanical testing device (Gao et al., 2011). A Vicon 10-camera motion analysis system (Vicon Motion Systems, Oxford, UK) and a Bertec split-belt fully instrumented treadmill (Bertec corporation, Columbus, OH, USA) were used to collect kinematic and kinetic data.

Procedures: Gait analysis was performed under 5 different plantarflexion resistance conditions [R1 (lowest resistance) to R5 (highest resistance)] wearing the custom articulated AFO in each subject.

Data Analysis: The data were post-processed with Visual3D (CMotion, Germantown, MD, USA). The sagittal ankle and knee joint data of 5 steps were normalized to stance and plotted under each plantarflexion resistance condition.

RESULTS

Change in plantarflexion resistance of the articulated AFO generally affected the ankle and knee joint angles and moments across subjects. Figure 1 shows the effect of systematic changes of plantarflexion resistance of the AFO on ankle and knee joint moments in a representative subject.

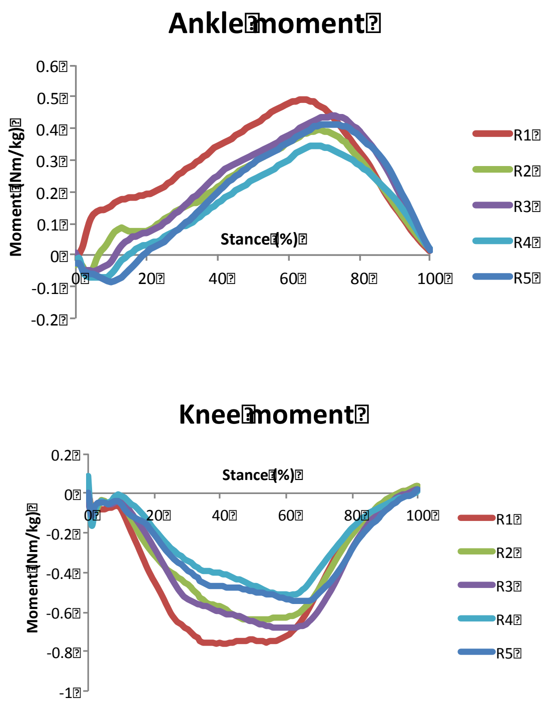

Figure 1. Effects of plantarflexion resistance [R1 (lowest) to R5 (highest)] on sagittal ankle and knee joint moments in a representative subject.

DISCUSSION

Plantarflexion resistance of the AFO appeared to have a very systematic effect on ankle and knee joint angles and moments. Knee flexion moments were reduced by increasing plantarflexion resistance of an AFO, suggesting an improvement in knee hyper-extension.

CONCLUSION

Plantarflexion resistance of an articulated AFO needs to be tuned for each patient to optimize gait.

CLINICAL APPLICATIONS

Articulated AFOs can benefit patients with stroke the most when their plantarflexion resistance is appropriately tuned.

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