Effect of AFO Design on Walking in Individuals with Hemiplegia and Plantar Flexion Contractures from CVA

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Introduction

Hemiplegia following a cerebrovascular accident (CVA) often results in impaired walking in adults. A common therapeutic approach to improve the walking ability of the person with hemiplegia is the prescription of an ankle-foot orthosis (AFO), yet several studies have shown that an inappropriate design can make walking more difficult. The use of inappropriate orthoses stems from the vagueness of the clinical criteria currently available to guide clinicians in their selection among the large number of possible contour and control options. Our initial study identified post CVA individuals with full passive dorsiflexion walked faster in an articulating brace and had restricted swing phase knee flexion in a rigid brace.(Weiss et al) We expanded our study population to include a group of individuals with decreased passive ankle range of motion. The purpose of this study was to compare stride characteristics, moments and motion for individuals with post-stroke hemiplegia and plantar flexion contractures while wearing three different plastic AFO designs.

Statement of Clinical Significance

An inappropriate brace design can make walking more difficult, yet clinical criteria for the selection of orthosis type is lacking. Availability of passive ankle range of motion may be an important indicator in the selection of an orthosis that will best improve the walking ability of persons with hemiplegia following a stroke.

Methodology

Eleven individuals at least 6 months post CVA with ankle plantar flexion contractures from 5 to 10 degrees were studied. Each subject was tested in 3 different designs of plastic AFOs and a shoes only condition. The three orthotic conditions included a rigid contour, one with a dorsiflexion stop and a dorsiflexion assist (DA/DS) and the other with free dorsiflexion and a plantar flexion stop (PS). In random order participants wore each brace for at least two weeks prior to gait testing. Kinematics of the hemiplegic lower extremity and stride characteristics were recorded during walking while wearing the AFOs and with shoes only. Ankle passive range of motion was assessed with a standard goniometer. Gait velocity, stride characteristics and phases of gait were determined by compression closing switches taped to the bottom of each shoe, as the subjects walked across a 6-meter walkway. Three-dimensional motion of the pelvis and hemiparetic lower extremity was recorded over a 4-meter long calibrated field in the center of the 6-meter walkway using the VICON motion analysis system. Ground reaction forces were recorded with a Kistler force plate camouflaged in the middle of the walkway. An inverse dynamics model was used to determine the net joint moments for the lower extremity. Mean stride characteristics, peak joint angles and moments were compared across the 4 conditions (3 AFO’s, and shoes only) using ANOVA with repeated measures.

Results

In the rigid brace, gait velocity was significantly faster compared to shoes only (35%N vs 29%N). This was accomplished by a longer stride length (52%N vs 46%N) and an increased cadence (65%N vs 61%N). (Table)

Table. Group mean (and standard deviation) for stride characteristics while walking in shoes and 3 AFO designs expressed as a percent of normal (n=11)

	Velocity %Normal	*Stride Length* %Normal	*Cadence* %Normal
Shoes only	29 (14) *	46 (14) *	61 (15) *
Rigid AFO	35 (15) *	52 (15) *	65 (14) *
DA/DS	32 (14)	50 (14)	62 (14)
PS	31 (14)	48 (14)	62 (15)

* denotes significant difference at $p<.05$

Ankle plantar flexion at initial contact was significantly less in all 3 braces compared to shoes only (2-4º vs 12º). The rigid brace significantly restricted peak stance dorsiflexion during pre swing compared to the other conditions but only reached statistical significance compared to the DA/DS brace (5º vs 9º). During mid swing, all three braces achieved 0º dorsiflexion compared to 8º of plantar flexion in shoes only.

Knee flexion during loading response was significantly greater in the rigid and PS braces compared to shoes only (15º vs 9º). During pre swing, significantly less knee flexion was achieved in the rigid brace compared to shoes only. Peak knee flexion in initial swing however was not different in the 4 conditions.

No significant difference was found between the ankle moments in the 4 conditions at all points in the gait cycle. At the knee, a significantly greater flexion moment was produced at initial contact in the rigid and PS braces and during loading response in the rigid brace compared to shoes only.

Discussion

In this study, individuals with a mild plantar flexion contracture walked faster with a longer stride length and faster cadence in the rigid brace compared to shoes only. All braces provided more dorsiflexion in initial contact and mid swing compared to shoes only as expected. During pre swing there was less dorsiflexion in the rigid brace compared to other conditions. In these individuals with plantar flexion contractures, the rigid brace did not limit ankle plantar flexion more than the contracture until pre swing.

In the rigid and PS braces, greater knee flexion in loading may have facilitated forward progression in stance. In the rigid brace, knee flexion was restricted in pre swing but by initial swing there was no significant difference between the conditions.

With individuals post CVA with mild plantar flexion contractures, a rigid brace facilitates foot clearance. In this population, the restricted mobility of the brace is not significantly greater than that caused by the contracture itself.

References

Weiss WB et al. Presented at CGMAS Seventh Annual Meeting, Chattanooga, TN, Apr 2002 (Abstract)

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