Effect on Gait of Ankle Foot Orthosis-Footwear Combination in an Individual with Post-Stroke Hemiplegia

INTRODUCTION

'Tuning' of segmental kinematics using ankle foot orthosis-footwear combinations (AFO-FC) has been proposed to improve the gait of persons with cerebral palsy and stroke (Owen 2002; Jagadamma et al. 2008, 2009). An AFO-FC consists of a non-articulated AFO in which ankle and shank alignments are considered separately. Modified footwear is used in addition to wedges under the heel to adjust the shank-to-floor angle (SVA), i.e., the position of the lower leg relative to the ground when standing (Owen 2007). 'Tuning' of the AFO-FC involves manipulation of the ground reaction force (GRF) relationship to the knee and hip joints to improve gait performance. Although this orthotic approach is being advocated for use in stroke (NHS 2009), limited evidence exists regarding effectiveness. The purpose of this case study was to investigate the effect on gait of a tuned AFO-FC in an individual with post-stroke hemiplegia followed for 6 months.

METHOD

The Northwestern University Institutional Review Board approved this study and informed consent was obtained from the subject prior to participation.

Subject: 56 yr old male (190cm, 88.5kg) who sustained a right (R) stroke in May 2008 with subsequent left (L) hemiplegia, hemi-sensory impairment, aphasia, and impaired motor planning. Five months post-stroke, the subject ambulated with a L articulated AFO with modified independence, but had minimal weight bearing onto the L lower limb, absent terminal stance on the L, trunk substitution and circumduction for L lower limb swing. Nine months post-stroke, the subject was fit with a L AFO-FC with ankle angle of 5º plantar flexion and SVA of 14º (Fig 1). Eleven months post-stroke, the subject presented with passive range of motion of 5º hyperextension of the L knee, 10º dorsiflexion of the L ankle with knee flexed, and 5º plantar flexion with knee extended. He was ambulating regularly with the AFO-FC, no assistive device, with improved weight shift and bearing on the L lower limb. Subject reported discontinuation of wheelchair use for community ambulation.

Figure 1. AFO with heel wedge (L) and AFO-FC (R).

Apparatus: All gait data were acquired using marker based motion analysis and an 8-camera real-time motion capture system (MAC, Santa Rosa, CA) with 6 force-plates (AMTI, Watertown, MA) embedded in the floor of a 10m walkway. The same investigator placed all markers on subjects for all gait analyses. Force data were acquired simultaneous with motion data.

Procedures: Gait analyses were performed on three occasions post-stroke (conditions tested on each occasion are indicated in parentheses): 11 months (L AFO-FC; L PLS-AFO with R quad cane), 16 months (L AFO-FC pre- and post-modification of shoe) and 17 months (L AFO-FC; No AFO with quad cane). At 11 months the subject would not ambulate without an AFO, hence data was collected with an off-the-shelf posterior leaf spring AFO (PLS-AFO), which had been provided previously when his articulated AFO broke.

Data Analysis: EVa Cortex and Orthotrak software (MAC, Santa Rosa, CA) were used to process data and calculate temporospatial data, kinematics and kinetics.

RESULTS

Walking speed improved with use of the AFO-FC at 11 months with another increase at 16 months when additional tuning was conducted (Table 1). Speed was maintained with AFO-FC at 17 months. Improvements in knee and pelvis kinematics, ankle kinetics and GRF were also recorded.

	11 months		16 months		17 months	
	PLS-AFO	AFO-FC	AFO-FC*	AFO-FC^	No AFO	AFO-FC
Stride Length (cm)	45.5	54.5	72.8	77.6	47.3	76.0
Speed (cm/s)	26.2	28.9	59.3	65.6	19.7	65.6
Cadence (steps/min)	68.8	64.2	98.0	101.7	50.1	104.2
Step Width (cm)	27.7	28.2	23.7	22.9	32.8	23.7

*shank to vertical angle (SVA) = 14 degrees. ^SVA = 11 degrees.
Table 1. Temporospatial data.

DISCUSSION & CONCLUSION

Gait continued to change over time in this subject, so it was not possible to attribute all gait improvements solely to orthotic management. However, since gait was better at 17 months with the AFO-FC than with No AFO and gait with No AFO was the same as with PLS-AFO at 11 months, substantial improvement in gait could be attributed to orthotic management. Additional tuning of the AFO-FC at 16 months based on gait data resulted in further improvements in gait suggesting that tuning is important and can be facilitated by gait analysis.

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