The Effects of Ankle Foot Orthoses on Knee and Ankle Motion in the Hemiplegic Population

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Introduction

Ankle foot orthoses (AFO's) are commonly prescribed for children with cerebral palsy (CP) to improve lower extremity motion during ambulation. The purpose of this study was to assess the beneficial effects of AFO's on both knee and ankle motion during ambulation. Additional analysis was performed to reveal if the beneficial effects were dependent upon the type of AFO (PLS, SAFO, HAFO) and/or level of involvement (hemiplegic patterns type I-IV).

Statement of Clinical Significance

This study provides insight to the specific benefits of AFO's in the cerebral palsy population.

Methodology

This nonrandomized retrospective study included 49 patients with cerebral palsy, spastic hemiplegia with no prior surgical interventions. Subjects were a convenience sample drawn from a population who had undergone routine gait analysis testing at the Center for Motion Analysis at Connecticut Children's Medical Center.

Three dimensional kinematic and kinetic data were collected for each subject during barefoot and brace walks[1]. The subjects were divided by level of involvement into Type I-IV as described by Winters et al[2].

Results

There were no significant differences with regards to distribution of brace type among the four different levels of involvement (χ^2= 5.00, p = 0.55) as shown in Table 1.

Table 1: Distribution of three brace types among the four different levels of involvement

	TYPE I (n = 8)	**TYPE II** (n = 21)	**TYPE III** (n = 9)	**TYPE IV** (n = 11)	**Total** (n = 49)
PLS	2	6	4	2	14
HAFO	5	12	2	6	25
SAF0	1	3	3	3	10

All of the subjects demonstrated equinus in swing during barefoot ambulation. During ambulation in the AFO's a significant improvement in ankle motion was demonstrated in all three brace types and across all four levels of involvement as shown in Table 2.

Table 2: Changes in average ankle position during swing barefoot versus brace relative to level of involvement and brace type (Δ = difference between barefoot and brace values, * indicates significant difference at p ≤ 0.05).

	TYPE I	**TYPE II**	**TYPE III**	**TYPE IV**	**PLS**	**HAFO**	**SAFO**
Average ankle position during swing	Δ =5.0 ± 1.2 p = 0.00 *	Δ= 8.6 ± 1.4 p= 0.00 *	Δ= 7.6 ± 1.9 p = 0.00 *	Δ= 15.2 ± 2.8 p= 0.00 *	Δ=6.8 ± 1.4 p = 0.00 *	Δ= 10.1± 1.5 p = 0.00 *	Δ= 10.8± 2.6 p = 0.00 *

Knee motion improved during ambulation in the AFO's in several of the groups as shown in Table 3. There was a mild improvement in the amplitude of peak knee flexion in swing in the TYPE II group and in those subjects wearing HAFO's. There was a trend towards improved timing of peak knee flexion in all groups (significant improvements in TYPE I, TYPE II, TYPE IV and in subjects wearing HAFO's and SAFO's). Knee extension during terminal swing improved significantly in the TYPE II and TYPE III groups and in subjects wearing PLS braces.

Table 3: Changes in knee motion barefoot versus brace relative to level of involvement and brace type (Δ = difference between barefoot and brace values, * indicates significant difference at $p \leq 0.05$).

	TYPE I	TYPE II	TYPE III	TYPE IV	PLS	HAFO	SAFO
Amplitude of Peak Knee Flexion in swing	Δ =1.4 ± 2.7 p = 0.62	Δ= 3.3 ± 1.3 p= 0.02 *	Δ= 2.7 ± 3.0 p = 0.40	Δ= 4.0 ± 2.0 p= 0.08	Δ= 2.6 ± 2.4 p = 0.30	Δ= 4.0 ± 1.4 p = 0.01 *	Δ= 1.0 ± 0.9 p = 0.27
Peak knee flexion in swing (% gait cycle)	Δ = 3.7 ± 1.5 p = 0.05 *	Δ= 1.8 ± 0.8 p = 0.03 *	Δ= 3.4 ± 1.7 p= 0.08	Δ= 4.9 ± 1.4 p = 0.01 *	Δ= 2.4±1.1 p = 0.06	Δ= 2.2±0.9 p = 0.02 *	Δ= 4.8 ± 1.2 p = 0.00 *
Knee extension in terminal swing	Δ = 0.9 ± 3.1 p = 0.79	Δ= 4.2 ± 1.6 p = 0.01 *	Δ= 5.9 ± 2.1 p = 0.03 *	Δ= 3.3±3.0 p = 0.31	Δ= 5.9±1.6 p = 0.00 *	Δ = 2.2 ± 1.8 p = 0.22	Δ = 4.6 ± 2.5 p = 0.10

Pre-positioning of the foot at initial contact (IC) was improved by the use of an AFO. During barefoot ambulation none of the subjects were able to achieve a heel IC. While ambulating in the AFO's the incidence of a heel IC was more frequent (33 subjects). This was obtained through a reduction of equinus in combination with greater knee extension at IC. Obtaining a heel IC during AFO ambulation was not related to the brace type (χ^2=0.35, p = 0.84) or level of involvement (χ^2= 4.14, p = 0.25)

Discussion

These findings suggest that AFO's provide beneficial changes in motion at both the ankle and knee in patients with hemiplegia of all levels of involvement. Findings regarding changes at the ankle are consistent with previous research[3,4]. Changes at the knee, not noted previously, result in clearance improvements and better pre-positioning. Changes in PKF may be related to stance phase alterations caused by bracing. Also, greater momentum of the shank in the AFO condition during terminal swing might provide additional force to over power some of the hamstring spasticity allowing for greater knee extension at IC.

References

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