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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

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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

study. Both male and female were included in the study with age ranging from5-12 years. Children with Cerebral palsy spastic diplegic child with GMFC level 1,2,3 were included who do not have contracture of lower limb especially at knee and ankle and were not having visual and hearing impairment and were not having other associated neurological or orthopedics condition.

In the plan of study after obtaining consent from child's parent at the First Stage i.e. at Day 1, evaluation and assessment were done followed by measurement and cast of Plaster of Paris. The Gait of the child was analyzed without any orthosis. At the second stage i.e. on Day 10 child was fitted with Static AFO and given to use at home after proper gait training. At the third stage i.e. at Day 40 measurement and readings of parameter values with static AFO was noted and then the child was given with Articulated AFO with Flexible Ankle hinges for next 30 days. At the fourth stage i.e. on Day 70 measurement and readings of parameter values with Articulated AFO with Flexible Ankle hinges were noted and photographs were taken.

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:

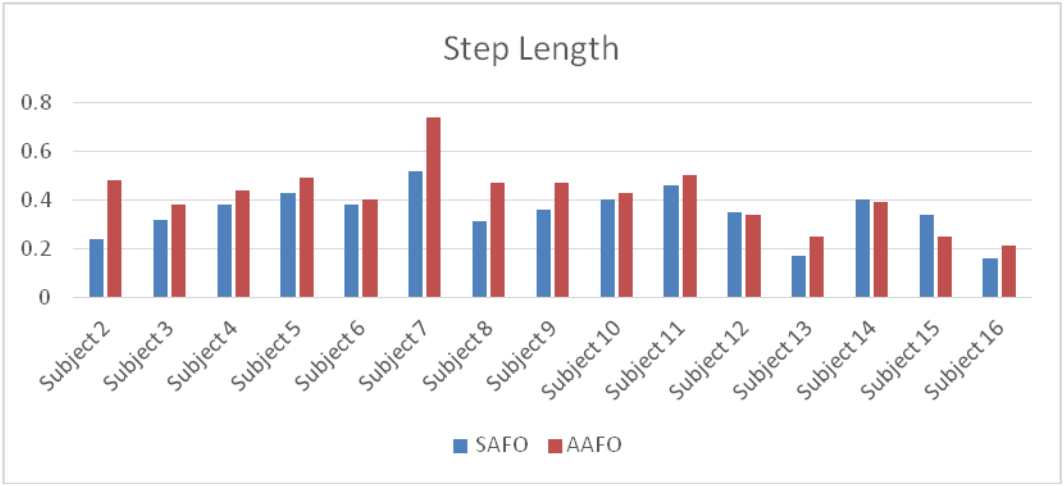
The mean step length of patients using Solid AFO is 0.3338 (±0.1114) meters and with Articulated AFO using Flexible Ankle hinges is 0.3994 (±0.1414) meters of as shown in table.

STEP LENGTH WITHIN THE GROUP:

Table 1.1: Types of Orthotic designs mean (M), standard deviation (SD), total number of subjects (N), and "t" value of step length within Solid AFO vis -a-vis Articulated AFO using Flexible Ankle hinges.

Orthotic Design	M	SD	N	t-value	Remarks
Solid AFO	0.3338	0.1114	16		
AAFO using Flexible Ankle hinges	0.3994	0.1414	16	t=3.114	P=0.0071(P < 0.05)

Significant at 0.05 level



GRAPH 1.1: Step length of Solid AFO (SAFO) and Articulated AFO using Flexible Ankle hinges Tamarack type (AAFO).

X–axis:- Step Length in meter. Y- axis: - Number of Subjects

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.

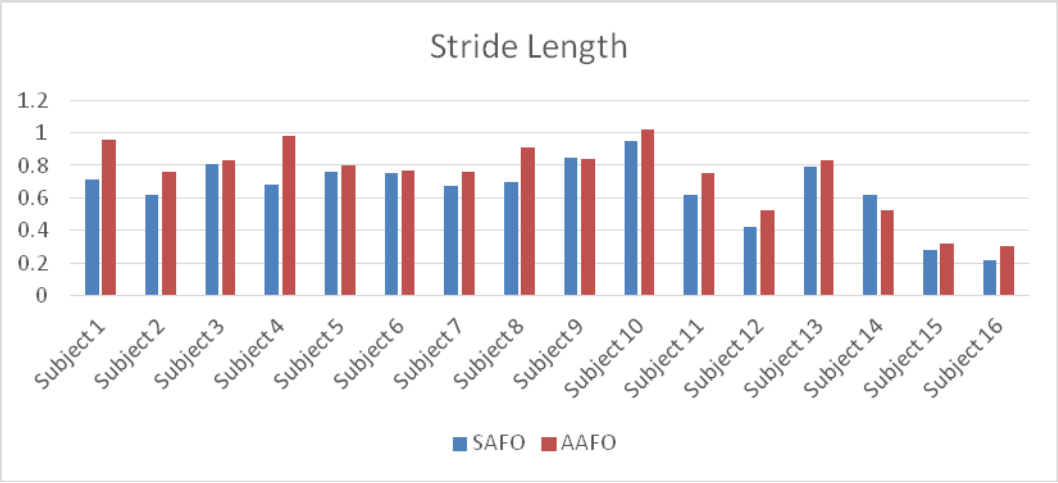
STRIDE LENGTH WITHIN THE GROUP:

Table 1.2: Types of Orthotic designs mean (M), standard deviation (SD), total number of subjects (N), and "t" value of stride length within Solid AFO vis -a-vis Articulated AFO using Flexible Ankle hinges (Tamarack type).

