Moving Towards Tuning of Ankle-Foot Orthoses (AFOs): The Influence of Carbon and Plastic AFOs for Individuals with Multiple Sclerosis

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Research Objective: To determine the immediate effects of plastic and carbon ankle foot orthoses (AFOs) on individuals with multiple sclerosis (MS) leading to follow up work investigating techniques and advantages of tuning AFOs in the MS population.

Overall Hypothesis: Wearing an AFO can help improve balance, fatigue, and gait patterns for individuals with MS. However, the use of AFOs could hinder certain dynamic movements necessary for everyday tasks. Tuning could mitigate the negative effects AFOs have by customizing the brace to the individual's needs.

AFOs and Multiple Sclerosis

- Multiple Sclerosis (MS) is an autoimmune disease where the body's immune system attacks the myelin that surrounds the nerves within the central nervous system (CNS) [1].
- Carbon fiber and plastic AFOs are commonly prescribed to individuals with MS to address gait, balance, and fatigue deficits.

Figure 1: Traditional Plastic AFO

Figure 2: Carbon Fiber AFO

Results and Discussion

Static Balance:
Although not statistically significant, trends emerged showing AFOs aided in static balancing tasks (Figure 3).

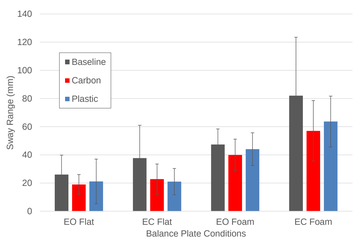

Figure 3: Quiet Standing Posturography – Mediolateral Sway Range

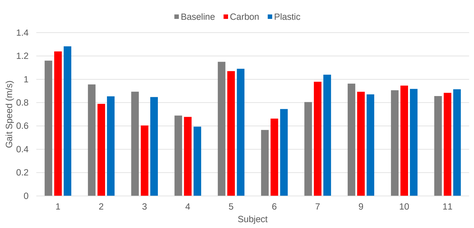

Figure 4: Gait Speed during 10 meter walk

Gait: Gait speed data showed varying results between each participant (Figure 4).

- Overall, no significant differences ($p>0.05$) between the three conditions for any test.
- Majority prefer carbon AFO (Figure 5).
- Results show importance of individual responses to AFOs and patient preference.

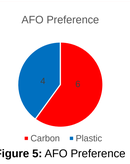

Figure 5: AFO Preference

Our New Focus: AFO Tuning

- In the previous study, all were off-the-shelf with only slight adjustments per person to ensure fit and alleviate any pain from pinching.
- Participants in a new study will be undergoing a tuning process with a new or existing AFO.

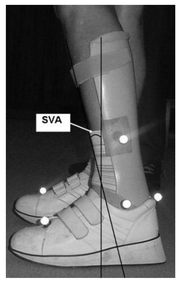

Figure 6: Tuned AFO with increased SVA (From [2])

- Tuning is believed to help optimize the effectiveness of AFOs.
- AFO tuning techniques include:
  - Adding wedges under the heel to increase shank-to-vertical angle (SVA) (Figure 6)
  - Adjusting the footplate stiffness
- However, there are no guidelines or tools to help in prescription
- Current visual analysis for prescription process does not account for subtle gait changes or kinematic and kinetic aspects of gait.

Methodology

Gait Analysis: Passive reflective motion capture with Vicon camera system and Bertec in-floor force plates

Figure 7: Pearl Reflective Marker

Balance: Quiet Standing Posturography and Limits of Stability

Gait Endurance: 6 minute walk test

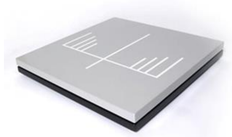

Figure 8: Bertec Balance Plate

Participants are tested at 3 points within the tuning process:

- Pre-Tuning
- Post-Tuning
- 12 Weeks Post-Tuning

Post-Processing and Analysis

- Motion capture uses location and relative position to map the markers through the volume
- Connected into a skeleton (Figure 9), these track segments and allow for creation of a digital avatar

Figure 9: Skeleton

- Shank-to-vertical angle (SVA) is calculated at midstance
  - When proximal heel marker of opposite limb passes proximal heel marker of reference limb
- Evaluation: Ensure SVA achieves an angle of 10 – 12° during midstance
- Analysis is used to evaluate effectiveness of tuning process
  - SVA of 10 – 12° during midstance
  - Proper alignment of ground reaction forces (GRF) (Figure 10)

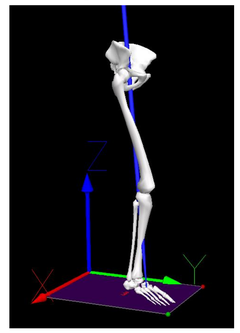

Figure 10: Ground Reaction Force

- Goal is to accommodate for contractures and promote tibial advancement through the gait cycle
- We are currently in the data collection process. So far one subject has completed the testing

Acknowledgements and References

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- Christina Cooper – Physical Therapist (Kettering Neurorehab and Balance Center)

References:

1. National Multiple Sclerosis Society. (n.d.). Retrieved July 7, 2017, from http://www.nationalmssociety.org/
2. Jagadamma, K. C., Owen, E., Coutts, F. J., Herman, J., Yirrell, J., Mercer, T. H., & Van Der Linden, M. L. (2010). The Effects of Tuning an Ankle-Foot Orthosis Footwear Combination on Kinematics and Kinetics of the Knee Joint of an Adult with Hemiplegia. *Prosthetics and Orthotics International*, *34*(3), 270–276. https://doi.org/10.3109/03093646.2010.503225