Available online freely at www.isisn.org

Bioscience Research

Print ISSN: 1811-9506 Online ISSN: 2218-3973

Journal by Innovative Scientific Information & Services Network

RESEARCH ARTICLE BIOSCIENCE RESEARCH, 2018 15(4):2893-2898. **OPEN ACCESS**

Immediate effect of solid ankle foot orthosis versus ground reaction ankle foot orthosis on balance in children with *spastic diplegia*

Doaa Ahmed Sanad[1], Hamada El-Sayed Ayoub[1] and Ahmed Mamdouh Mohamed Abdelkader[2]

[1]Pediatric P.T Department, Faculty of Physical Therapy, Cairo University, **Egypt.**
[2]Integumentary Department, Faculty of Physical Therapy, Deraya University.**Egypt.**

***Correspondence: dr.hamada.ayob@gmail.com** **Accepted: 20** Oct.2018 **Published online: 02** Nov. 2018

Children with cerebral palsy usually demonstrate balance defect. Orthotic management may help in improving balance in these children. The aim of the study was to evaluate the immediate effect of solid ankle foot orthoses (AFOs) versus ground reaction ankle foot orthoses (GRAFOs) on balance in diplegic children. Thirty children with spastic diplegic cerebral palsy from both genders participated in this study. They were divided randomly into two equal groups; the first study group wore solid AFOs while standing on Biodex balance board. The second study group wore ground GRAFOs while standing on Biodex balance board. All children balance were assessed without wearing orthoses and while wearing orthoses using Biodex balance system. The result of this study revealed that there was a significant difference between the two study groups (p=0.008) in favor to the second one. The GRAFOs achieves more immediate balance improvement when compared with solid AFOs in children with spastic diplegic cerebral palsy.

Keywords: Diplegia, Balance, Ankle Foot Orthosis, Ground reaction Ankle Foot Orthosis

INTRODUCTION

Cerebral palsy (CP) is defined that ; It's a group of everlasting disorders in movement and posture development, resulting in activity restriction, that are caused by non-progressive disorders that occurred in the developing fetal or infant brain. The motor disorders of CP are often associated with disturbances of sensation, perception, cognition, communication, behavior, epilepsy and secondary musculoskeletal problems.(1)

From the viewpoint of the International Classification of Functioning, Disability and Health (ICF), CP presents with "impairments" in body function and structure such as muscle tone, strength, reflexes and range of motion. Significant "activity" limitations can also be present (e.g., dressing, feeding, functional mobility) as well as restricted "participation" (e.g., playing, participating in school) in social and community roles for the child.(2)

Spastic diplegia is the most common type of CP, it represents about 44% of the total incidence of CP .It is used when there is motor impairment in the upper extremities as well as the lower extremities, although it is milder in the upper extremities than the lower one. Most children have significant weakness in the trunk and spasticity of the extremities.(3)

The children with spastic diplegia have difficulty with balance because of poor muscle control in the arms and legs. Protective responses of catching oneself when falling are impaired. The maintain and regain the center of gravity (COG)

within the base of support (BOS) in response to outside perturbations or voluntary movements is impaired.[4]

A wide range of orthoses such as solid ankle foot orthoses (AFOs), dynamic AFOs and floor reaction AFOs have all been shown to improve balance during standing and walking in these children Limitation of normal tibial rotation over the foot during standing is a disadvantage of wearing a solid AFO during ambulation, as this causes decreased ankle dorsiflexion and early heel rising during stance phase if it is not tuned correctly. [5-7]

Ground reaction AFOs (GRAFOs) are modified solid types with an anterior trim line at the ankle and tibia therefore fix the ankle in an appropriate position and reduce excessive knee flexion during standing and walking in children with diplegic CP.[8]

Postural stability, or balance, is the ability to maintain the body in equilibrium. It is also defined as the ability to maintain or control the center of mass in relation to the base of support to prevent falls and complete desired movements in order to maintain a stable stance position.[9]

MATERIALS AND METHODS

This randomize within-subject study was conducted to evaluate the immediate effect of AFO versus GRAFO on balance in children with diplegic CP.

