The effectiveness of ankle foot orthosis on gait in children with spastic diplegic cerebral palsy

Abstract

Introduction: Cerebral palsy is a life lasting disability and is one of the most expensive diseases. CP is defined as a non-progressive, chronic, involuntary movement disorder secondary to an injury or lesion of the immature brain. The lesion usually occurs prenatally on prenatally: only about 10 per cent of the lesions are of postnatal origin. In most patients, a specific cause is not identified. Orthotic management is a widely utilized method of treatment in children with CP due to its conservative nature. Orthosis continue to have an important role in many therapeutic regimens for children with CP. However, there have been differences in design variants of Orthosis prescribed for the common problem of Spastic Cerebral Palsy. Three AFO configurations frequently prescribed for children with spastic cerebral palsy they are Hinged AFO (HAFO), the Posterior leaf spring (PLS AFO), and the Solid AFO (SAFO).

Methods: Thirty subjects with Spasticdieplegic Cerebral palsy aged from 5-15 years with (male=20 and female=16) chosen through randomized sampling and taken in this study. The Selected subjects underwent indicated AFOs (SAFO, PLSAFO, HAFO). Each intervention was given up to three months with wearing schedule 6-12 hours per day.

Results: Results shows a significant improvement in Gait Parameters i.e. Step length (p<0.020), stride length (p<0.003), cadence (p<0.005), Velocity (p<0.002), but not significant difference in comparison between SAFO, PLSAFO and HAFO.

Conclusion: The findings of the study support the hypothesis that there were significant differences between the three design variants of AFO in improving gait parameters in subject with spasticdieplegic Cerebral Palsy.

Keywords: spastic diplegic cerebral palsy, ankle foot orthosis, gait parameters

Introduction

Cerebral palsy is a syndrome caused by a lesion of the brain; it is characterized by abnormal control of motor function and it may interfere with sensory function and intellectual development.1-4 CP is defined as a non-progressive, chronic, involuntary movement disorder secondary to an injury or lesion of the immature brain. In some cases a cognitive deficit may also be present.5,6 The known causes of the syndrome include mal development of the brain, vascular and traumatic insults, toxic substances, metabolic disorders, and infections. The lesion usually occurs prenatally on prenatally: only about 10 per cent of the lesions are of postnatal origin. In most patients, a specific cause is not identified.7 The characteristic signs are spasticity, movement disorders, muscle weakness, ataxia, and rigidity. Cerebral palsy is the most common cause of severe physical and motor disability in childhood.12-14

The objectives of the treatment are:

a. Decreasing to the minimum of the muscular contractions and bony deformities, by decreasing or even normalizing muscle tone, and increasing joint mobility;
b. Increasing muscular strength on weak muscles;
c. Improvement of mobility and gaining motor functional skills.15

