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Title
AFO alignment, stiffness, and pre-load torque uniquely influence biomechanical variables in gait

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Summary
In this study, an instrumented multi-function ankle-foot orthosis with independently adjustable stiffness, torque threshold and ankle alignment was used to investigate the unique and isolated influence of these AFO mechanical characteristics on gait kinetics and kinematics for a patient with CMT.

Introduction/ basics
It is well established that ankle-foot orthoses (AFOs) influence sagittal plane gait biomechanics3. The characteristic mechanical behavior of AFO functional types has been reported1, and there is considerable interest in orthotics research related to the effect of shank alignment and AFO stiffness on paretic gait. However, the isolated and unique influence of AFO mechanical characteristics has not been well established. Traditional orthoses do not possess the ability to present the ankle with adjustable dorsiflexion and plantarflexion threshold torque. With the advent of the multi-function ankle component, AFOs with independently adjustable alignment, variable stiffness springs, and adjustable plantarflexion and dorsiflexion threshold torque are possible. For this study, an instrumented multi-function ankle component was used to determine the isolated influence of AFO mechanical characteristics on gait for a patient with CMT.

Material method; implementation/ process
A carbon composite instrumented Evaluation Orthosis was fabricated using a strain gage load cell and angular displacement transducer to measure ankle angle. The sensors were interfaced to a slate computer running and App for data collection and visualization by Bluetooth® wireless. The App also recorded and synchronized slow motion video with kinetic and kinematic data captured during trials. A single subject with Charcot Marie Tooth was evaluated. The

subject presented with bilateral plantarflexion contracture, dorsiflexor weakness, and mild quadriceps insufficiency. The AFO was fit to the subject and clinical trails were performed to determine the isolated influence of multi-function AFO mechanical characteristics on the patient's gait. During the trials, the variable of interest was randomly adjusted while the other variables were held constant. Moment and ankle angle data were then plotted as representative gait cycles.

Results

The data recorded by the instrumented evaluation orthosis demonstrated unique and systematic influence of alignment settings on ankle angle throughout the gait cycle. Ankle angle was maintained throughout swing phase for all plantarflexion resist threshold torque settings above 1 Nm. Rate of change of ankle angle in first rocker was inversely related to torque threshold of the plantarflexion resist spring at constant spring stiffness. The gait phase at which plantarflexion was initiated was systematically influenced by threshold torque. Initiation of plantarflexion in first rocker was delayed by higher threshold torque. The rate of change of ankle torque in 1st rocker did not appear to be systematically influenced by pre-load torque at constant spring stiffness, but was influenced by spring stiffness at constant threshold torque.

Discussion/ conclusion; conclusion for the practice

An instrumented multi-function AFO revealed systematic and isolated influence of ankle alignment, spring stiffness and threshold torque settings on gait kinetics and kinematics for a patient with Charcot Marie Tooth. The results of this trial for alignment and threshold torque are consistent with known AFO influence on biomechanical variables for multi-function AFOs captured from Vicon motion studies using similar multi-function AFOs in other paretic gait studies3. However, the study is the first to suggest the unique influence of spring stiffness and threshold torque in an AFO. An improved understanding of theses isolated AFO mechanical characteristics could help to improve the clinician's ability to target the orthotic treatment to the unique supportive needs of the patient. This understanding also supports systematic tuning algorithms aimed at AFO kinematic optimization.

References

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