Orthotic Design	M	SD	N	t-value	Remarks
Solid AFO	0.6531	0.1970	16	t=3.525	P=0.0031 (P < 0.05)
AAFO using Flexible Ankle hinges	0.7419	0.2178	16		

**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.



GRAPH 1.2: Stride length of Solid AFO (SAFO) and Articulated AFO using Flexible Ankle hinges Tamarack type (AAFO).

X–axis: -Number of Subjects, Y- axis: - Stride length in meter

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.

SPEED/ VELOCITY WITHIN THE GROUP:

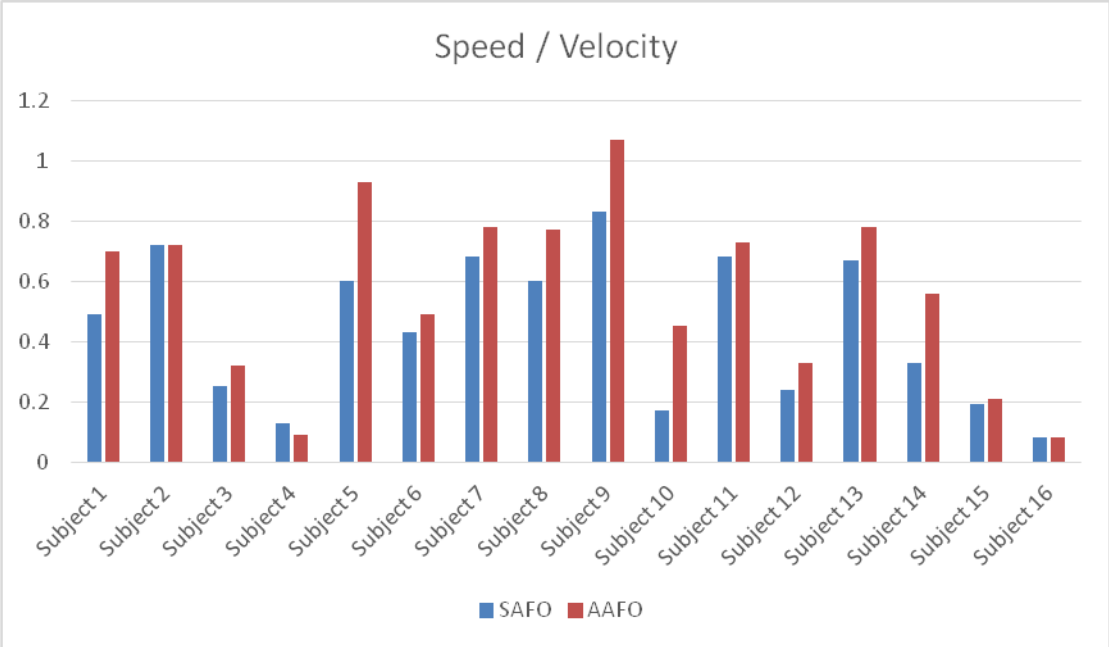
From table, 1.3 it can be seen that the t value is 4.339 which is significant at 0.05 levels with degree of freedom 4. It indicates that the mean value of Solid AFO differ significantly than Articulated AFO using Flexible Ankle hinges. Further the

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 -a-vis Articulated AFO using Flexible Ankle hinges.

Orthotic Design	M	SD	N	t-value	Remarks
Solid AFO	0.4431	0.5631	16	t=4.339	P=0.0006 (P < 0.05)
AAFO using Flexible Ankle hinges	0.2452	0.2959	16		

**Significant at 0.05 level*



GRAPH 1.3: Speed/ Velocity of Solid AFO (SAFO) and Articulated AFO using Flexible Ankle hinges (AAFO).
X–axis: - Number of Subjects
Y- axis: - Speed/ Velocity in meter/sec

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.