Ankle–Foot Orthosis (AFOs) are designed to: prevent deformity, support normal joint alignment and mechanics, provide variable range of motion when appropriate, and facilitate function (Rosenthal 1984, Brodke et al.16 Knutson et al.17 Tecklin 1994). The chief role of the AFO in this application is to limit unwanted ankle and subtler movement, primarily ankle plantar flexion, and indirectly to affect knee and hip function.19 Three AFO configurations frequently prescribed for children with spastic cerebral palsy they are hinged ankle foot orthosis Posterior leaf spring (PLS AFO), and the Solid AFO (SAFO). A polypropylene fixed or solid ankle-foot orthosis (SAFO) has been the most commonly prescribed brace for reducing excessive ankle plantar flexion during stance. The SAFO is made of polypropylene that covers the entire posterior calf and the medio lateral borders and sole of the foot, with straps across the anterior upper tibia and front of the ankle. It biomechanically controls the ankle by using a three-force system to prevent excessive ankle plantar flexion during stance.21,22 The use of rigid AFOs to ensure the soleus muscle is stretched for more than 6 hours every day has also been suggested as a way to prevent contractures developing.10 New developments in orthotic design that apply a measured and controlled torque over both the knee and ankle joints may perhaps be more effective at correcting contractures.14,23 The Posterior Leaf Spring AFO (PLS AFO), which allows slight plantar flexion as well as dorsiflexion in stance because of its posterior trim line, has been reported to promote ‘normal’ ankle rocker function and create a more dynamic gait (Ounpuu et al. 1996, Brunner et al.24 The Hinged AFO (HAFO), which allows free dorsiflexion in stance phase.
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The effectiveness of ankle foot orthosis (AFO) on gait in children with spastic diplegic cerebral palsy has been noted to normalize ankle motion during the stance phase of gait and facilitate the performance of developmental motor skills (Middleton et al. 1988, Rethlefsen et al. 1995, Wilson et al. 1997, Rethlefsen et al. 1999). Using gait analysis, rigid AFOs have been shown to influence directly the extent to which forces act on the body during standing and walking. In his classification of gait patterns in spastic hemiplegic, Winters recommended the more flexible posterior leaf spring (PLS) AFO to prevent equinus only in swing phase, and the rigid AFO for preventing equinus in the stance and swing phases of gait. More specifically, the goals of orthotic management are to facilitate function by preventing deformity achieve a stable base, improve dynamic efficiency of gait, and supporting normal joint alignment, by controlling or eliminating ankle and subtler motion to prevent contractures and improve gait by reducing tone and spasticity, improving propioception and balance. Ankle-foot orthosis (AFO) prescription in children with spastic diplegia is intended to amend the ‘typical’ diplegic gait pattern characterized by hip flexion, adduction, and internal rotation, knee flexion, and ankle equines with hind foot values (Gage 1991), thus enhancing function. Although ankle-foot orthosis (AFOs) are frequently prescribed for ambulatory children with spastic CP, a limited number of investigations have substantiated the effectiveness of orthotic intervention or validated claims made regarding the benefits of different AFO configurations. The purpose of this study was to determine effectiveness three commonly prescribed AFO configurations (HAFO, PLSAFO, SAFO), with, Gait parameter’s, in ambulatory children with spastic diplegic.

Materials and method

In order to meet the purpose of the study a planned and careful procedure was chosen before proceeding further. A sample of 36 subjects were chosen through randomized sampling with (male=20 and female=16) diagnosed with Spastic diplegic Cerebral palsy were referred from NIOH OPD, The study protocol was approved by Institutional Ethical Committee and conducted in lab of National Institute for the Orthopedically Handicapped, Kolkata, India. All the participants were requested to sign an informed consent form, age group between 5-15 years who were capable of independent ambulation without assistive devices and not undergone any Orthopedic and neurosurgical intervention in preceding year, Except physiotherapy and occupational therapy After screening and evaluation, detailed description and purpose of the study was mentioned verbally to each participant and those subjects who agreed to participated in the study. The selected patient were randomly assigned to group A (n=12M/F), group B (n=12M/F) and group C (n=12M/F). The Selected subjects underwent indicated AFOs (SAFO, PLSAFO, and HAFO). Each intervention was given up to three months with wearing schedule 6-12 hours per day after which they were given specific interventions, along with demonstration of the correct way of using the intervention (SAFO, PLSAFO and HAFO).

Intervention protocol

Demographic data such as sex, age, height and weight were collected from the subjects. The subjects were screened and then subjects were randomly divided in three groups of 10 each who received different orthotic interventions. Subjects in Group A continued wearing the SOLID ankle foot orthosis while Subjects in Group B were provided with a POSTERIOR LEAF SPRING ankle foot orthosis and Group C were provided with HINGED ankle foot orthosis An ankle mold was made for each child upon initiation into the study by a single orthotics and the original mold was used to fabricate all three AFO configurations.

