Effect of Ankle-Foot Orthosis Stiffness on Muscle Coordination During Transient Walking in Healthy Adults

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Background

Cerebral palsy (CP) is a movement disorder caused by injury to the motor cortex which can lead to impaired motor control

Ankle-foot orthoses (AFOs) are commonly prescribed to improve the gait mechanics of individuals with CP

Although around 30% of daily motion is transient[1,2], few studies have considered the effect of AFO stiffness on transient walking

If AFO mechanical properties affect steady-state and transient walking differently, AFO design and prescription may be further informed by considering their effect on transient motion

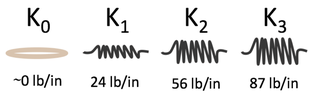
Goal: Investigate the effects of bilateral dorsiflexion-resisting AFO stiffness on muscle activation during transient walking in healthy adults

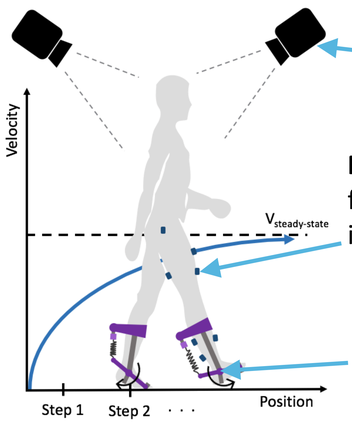
Methods *Pilot study in healthy adults*

Participant: 1 healthy adult fitted with bilateral AFOs
Male, Age: 25
H: 178 cm, W: 73 kg

Procedure: Data collected while participant accelerated from standing to steady-state walking

Intervention: 4 different AFO stiffness conditions

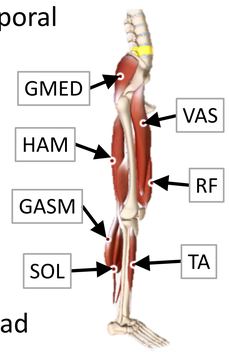


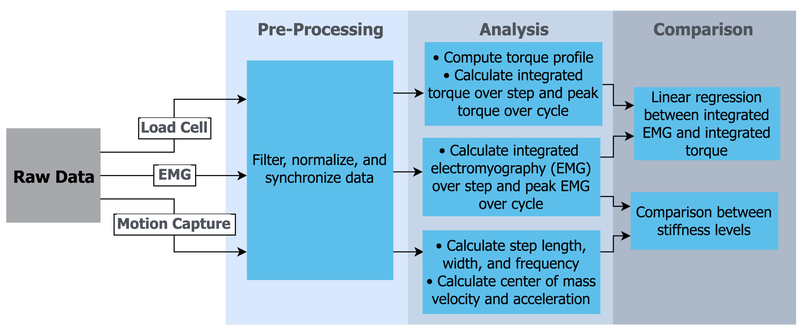


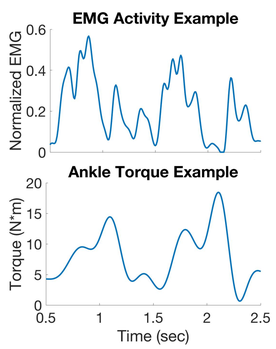
Marker trajectories for spatiotemporal outcomes

Muscle activity from 7 muscles in each leg

AFO Ankle Torque from load cell force data

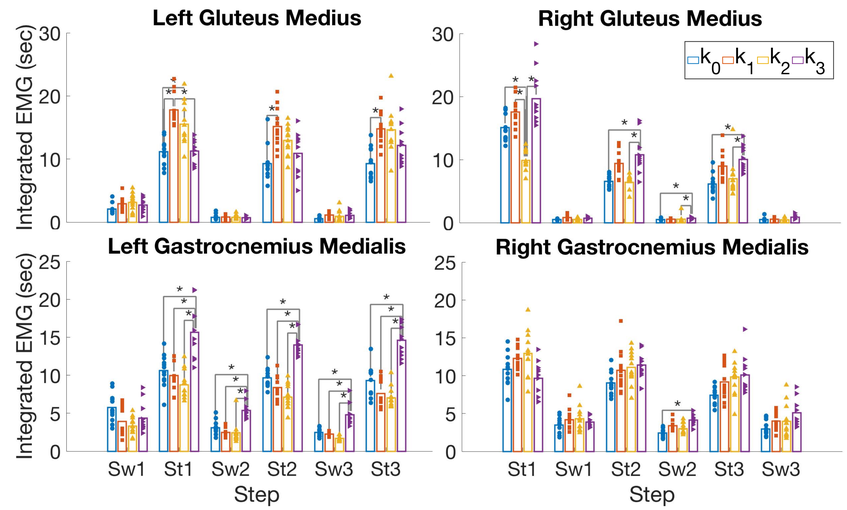






Results

Effect of AFO Stiffness



Gluteus medius (GMED): some significant differences between k_0 case (no spring) and spring stiffness cases

Gastrocnemius medialis (GASM): observed differences for left leg between k_3 spring stiffness and other conditions, but this pattern was not replicated for the right leg

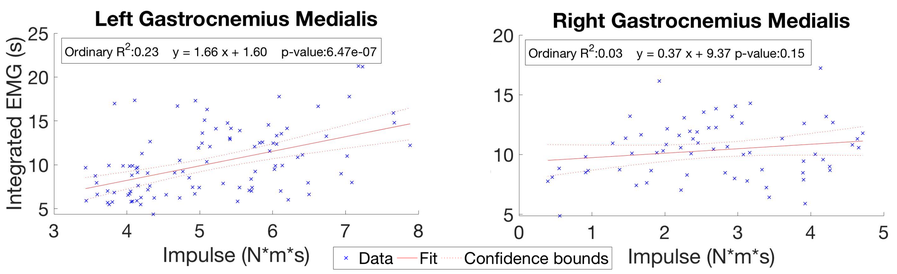
In other muscles, observed fewer statistically significant differences

Sw = Swing phase of gait cycle (GC)
St = Stance (support) phase of GC

Effect of AFO Torque

We were unable to identify a linear relationship between integrated EMG and impulse (integrated torque) for stance steps for each muscle

In general, swing steps showed no correlation between integrated EMG and impulse



Discussion and Future Work

This pilot study found that ankle-foot orthoses caused changes in muscle activity during transient walking, which may inform AFO design and prescription upon further validation

Similar study[5] involving steady-state walking only identified a significant difference in gastrocnemius activity, indicating that our observed changes in muscle activity may be unique to transient walking

Future work involves collecting data from more participants and investigating different types of models (i.e. feedback control)

References

[1] Orendurff, M.S. et , *J Rehabil Res Dev,* 2008
[2] Najafi, B. et al, *Gait Posture*, 2010
[3] Gottshalk, F. et al, *J Anat*, 1989
[4] Francis, C.A. et al, *Gait Posture*, 2013
[5] Harper, N.G. et al, *Clin Biomech*, 2014

Acknowledgments

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