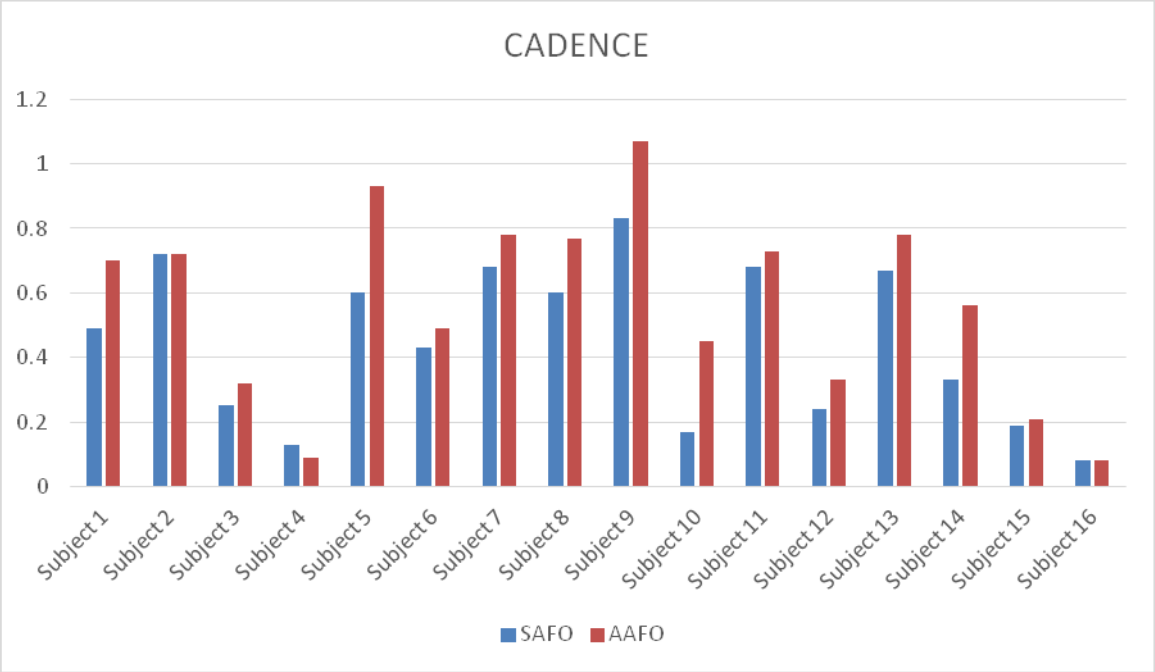
CADENCE WITHIN THE GROUP:

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 -a-vis Articulated AFO using Flexible Ankle hinges.

Orthotic Design	M	SD	N	t-value	Remarks
Solid AFO	91.56	35.46	16	t=2.647	P=0.0183(P < 0.05)
AAFO using Flexible Ankle hinges	104.3	31.99	16		

**Significant at 0.05 level*

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.

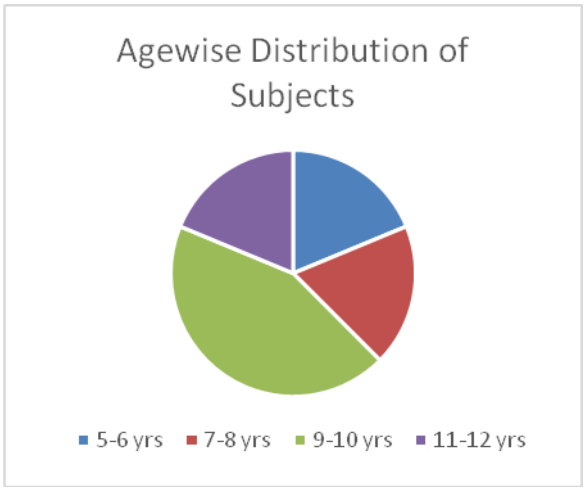


GRAPH 1.4: Cadence of Solid AFO (SAFO) and Articulated AFO using Flexible Ankle hinges (AAFO).
X–axis: - No. of Subjects
Y- axis: - Cadence in Steps/min.

DEMOGRAPHICAL CHARACTERISTIC WISE DISTRIBUTION OF SUBJECTS:

Table no.1.5 Age wise distribution of the subjects

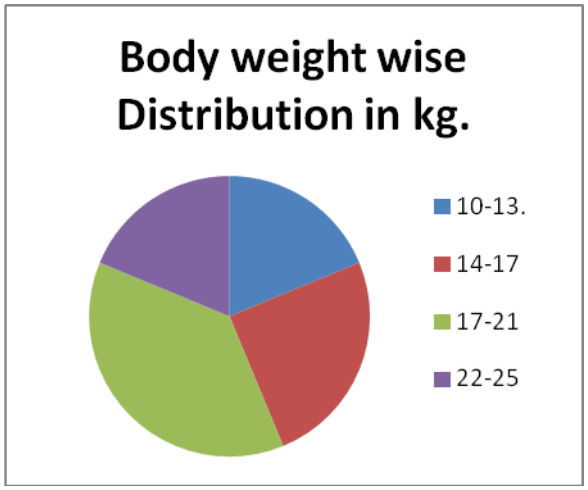
Age group (in years)	Number of Subjects
05- 06	3
07- 08	3
09-10	7
11-12	3



Pie Chart – 1 Age wise distribution of the subjects

Table no.5 Body weight wise distribution of the subjects

Body weight groups in kg	Number of Subjects
10-13	03
14-17	03
18-21	07
22-25	03



Pie Chart – 2 Body weight wise distribution of the subjects

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.

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Conflict of Interest: None

Source of Funding: None

Ethical Approval: Approved

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