Thirty children with spastic diplegic CP from both genders participated in this study, they were selected from out- patient clinic, Faculty of Physical Therapy, Cairo University, their ages were between 5-8 years chronologically, their spasticity ranged from 1 to 1+ according to modified Ashwarth scale[10], had neither convulsions nor fixed deformities in the lower limbs and had no history of surgical interference at least during the last 6 months, Their heights were at least one meter to be able to see the screen of Biodex balance system.

They were divided randomly through random allocation as per odd and even numbers were done for study participants into two study groups; the first study group A (*n=15 odd No. participant*); their balance were evaluated while standing on Biodex balance board without wearing the solid ankle foot orthoses and while wearing the solid ankle foot orthosis. The second study group B (*n=15 even No. participant*) their balance were evaluated while standing on Biodex balance board without wearing the ground reaction ankle foot orthosis and while wearing the ground reaction ankle foot orthosis.

The protocol of this study was approved by the ethics committee, Faculty of Physical Therapy, Cairo University before its commencement.

Biodex Balance System was used to assess postural control or balance in all children with diplegia enrolled in this study without wearing and while wearing orthoses.

The AFOs in this study were custom molded made of 3-mm thickness polypropylene using a negative cast technique. The proximal part of the brace extended posteriorly to just below the fibular head and its footplate extended to the tips of the toes.

While the Ground reaction AFOs (GRAFOs) in this study were custom molded made of 3-mm thickness polypropylene using a negative cast technique. The proximal part of the brace extended anteriorly to just below the fibular head and its footplate extended to the tips of the toes.[11]

For balance assessment using the Biodex balance system; All subjects were given an explanatory session before the evaluative procedure to be aware of the different test steps. Each child in both groups was asked to stand on the center of the locked platform with two legs stance. Safety support rails and biofeedback display were adjusted for each child to ensure comfort and safety. The display adjusted so that the child can look straight at it while test parameters were introduced to the device including Child's height, chronological age and platform firmness (starting with level 8 descending to end at level 6), the test duration was 30 seconds. Three times repetitions for each trial, the mean of the three trials was calculated and recorded.

Patients centering was achieved by asking the child to stand on both feet while grasping the handrails. The child was instructed to achieve a centered position on slightly unstable platform by shifting his feet position until keeping the cursor (which represent the center of the platform) centered on the screen grid while standing in a comfortable and upright position. Once centering achieved and the cursor in the center of the display target, instruction was given to the child to maintain his feet position till stabilizing the platform. This followed by recording feet angles and heels coordinate from the platform. After introducing these angles into the Biodex system, the test then begins. As the platform advanced into an unstable state, the child was instructed to

focus on the screen and maintain the cursor in the middle of the bulls eye on the screen. At the end of each test trial, a printout report was obtained. This report includes information regarding overall stability index.

For statistical analysis; SPSS for windows, version 22 (SPSS, Inc., Chicago, IL) was used. The current test involved two independent variables. The first one was the (tested group); between subject factors which had two levels (the first study group A (n=15) using AFO and the second study group B (n=15) using GRAFO. The second one was the (evaluation times); within subject factor which had two levels (before and after wearing orthoses). In addition, this test involved one tested dependent variable (Overall balance scores). There were no outliers, as assessed by box plot. The data was normally distributed, as assessed by Shapiro-Wilk's test of normality ($p > .05$). There was homogeneity of variances ($p > .05$) and covariances ($p > .05$), as assessed by Levene's test of homogeneity of variances and Box's M test, respectively. Accordingly, paired and un-paired t test were used to compare the tested dependent variable within and between the two groups with the initial alpha level set at 0.05.

In this study; Thirty children with spastic diplegic CP enrolled in this study divided into two study groups; The first study group A consisted of 15 children (6 boys and 9 girls), their mean ± SD of ages were 6.45±1.68 years. The second study group B consisted of 15 children (4 boys and 11 girls), their mean ± SD of ages were 6.41±1.71 years. There were no statistically significant differences ($P>0.05$) between subjects in both groups concerning age. Also, Chi square revealed no significant differences between both groups in sex distribution ($p>0.05$) (Table 1).

