THE EFFECT OF AFO OPTIMIZATION ON BIOMECHANICAL VARIABLES TREATING NEUROMUSCULAR CONDITIONS
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INTRODUCTION
Research demonstrates that ankle foot orthosis stiffness can influence biomechanical variables in the treatment of some pathologic neuromuscular conditions (Kobayashi, 2011, 2013). Studies have recommended a variety of stiffnesses to compensate for the biomechanical deficits at the ankle and knee associated with these conditions (Wong, 2009). The clinical optimization of ankle foot orthosis mechanical characteristics is an iterative, and highly individualized process. Optimal mechanical characteristics, and the path to orthotic optimization may be influenced by the pattern of biomechanical deficits. In this pilot study, the effect of ankle foot orthosis mechanical characteristics on biomechanical variables is measured and evaluated in the context of biomechanical deficits and a standardized adjustment procedure as a path to orthotic optimization.

METHOD
Subjects: Subjects included in this study were diagnosed with multiple sclerosis or stroke. All subjects were ambulatory with unilateral weakness or hypertonicity of the ankle and knee. The orthoses worn by subjects were custom, double upright ankle foot orthoses with Triple Action™ ankle joints. The orthoses were rigid carbon composite to isolate control of sagittal stiffness and ankle alignment to the ankle joints.

Apparatus: An eight camera Vicon motion analysis system was used to measure biomechanical variables. Motion data were captured from both lower extremities.

Procedures: Kinematic measurements were made with subjects in quiet standing, and walking on a level treadmill. Triple Action™ ankle joints were used to facilitate the independent adjustment of plantarflexion torque, dorsiflexion torque, range of motion, and null torque ankle alignment. The default, clinically optimized ankle joint settings were determined using a standardized adjustment procedure. During motion trials, ankle joint settings were independently adjusted to change the orthosis mechanical characteristics with non-adjusted settings fixed at their default values.

Data Analysis: Motion data were pre-processed to automate and objectively identify events through the gait cycle for kinematic measurements. Events during quiet standing, terminal swing, early and late stance phases of gait were analyzed to compare normative values, rates of change, and standard deviation.

RESULTS
Using the standardized adjustment procedure, clinicians independently arrived at similar optimized ankle joint settings. In static weight bearing, the ankle joint alignment setting at maximum torque correlated to changes in ankle and knee flexion angles for subjects with motor insufficiency. In gait trials, changes in null torque alignment towards dorsiflexion correlated with increased foot to floor contact angle for subjects with motor insufficiency at initial contact. For subjects with hypertonicity, initial contact foot to floor angle was less reliably correlated to null torque alignment. Decreased plantarflexion resist significantly correlated with increased plantarflexion excursion in terminal swing for subjects with hypertonicity. In late stance, decreased plantarflexion resist correlated with increased knee extension for subjects with motor insufficiency. For subjects with hypertonicity, decreased dorsiflexion resist correlated with decreased knee extension.

DISCUSSION
Motion data from this pilot study suggest that correlations exist between AFO mechanical characteristics and biomechanical variables. In some cases the orthotic influence was predictable, but appeared to be significantly effected by the pattern of biomechanical deficits. The influence of null torque alignment was more predictable under higher torque conditions. The standardized adjustment procedure was useful in determining default component settings as a basis for comparison.

CONCLUSION
Though AFO mechanical characteristics were shown in some cases to predictably influence biomechanical variables, further research is necessary to establish a broader correlation, and a standardized adjustment procedure to clarify the path to orthotic optimization.

CLINICAL APPLICATIONS
The orthotic treatment of lower extremity biomechanical deficits is an important area of orthotics. An improved understanding of the optimization process is necessary to help improve clinical outcomes.

REFERENCE
Wong, M. J. Rehab 1, 2009