Gait analysis

The gait analysis system called CDG (Ultra flex Computer Demography Gait Analyzer) supplied by Infortronics Medical Industrial Engineering was used for data collection. Each participant was asked to wear orthosis with shoes and then made to wrap the microcontroller called Ultra flex unit around the waist and a pair of foot sensors or CDG shoes of approximate size were put below the foot to collect force distribution. The cable of CDG shoes was connected to Ultra flex unit. The foot sensors data was digitally acquired at a sampling frequency of 100 Hz and stored in Memory stick of Ultra flex unit. The Ultra flex is a portable battery operated microcontroller unit storage facilities for off-line analysis. The gait data of all the subjects was evaluated in gait and biomechanics lab of National Institute for the Orthopedically Handicapped, Kolkata, India. All the dates were analyzed in CDG software and normalized with respect to the patients’ physiological parameters. Prior to test there was 5 min of resting period for accommodation of the system. Two trials were given for the participant to get acquainted to the machine and walk in a straight line labeled of 1000 cm. Patients were asked to walk with a self-selected comfortable pattern Gait parameters analyzed included velocity, stride length, step length, and cadence.

Statistical analysis

The data was managed on Excel spread sheet. Statistical analyses were made with software SPSS 16.0. This study consisted of three groups having SAFO, PLS AFO and HAFO. Each group has 10 subjects with Spastic Cerebral Palsy. Before the statistical analysis between the groups, the test of normality that is Shapiro-Wilk test and test of homogeneity that is Levene’s test for equality of variance were used. A significant difference was defined when the p-value <= 0.05, and results were given with a 95% confidence interval. To analyze the difference in the intervention in the groups, ANOVA post-hoc test was performed for interval data. Data were analyzed using one-way repeated measures analysis of variance (ANOVA) to determine if there were significant differences within the three assessment conditions (HAFO, PLS, and SAFO).

Results and discussion

In this study significant improvement found in PLSAFO in stride length in compare to SAFO (p=0.006) and HAFO (p=0.012) although increases in stride length with AFO use are common, (Abel et al. 1998, White et al. 2017). This study significant increase in the cadence in PLSAFO than HAFO (p=0.048) than SAFO (p=0.004). This result shows that PLSAFO gives better improvement in spastic C.P and supported by study of White et al. 2010. Brodke et al. 2010, Knutson et al. 1996; Carlson et al.; Radtka et al; Abel et al. 1998. On the other hand, Buckon et al. 2016 found that the use of AFOs in CP children increased stride length, reduced cadence but did not significantly change walking velocity. In the study significant improvement found in PLSAFO in stride length in compare to SAFO (p=0.006) and HAFO (p=0.012). This supports the study of Buckon et al. but in present study it shows the improvement in velocity which is devoid from the result of Buckon et al. but supported by Shlomo

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SAFO Mean±SD PLSAFO Mean±SD H AFO Mean±SD ANOVA

| Variable       | SAFO Mean±SD | PLSAFO Mean±SD | H AFO Mean±SD | F   | P   |
|----------------|--------------|----------------|---------------|-----|-----|
| STEP LENGTH    | 0.30649±0.12115441 | 0.437±0.108412  | 0.29549±0.11973 | 4.56 | 0.02|
| STRIDE LENGTH  | 0.562325±0.1348081 | 0.727775±0.084919 | 0.57738±0.100791 | 7.064 | 0.003|
| CADANCE        | 76.2±11.915   | 94.6±13.68048   | 81.5±9.204468  | 6.503 | 0.005|
| VELOCITY (m/sec) | 0.23±0.03537  | 0.32±0.062397   | 0.26±0.045947  | 7.777 | 0.002|

P=0.002, so there is a significant differences of mean value in Step length 0.30649±0.12115441 (SAFO), 0.437±0.108412 (PLSAFO), 0.29549±0.11973 (H AFO). P=0.003 significant differences of mean value in Stride length 0.562325±0.1348081 (SAFO), 0.727775±0.084919 (PLSAFO), 0.57738±0.100791 (H AFO). P=0.005 significant differences of mean value in cadence 76.2±11.915 (SAFO), 94.6±13.68048 (PLSAFO), 81.5±9.204468 (H AFO). P=0.002 so there is a significant differences of mean value in velocity 0.23±0.03537 (SAFO), 0.32±0.062397 (PLSAFO), 0.26±0.045947 (H AFO).

Velocity: It was found significant difference of velocity (p=0.002) with SAFO, PLS AFO, and H AFO individually but comparison of three AFO it was found that PLSAFO was more significant P=0.006 with SAFO and p=0.012 with H AFO.21, 22.

