Comparative Analysis of Solid AFO vis-à-vis Articulated AFO using Flexible Ankle Hinges in Children with Cerebral Palsy Spastic Diplegia Age Group 5-12 Years in Terms of Gait Parameters

Haribhau S. Dongre¹, Kishan Singh², Lukeshkumar R. Bhuyar³

¹Lecturer P&O, ²Demonstrator P&O, Dept. of Prosthetics and Orthotics, All India Institute of Physical Medicine & Rehabilitation, Mahalaxmi, Mumbai-400034.

Corresponding Author: Lukeshkumar R. Bhuyar

DOI: https://doi.org/10.52403/ijhsr.20220211

ABSTRACT

In this study, we have studied 16 subjects with Cerebral Palsy spastic diplegia age group 5-12 years (9 male, 7 female) with GMFC level 1, 2 or 3 with the consent of their parents. We had evaluated these subjects and took their measurements and prepared Static AFOs and given it to the subjects to use it for 30 days. The spatiotemporal gait parameters like step length, stride length, speed and cadence were recorded with static AFOs and then given with Articulated AFOs for next 30 days. The reading was recorded for Articulated AFOs. The data collected were analyzed using paired t test using software InStat GraphPad. The results of the study shown that the performance of subjects was better with Articulated AFOs in comparison with Static AFOs. These results will help the professionals to choose the appropriate design for Children with Cerebral Palsy.

Key Words: Cerebral Palsy, Articulated AFO, Equinovarus, Static AFO, Gait, Spasticity.

INTRODUCTION

After reviewing recent literatures, in India there are hardly any studies done in the use of Static and Dynamic AFO using Flexible Ankle hinges (Tamarack type) to check their effectiveness in CP children with spastic diplegia.

The majority of Spastic Cerebral Palsy children exhibit high tone in the extensor muscles of the lower extremity. Spastic planter flexors and invertors pull the foot in to an equinovarus position.

In this research we aim to study the efficacy of Solid AFO vis-à-vis Articulated AFO using Flexible Ankle hinges in children with Cerebral Palsy spastic diplegia with age group 5-12 years in terms of Gait Parameters.

Objective of this study is to compare the biomechanical effectiveness of the solid AFO with articulated AFO using Flexible Ankle hinges in children with Cerebral Palsy spastic diplegia with age group 5-12 years by using the spatiotemporal parameters of the gait.

MATERIALS AND METHODS

This research was conducted at Prosthetic and Orthotic Department of Tertiary Rehabilitation Centre where Cerebral Palsy children with Spastic Diplegia in the age group 5-12 years were recruited with prior consent. The study took nine months’ time duration to derive the results. Sixteen children were taken as sample size with convenience sampling and study design as Prospective interventional...
Haribhau S. Dongre et al. Comparative analysis of solid AFO vis-à-vis articulated AFO using flexible ankle hinges in children with cerebral palsy spastic diplegia age group 5-12 years in terms of gait parameters.

The data were recorded and analyzed using Paired “t” test is used to compare the outcomes measured between both the designs of orthoses and level of significance as $p \leq 0.05$.

**Statistical Analysis**

The recorded data is analyzed using Paired “t” test to compare the outcomes measured between both the designs of orthoses and level of significance as $p \leq 0.05$. Spatiotemporal parameters i.e. Step length, Stride length, Speed and Cadence were used. All the data are analyzed by paired “t” test using software “Graph Pad Instat”.

**RESULTS**

The results of the study can guide the practitioners to choose appropriate Orthotic design which varies from subject to subject and is influenced by body contours, climate, activity level and personal preferences.

**GAIT PARAMETERS:**

1.1. **STEP LENGTH:**

The mean step length of patients using Solid AFO is 0.3338 ($\pm 0.1114$) meters and with Articulated AFO using Flexible Ankle hinges 0.3994 ($\pm 0.1414$) meters as shown in table.

**STEP LENGTH WITHIN THE GROUP:**

<table>
<thead>
<tr>
<th>Orthotic Design</th>
<th>M</th>
<th>SD</th>
<th>N</th>
<th>t-value</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid AFO</td>
<td>0.3338</td>
<td>0.1114</td>
<td>16</td>
<td>t=3.114</td>
<td>P=0.0071(P &lt; 0.05)</td>
</tr>
<tr>
<td>AAFO using Flexible Ankle hinges</td>
<td>0.3994</td>
<td>0.1414</td>
<td>16</td>
<td>t=3.114</td>
<td></td>
</tr>
</tbody>
</table>

Significant at 0.05 level
Comparative analysis of solid AFO vis-à-vis articulated AFO using flexible ankle hinges in children with cerebral palsy spastic diplegia age group 5-12 years in terms of gait parameters.

