Comparison of an Advanced Ground Reaction Design Ankle Foot Orthosis and a Traditional Articulated Ankle Foot Orthosis on Gait, Balance, and Muscle Activation in Individuals with Hemiparesis

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Background: An ankle foot orthosis (AFO) is often prescribed for patients with hemiparesis to facilitate restoration of walking ability, and has been shown to improve gait speed and quality, and decrease likelihood of falls. Orthoses which limit the degree of plantarflexion can facilitate effective swing limb clearance. Stance limb instability is often caused by weakness in the plantarflexor and/or quadriceps muscles, and an orthosis that limits the degree of dorsiflexion can control the tibia and increase stance limb stability. The ground reaction ankle foot orthosis (GRAFO) is a specific type of AFO that is designed to harness the ground reaction moment to increase stability in stance. To date, there is no published research on the GRAFO in adults with hemiplegia, despite the fact that many adults with hemiplegia have weak plantarflexors that impair the ability to control the stance phase of gait. Given the biomechanical effects of this design of AFO, it seems likely that this design would benefit adult patients with hemiplegia.

Methods: Ten individuals with residual hemiparesis from acquired brain injury were recruited from rehabilitation services or from the community. Inclusion criteria included: 1.) ability to ambulate 10 meters without physical assistance, with or without the use of assistive device 2.) identified as appropriate for orthotic management by primary physical therapist, and 3.) ≤ 3/5 Manual Muscle Test (MMT) grade in plantarflexor muscle group of affected lower extremity. Individuals with a premorbid condition which would impact walking ability were excluded from the study. Participants were evaluated and casted for both the custom traditional articulated (AAFO) and advanced ground reaction design AFO. The AAFO controls the limb by blocking plantarflexion and providing mild transverse plane, inversion, and eversion control of the foot. Dorsiflexion was not impeded. The advanced ground reaction design AFO was a Dynamic Bracing Solutions (DBS) Balancer™. Advanced Tri-planar control of the limb was achieved through the use of a unique segmented weight bearing impression technique, very specific cast modifications, very specific alignment parameters, intimate fit, and very rigid materials. Walking function and balance were assessed wearing customary footwear only, in the AAFO, and in the advanced ground reaction design AFO, with order of orthotic condition randomized. The participant wore long pants, blinding the evaluator to the orthotic type. Walking speed was captured using the 10 meter walk test (10mW) at self-selected pace. Walking endurance was assessed with the 6 minute walk test (6MWT), and balance was assessed using the Timed Up and Go Test (TUG).

Results: One subject’s data was excluded from analysis due to extreme differences from remaining cohort. Of the remaining 9 subjects (4 male, 5 female), average age was 54.8 (range 38-70) years old and average time since stroke onset was 3.53 (0.14-7.51) years. There was a statistically significant difference between the no AFO and the AAFO condition for all 3 outcome measures (TUG, 10mW, 6MWT), p= 0.28, 0.28, and 0.008 respectively). The only statistically significant difference between the AAFO and the advanced ground reaction design AFO was found in the 6MWT (p=0.008). No statistically significant differences were found between the AAFO and the advanced ground reaction design AFO for any of the other outcome measures.
measures. Observational gait analysis revealed that the majority of subjects hyperextended at the knee during stance in the no AFO condition. This gait deviation was not fully corrected with the AAFO but was normalized with the advanced ground reaction design AFO. Three of the 9 subjects had immediate positive responses to the advanced ground reaction design AFO, with the greatest improvements in all 3 outcome measures occurring when using the advanced ground reaction design AFO. These 3 subjects had an average increase of 57.5m in the 6MWT, .19 m/sec in the 10 m, and 14.87 sec in the TUG between the AAFO and advanced ground reaction design AFO (improvements in the 6MWT and TUG exceeded the minimal detectable change (MDC) for each measure).

**Discussion:** This pilot study demonstrates that an AFO provides immediate improvements to gait and balance in persons with hemiplegia. The study also suggests that in some patients with plantarflexor weakness following stroke, an AFO which controls dorsiflexion as well as plantarflexion facilitates immediate improvements which are superior to improvements provided by a traditional AFO which only limits plantarflexion. Based on observational analysis, the advanced ground reaction design AFO normalized knee joint angles on the hemiplegic side, while the traditional AAFO allowed continued knee hyperextension. In addition, the advanced ground reaction design AFO appeared to have the greatest impact on walking endurance, compared to the traditional AAFO. These results indicate that further study of this design is warranted.