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limb stance, stride length, and velocity. Further investigation should focus on identifying other patient (Mark F. Abel, MD, Gregory A. Juhl, Christopher L. Vaughan, PhD, Diane L. Damiano, PhD, and PT) Buckon et al. The PLS was the most effective in normalizing gait parameters and improving stance phase knee motion in children with a tendency towards knee flexion in stance. Both the HAFO and PLS enhanced the performance in gait allowing children with spastic diplegic to approach the functional level of their normally developing peers.

Graph I Age group of subjects having SAFO, PLS and hinged ankle foot orthosis.

Graph II Difference in height in subjects with using SAFO, PLS and Hinged ankle foot orthosis.

Graph III Difference in weight in subjects with using SAFO, PLS and Hinged ankle foot orthosis.
Table 1: Demographic data

| Subject | SAFO Mean±SD | PLSAFO Mean±SD | HAFO Mean±SD |
|---------|--------------|----------------|--------------|
| AGE     | 9.25±2.2     | 8.95±2.690415  | 10.36±3.535  |
| HEIGHT  | 129.1±3.5103 | 129.3±3.433495 | 130.4±4.62361|
| WEIGHT  | 25.2±2.78089 | 22.9±2.5144    | 24.1±3.541814|

The mean age (Mean±SD) 9.25±2.2 (SAFO), 8.95±2.690415 (PLSAFO), & 10.36±3.535 (HAFO)
The mean height (Mean±SD) 129.1±3.5103 (SAFO), 129.3±3.433495 (PLSAFO) & 130.4±4.62361 (HAFO)
The mean weight (Mean±SD) 25.2±2.78089 (SAFO), 22.9±2.5144 (PLSAFO) & 24.1±3.541814 (HAFO)

Conclusion

The findings of the study that there were significant differences between the three design variants of AFO in improving gait parameters in subject with spastic diplegic Cerebral Palsy. AFOs are typically prescribed to prevent deformity, contracture, support normal joint alignment, improve gait stability and provide variable range of motion. Orthotic management in spastic cerebral palsy is to produce a more normal gait pattern by positioning peripheral joints in a way that reduces pathological reflex patterns or by blocking pathological movement of the joint. Our current results show that the use of AFOs enhances the improvement in gait parameters i.e. step length, stride length, cadence and velocity. Limited sample size along with no other classification of cp is not considered and subjects chosen from single source may be the limitation in this study. The results show that the PLS AFO has more significant in comparison with SAFO and HAFO in all the parameters.

Future recommendation

The benefits of most orthotic interventions used in physical management regimen for children with cerebral palsy remain controversial. There continues to be significant variation in the orthotic management of children with CP among treatment centers as a result of conflicting treatment paradigms.

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Conflict of interest

None.