From table, 1.1 it can be seen that the t value is 3.114 which is significant at 0.05 levels with degree of freedom 4. It indicates that the mean value of Solid AFO differ significantly than Articulated AFO using Flexible Ankle hinges. Further the mean value of step length in Solid AFO whose mean value of step length is 0.3338 which is lower than that of Articulated AFO using Flexible Ankle hinges is 0.3994 (table no. 7.1.1). It may therefore be said that Articulated AFO using Flexible Ankle hinges has found to be slightly significantly superior to Solid AFO in terms of step length.

1.2. STRIDE LENGTH:

The mean stride length of patients using Solid AFO is 0.6531 (±0.1970) meters and with Articulated AFO using Flexible Ankle hinges is 0.7419 (±0.2178) meters of as shown in table.

<table>
<thead>
<tr>
<th>Orthotic Design</th>
<th>M</th>
<th>SD</th>
<th>N</th>
<th>t-value</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid AFO</td>
<td>0.6531</td>
<td>0.1970</td>
<td>16</td>
<td>t=3.525</td>
<td>P=0.0031 (P &lt; 0.05)</td>
</tr>
<tr>
<td>AAFO using Flexible Ankle hinges</td>
<td>0.7419</td>
<td>0.2178</td>
<td>16</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Significant at 0.05 level

From table, 1.2 it can be seen that the t value is 3.525 which is significant at 0.05 levels with degree of freedom 4. It indicates that the mean value of Solid AFO differ significantly than Articulated AFO using Flexible Ankle hinges. Further the mean value of stride length in Solid AFO whose mean value of stride length is 0.6531 which is lower than that of Articulated AFO using Flexible Ankle hinges is 0.7419 (table no. 1.2). It may therefore be said that Articulated AFO using Flexible Ankle hinges (Tamarack type) has found to be slightly significantly superior to Solid AFO in terms of stride length.

1.3 SPEED/ VELOCITY:

The mean Speed of patients using Solid AFO is 0.4431 (±0.5631) meters per second and with Articulated AFO using Flexible Ankle hinges is 0.2452 (±0.2959) meters per second of as shown in table.

<table>
<thead>
<tr>
<th>Orthotic Design</th>
<th>M</th>
<th>SD</th>
<th>N</th>
<th>t-value</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid AFO</td>
<td>0.4431</td>
<td>0.5631</td>
<td>16</td>
<td>t=4.339</td>
<td>P=0.0001 (P &lt; 0.05)</td>
</tr>
<tr>
<td>AAFO using Flexible Ankle hinges</td>
<td>0.2452</td>
<td>0.2959</td>
<td>16</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Significant at 0.05 level

From table, 1.3 it can be seen that the t value is 4.339 which is significant at 0.05 levels with degree of freedom 4. It indicates that the mean value of Solid AFO differ significantly than Articulated AFO using Flexible Ankle hinges. Further the
 Comparative analysis of solid AFO vis-à-vis articulated AFO using flexible ankle hinges in children with cerebral palsy spastic diplegia age group 5-12 years in terms of gait parameters.

Mean value of Speed in Solid AFO whose mean value of Speed is 0.4431 which is lower than that of Articulated AFO using Flexible Ankle hinges is 0.2452 (table no.1.3). It may therefore be said that Articulated AFO using Flexible Ankle hinges has found to be slightly significantly superior to Solid AFO in terms of stride length.

Table 1.3: Types of Orthotic designs mean (M), standard deviation (SD), total number of subjects (N), and “t” value of Speed within Solid AFO vis-à-vis Articulated AFO using Ankle hinges.

<table>
<thead>
<tr>
<th>Orthotic Design</th>
<th>M</th>
<th>SD</th>
<th>N</th>
<th>t-value</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid AFO</td>
<td>0.4431</td>
<td>0.5631</td>
<td>16</td>
<td>t=4.339</td>
<td>P=0.0006 (P &lt; 0.05)</td>
</tr>
<tr>
<td>AAFO using Flexible Ankle hinges</td>
<td>0.2452</td>
<td>0.2959</td>
<td>16</td>
<td></td>
<td>*Significant at 0.05 level</td>
</tr>
</tbody>
</table>

1.4 CADENCE:

The mean Speed of patients using Solid AFO is 91.56 (± 35.46) meters per second and with Articulated AFO using Flexible Ankle hinges is 104.3 (± 31.99) meters per second of as shown in table.

Table 1.4: Types of Orthotic designs mean (M), standard deviation (SD), total number of subjects (N), and “t” value of Speed within Solid AFO vis-à-vis Articulated AFO using Flexible Ankle hinges.

