The Efficacy of AFO Use in Ambulatory Children with Spastic Diplegia  
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Introduction  
Ankle foot orthoses (AFOs) are prescribed for ambulatory children with spastic diplegia to  
improve biomechanical alignment and functional capability. Orthotic prescription is often  
based upon clinical experiences, treatment paradigms (biomechanical vs  
neurodevelopmental), and the perceived desires of the child/family. Previous investigations  
have reported that AFO use in ambulatory children with spastic diplegia normalizes ankle  
kinematics/kinetics and gait parameters 1-4; however, a recent comparison of three AFO  
configurations to shoes alone concluded that all configurations promoted abnormal ankle  
kinematics in comparison to shoes alone with no significant improvement in walking  
efficiency 5. The purpose of this study was to examine the efficacy of three commonly  
prescribed AFO configurations (solid (SAFO), hinged (HAFO), posterior leaf spring (PLS)  
during gait and energy expenditure (O2 consumption) in ambulatory children with spastic  
diplegia.

Clinical Significance  
AFOs are an integral component in the management of ambulatory children with spastic  
cerebral palsy, therefore, delineation of the different AFO configuration effects is needed in  
order to establish guidelines for lower extremity orthotic prescription and management in this  
population.

Methodology  
Sixteen independently ambulatory children with a diagnosis of spastic diplegia (range 5+3 to  
15+3 yrs) participated in this study. Study design involved utilization of multiple single  
subjects with randomized crossover after a three month baseline where no orthotic was used.  
Children were assessed barefoot at baseline and in each orthotic configuration following a  
three-month accommodation period, for a total of four assessments per child over a one-year  
period of time. Gait analysis was performed using a 6-camera Vicon 370 system, 2 AMTI  
forceplates, and Vicon clinical manager. Energy consumption was performed using a  
SensorMedics 2900 Metabolic Cart in the dilution mode. Kinematic and kinetic variables at  
the pelvis, hip, knee, and ankle, gait parameters, and energy consumption data were analyzed  
using one-way repeated measures ANOVAs and linear contrasts. Statistical significance was  
established for each variable group using Bonferroni corrections.

Results  
AFO use did not significantly alter the gait kinematics or kinetics of proximal joints. All AFO  
configurations significantly increased the degree of ankle dorsiflexion at initial contact and  
during stance while limiting plantarflexion in swing. Despite excessive ankle dorsiflexion  
during stance in the HAFO, a significant concomitant increase in knee flexion was not  
observed. Orthotic configuration had no effect on the ankle plantar flexion/knee extension  
couple as stance phase knee flexion was similar in all conditions. All AFO configurations
increased stride length and decreased cadence resulting in no change in velocity. All AFO configurations significantly increased the energy efficiency of gait during self-selected and fast walking.

Table 1 Variable mean ± standard deviation

<table>
<thead>
<tr>
<th>Variable</th>
<th>Barefoot</th>
<th>HAFO</th>
<th>PLS</th>
<th>SAFO</th>
<th>Norm</th>
</tr>
</thead>
<tbody>
<tr>
<td>•knee fl min st °</td>
<td>8.1±10.4</td>
<td>11.8±10.7</td>
<td>9.8±7.4</td>
<td>8.2±11.1</td>
<td>.4±4.8</td>
</tr>
<tr>
<td>*ankle df ic °</td>
<td>-7.2±13</td>
<td>5.4±3.9  a</td>
<td>4.8±4.6  a</td>
<td>5.0±4.5  a</td>
<td>-4.2±3.1</td>
</tr>
<tr>
<td>*ankle pk df st °</td>
<td>5.7±12.9</td>
<td>18.6±8.3  a,b</td>
<td>14.8±7.3  a</td>
<td>12.5±5.3  a</td>
<td>9.2±2.6</td>
</tr>
<tr>
<td>*ankle pk pf sw °</td>
<td>24±19.8</td>
<td>-2.0±4.2  a</td>
<td>-26±5.0  a</td>
<td>-1.8±4.7  a</td>
<td>22.5±5.3</td>
</tr>
<tr>
<td>•ankle pk pf (Nm/kg)</td>
<td>.84±.18</td>
<td>1.09±.13  a</td>
<td>1.09±.13  a</td>
<td>1.08±.13  a</td>
<td>1.29±.15</td>
</tr>
<tr>
<td>•ankle pk gen st (w/kg)</td>
<td>1.59±.51</td>
<td>1.18±.31  a</td>
<td>1.23±.45  a,c</td>
<td>.83±.17  a</td>
<td>3.51±.44</td>
</tr>
<tr>
<td>•stride (m)</td>
<td>.91±.15</td>
<td>.99±.18  a</td>
<td>1.05±.15  a</td>
<td>1.02±.18  a</td>
<td>1.15±.13</td>
</tr>
<tr>
<td>•cadance (stps/min)</td>
<td>142±23</td>
<td>118±14  a</td>
<td>127±22  a</td>
<td>124±15  a</td>
<td>133±11</td>
</tr>
<tr>
<td>•velocity (m/s)</td>
<td>1.08±.22</td>
<td>.98±.21</td>
<td>1.11±.19</td>
<td>1.04±.18</td>
<td>1.28±.19</td>
</tr>
<tr>
<td>*cost (ml 0₂/kg/m) SS</td>
<td>.417±.11</td>
<td>.363±.09  a</td>
<td>.368±.08  a</td>
<td>.353±.09  a</td>
<td>.22</td>
</tr>
<tr>
<td>*cost (ml 0₂/kg/m) F</td>
<td>.398±.10</td>
<td>.360±.08  a</td>
<td>.352±.08  a</td>
<td>.338±.07  a</td>
<td>.22</td>
</tr>
</tbody>
</table>

fl, flexion; min, minimum; st, stance; df, dorsiflexion; ic, initial contact; pf, plantarflexion; sw, swing; gen, generation; SS, self-selected; F, fast; •, p ≤.012, *, p ≤.016.

a. mean of this condition differed significantly from the mean of the barefoot condition
b. mean of the HAFO differed significantly from the mean of the SAFO
c. mean of the PLS AFO differed significantly from the mean of the SAFO

Discussion

The results of this study support previous investigations and substantiate that the AFO configurations studied do not significantly alter the proximal joint kinematics and kinetics of ambulatory children with spastic diplegia 1-5, indicating that the mechanical benefits of these configurations are limited to the ankle joint. While all AFO configurations studied prevented equinus, increased stride length, decreased cadence, and enhanced the energy efficiency of gait subtle differences in configuration efficacy were seen. While unrestricted ankle dorsiflexion has been proposed to have functional benefits, detrimental effects were observed in this population of children, thus the use of a PLS or SAFO should be considered.

References