References

1. Thomas S Renshaw, Neil E Green, Paul P Griffin et al. Cerebral Palsy: Orthopaedic Management. J Bone Joint Surg Am. 1995; 77(10):1590–1606.
2. Freeman JM, Nelson KB. Intrapartum Asphyxia and Cerebral Palsy. Pediatrics. 1988;82(2):240–249.
3. Nelson KB, Leviton A. How much of neonatal encephalopathy is due to birth asphyxia? Am J Dis Child. 1991;145(11):1325–1331.
4. Nelson KB, Ellenberg JH. Antecedents of cerebral palsy. Multivariate analysis of risk. New England J Med. 1986;315(2):81–86.
5. Bridgert M Lawler, Jason Wening A. Functional Comparison of Solid and Articulated AFOs during Walking and Running In Children with Spastic Hemiplegic Cerebral Palsy. ACPOC; 2007.
6. Vogtle L, Sobs KM, Schuh LY, et al. Pain in adolescents and adults. ACCPDM 2005: Instructional course #4.
7. Russman BS. Cerebral Palsy: Definition, Manifestations and Etiology. Turk J Phys Med Rehabil. 2002;48(2):4–6.
8. Pellegrino L, Dornam JF. Definitions, etiology and epidemiology of cerebral palsy In Caring for Children with Cerebral Palsy A Team Approach. ERIC.1998:3–30.
9. Cans C, Dolk H, Piatt MJ, et al. on behalf of SCPE Collaborative Group. Recommendations from the SCPE collaborative group for defining and classifying cerebral palsy. Dev Med Child Neurol Suppl. 2007;109:35–38.
10. Rosenbaum P, Paneth N, Leviton A, et al. Definition and Classification Document, in The Definition and Classification of Cerebral Palsy. Dev Med Child Neurol Suppl. 2007;49:78–79.
11. Panteliadis CP, Classification’ In Cerebral Palsy: Principles and Management. Panteliadis CP, Strassburg HM Stuttgart Thieme. 2004.
12. Andrew k, Berth, Peterson, et al. Cerebral Palsy. Lancet. 2004;363(9924):1619–1631.
13. Kuban KC, Leviton A. Cerebral palsy. N Engl J Med. 1994;330(3):188–195.
14. Charlton P, Ferguson D, Peacock C, et al. Preliminary clinical experience of a contracture correction device. Prosthetics and Orthotics International. 1999;23(2):163–168.
15. Fiona Dobson, Meg E Morris, Richard Baker H. Kerr Graham Gait classification in children with cerebral palsy: A systematic review. Gait & Posture. 2007;25(1):140–152.
16. Brodkle DS, Skinner SR, Lamoureux LW, et al. Effects of ankle-foot orthoses on the Gait of Children. J Pediatr Orthop. 1989;9(6):702–708.
17. Knutson LM, Clark DE. Orthotic devices for ambulation in children with cerebral palsy and myelomeningocele. Phys Ther. 1991;71(12):947–960.
18. Buckon CE, Thomas SS, Jakobson-Huston S, et al. Comparison of three ankle–foot orthosis configurations for children with spastic hemiplegia. Dev Med Child Neuro. 2001;43(6):371–378.
19. Buckon E. Comparison of three ankle–foot orthosis configurations for children with spastic diplegia. Developmental Medicine & Child Neurology. 2004;46(9):590–598.
20. Radtka SA, Skinner SR, Dixon DM, et al. Comparison of Gait with Solid, Dynamic, and No Ankle-Foot Orthoses in Children With Spastic Cerebral Palsy. Phys Ther. 2007;87(10):865–868.
21. Condie D, Meadows C. Ankle-foot orthosis. In: Bowker P, editors. Bzomcanical Basis of Orthotic Management. Oxford, United Kingdom: Butterworth-Heinemann Ltd; 1993:99–123.
22. Brehm MA, Harlaar J, Schwartz M. Effect of Ankle-Foot Orthoses on Walking Efficiency And Gait In Children with Cerebral Palsy. J Rehabil Med. 2008;40(7):529–534.
23. Papavasiliou A. Management of motor problems in Cerebral Palsy: A critical Update for the clinician. Eur J Paediatr Neurol. 2009;13(5):387–396.
24. Chitra Sankar, Nandini Mundkur. Cerebral Palsy–Definition, Classification, Etiology and Early Diagnosis. Indian Journal of Pediatrics. 2005;72(10):865–868.

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25. Rosen MG, Dickinson JC. The incidence of cerebral palsy. Am J Obstet Gynecol. 1992;167(2):417–423.

26. Winters TF, Gage JR, Hicks R. Gait patterns in spastic hemiplegia in children and young adults. J Bone Joint Surg Am. 1987;69(3):437–441.

27. White H, Jenkins J, Neace WP et al. Clinically prescribed orthoses demonstrate an increase in velocity of gait in children with cerebral palsy: a retrospective study. Developmental Medicine & Child Neurology. 2002;44(4):227–232.

28. Carlson WE, Vaughan CL, Damiano DL, et al. Orthotic Management of gait in spastic diplegia. Am J Phys Med Rehabil. 1997;76(3):219–225.

29. Tardieu C, Lespargot A, Tabary C, et al. For how long must the soleus muscle be stretched each day to prevent contracture? Developmental Medicine & Child Neurology. 1988;30(1):3–10.

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