<table>
<thead>
<tr>
<th>Orthotic Design</th>
<th>M</th>
<th>SD</th>
<th>N</th>
<th>t-value</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid AFO</td>
<td>91.56</td>
<td>35.46</td>
<td>16</td>
<td>t=2.647</td>
<td>P=0.0183 (P &lt; 0.05)</td>
</tr>
<tr>
<td>AAFO using Flexible Ankle hinges</td>
<td>104.3</td>
<td>31.99</td>
<td>16</td>
<td></td>
<td>*Significant at 0.05 level</td>
</tr>
</tbody>
</table>

From table, 1.4 it can be seen that the t value is 2.647 which is significant at 0.05 levels with degree of freedom 4. It indicates that the mean value of Solid AFO differ significantly than Articulated AFO using Flexible Ankle hinges . Further the mean value of cadence in Solid AFO whose mean value of Cadence is 91.56 which is lower than that of Articulated AFO using Flexible Ankle hinges is 104.3 (table no.1.3). It may therefore be said that Articulated AFO using Flexible Ankle hinges has found to be slightly significantly superior to Solid AFO in terms of stride length.
Haribhau S. Dongre et al. Comparative analysis of solid AFO vis-à-vis articulated AFO using flexible ankle hinges in children with cerebral palsy spastic diplegia age group 5-12 years in terms of gait parameters.

**GRAPH 1.4**: Cadence of Solid AFO (SAFO) and Articulated AFO using Flexible Ankle hinges (AAFO).

- **X-axis**: No. of Subjects
- **Y-axis**: Cadence in Steps/min.

**DEMOGRAPHICAL CHARACTERISTIC WISE DISTRIBUTION OF SUBJECTS:**

<table>
<thead>
<tr>
<th>Age group (in years)</th>
<th>Number of Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>05-06</td>
<td>3</td>
</tr>
<tr>
<td>07-08</td>
<td>3</td>
</tr>
<tr>
<td>09-10</td>
<td>7</td>
</tr>
<tr>
<td>11-12</td>
<td>3</td>
</tr>
</tbody>
</table>

**Table no.1.5 Age wise distribution of the subjects**

**Body weight wise Distribution in kg.**

**PIE CHART – 2** Age wise distribution of the subjects

**Table no.5 Body weight wise distribution of the subjects**

<table>
<thead>
<tr>
<th>Body weight groups in kg</th>
<th>Number of Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-13</td>
<td>03</td>
</tr>
<tr>
<td>14-17</td>
<td>03</td>
</tr>
<tr>
<td>18-21</td>
<td>07</td>
</tr>
<tr>
<td>22-25</td>
<td>03</td>
</tr>
</tbody>
</table>

**DISCUSSION**

In the study, Solid Ankle Foot Orthosis and Articulated AFO using flexible ankle hinges was used respectively in the Orthotic treatment of 16 Children with Cerebral Palsy Spastic Diplegia age group 5-12 years and comparison was made between them using Gait Parameters i.e. Step length, Stride length, Speed and Cadence.

I. Analysis of Gait Parameters (Step length, Stride length, Cadence and Speed) with both the types of Orthotic designs:
The pioneers of scientific gait analysis were Aristotle in De Motu Animalium (On the Gait of Animals) and much later in 1680, Giovanni Alfonso Borelli also called De Motu Animalium et al. It is one of the very successful methods of finding various gait parameters and also to have comparative analysis with various types of lower extremity Orthoses.

From the Table 1.1, 1.2, 1.3 and 1.4 and Graph 1.1, 1.2, 1.3 and 1.4, it is evident, that the Gait parameters i.e. Step length, Stride length, Speed and Cadence have more significant values in Articulated AFO using flexible ankle hinges than in Solid AFO. Tables shows the mean and standard deviation (±SD) values of Step length in meter, Stride length in meter, Speed in meter per second and Cadence in steps per min for each Orthotic design. Also it is found out that as gait parameters have more significant values in Articulated AFO using flexible ankle hinges than in Solid AFO. Hence the Articulated AFO using flexible ankle hinges is more effective and suitable for Children with Cerebral Palsy Spastic Diplegia.

CONCLUSION

1. The study was performed on 16 subjects who have Cerebral Palsy Spastic Diplegia with age group 5-12 years with both Orthotic designs i.e. Articulated AFO using flexible ankle hinges and Solid AFO. It concludes that Articulated AFO using flexible ankle hinges is a better design in terms of Gait analysis as compared to Solid AFO. Also there are some more advantages such as ease and confidence while walking due to presence of Ankle movement.

2. In some patients those who are having less muscle power at Ankle joint they feel uncomfortable while using Articulated AFO with flexible ankle hinges. The reason for this may be inadequate physiotherapy exercises (as in case in Subject no.4 and Subject no.16). So due to this reason patient feel more comfortable with Solid AFO.

Acknowledgement: None

Conflict of Interest: None

Source of Funding: None

Ethical Approval: Approved

REFERENCES


7. Aboutorabi A, Arazpour M, AhmadiBani M, Saeedi H, Head JS. Efficacy of ankle foot orthoses types on walking in children


24. Zhang Y, Ma Y; Application of supervised machine learning algorithms in the classification of sagittal gait patterns.


How to cite this article: Dongre HS, Singh K, Bhuyar LR. Comparative analysis of solid AFO vis-à-vis articulated AFO using flexible ankle hinges in children with cerebral palsy spastic diplegia age group 5-12 years in terms of gait parameters. Int J Health Sci Res. 2022; 12(2): 83-90. DOI: https://doi.org/10.52403/ijhsr.20220211

******