The "pre" and "post" treatment mean ± SD values of overall balance index (Degrees) for both groups are presented in table (2)."Paired t test" comparing pre and post treatment mean values of overall balance index (Degrees) revealed that there was a significant improvement of children overall balance ($p<0.05$) in both groups. Considering the effect of the tested group (first independent variable) on overall balance index, "unpaired t test" revealed that; "pre" treatment mean values of overall balance index between both groups showed no significant differences ($p>0.05$). But, "post" treatment mean values of overall balance index between both groups showed a significant differences ($p<0.05$) in favor of group B.

RESULTS

Table (1): Demographic characteristics of both groups:

	Group A	Group B	Comparison		
	Mean ± SD	Mean ± SD	t-value	P-value	
Age (years)	6.45±1.68	6.41±1.71	0.001	1.00	
Gender			X^2		P-value
Girls	9		11		
Boys	6		4	0.6	0.439

SD: Standard Deviation, P: probability, X^2: Chi -Square.

Table (2): Pre and post treatment Mean ±SD, t and P values of overall balance index (Degrees) for both groups A and B:

Overall Balance Index (Degrees)	Means ± SD	Means ± SD	% of improvement	t-value	P- value
	Pre test	Post test			
Group A	2.913±0.368	2.453±0.398	15.80	9.28	0.0001*
Group B	2.901±0.382	2.06±0.372	28.97	12.23	0.0001*
t-value	0.1	2.83			
P- value	0.92	0.008*			

*Significant level is set at alpha level <0.05.

DISCUSSION

Children with spastic diplegia have impairments in protective responses of catching themselves when falling. Keeping the center of gravity (COG) within the base of support (BOS) either during static positions or dynamic movements are impaired. Both static and dynamic balance are required for daily life activities as walking, running, stair climbing, and sports. Dynamic activities move the COG between boundaries of the BOS and sometimes outside associated with CP. Contractures secondary to spasticity or soft tissue abnormalities can restrict movement and thereby disrupt the efficacy of postural reactions and balance, thus changes in musculoskeletal alignment and joint biomechanics can reduce the child's ability to exhibit adequate protective reactions. Adequate muscle strength is also necessary to produce joint stability and adequate equilibrium reactions and balance, therefore children with cerebral palsy may be associated with deficits in postural control and balance.

The crouch position in children with diplegic CP results from deficit in the plantar flexion/knee extension coupling. This may be a result of gastrocnemius muscle spasticity and quadriceps muscles weakness. The GRF at crouch position is behind the knee axis, while muscles are not strong enough to correct plantar flexion/knee extension imbalance in these children.

Leg and foot segmental mal-alignment in children with CP especially those children with diplegic type move the line of action of GRF lateral to the centre of the knee joint and can change the moment arm of the GRF about the knee axis.[8]

Various ankle-foot orthoses (AFOs) have been used to correct the equinus gait pattern in children with spastic CP. The solid or fixed polypropylene AFO has been traditionally used to decrease equinus positioning and prevent ankle plantar flexor contractures. A disadvantage of the solid AFO is its limitation of normal movement of the tibia forward over the weight bearing foot resulting in decreased ankle dorsiflexion and early heel rise in stance. The hinged or articulated polypropylene AFO with a plantar flexion stop has been increasingly recommended by clinicians to decrease equinus positioning.8 Unlike the solid AFO, the hinged AFO allows the tibia to move forward over the weight bearing foot during stance resulting in a more normal ankle dorsiflexion.

There have been only a few reports about the effect of AFOs on standing balance. The report of *Burtner,* et al., revealed that dynamic AFOs are more advantageous for children with CP when balance control is required during unexpected perturbations in standing, compared to solid AFOs. And the report of *Pohl,* et al., revealed that the excursion of postural sway decreased with a functional AFO in the patients with traumatic brain injury or stroke, whereas *Chen,* et al., reported no beneficial effect of anterior AFO on postural stability in hemiplegic patients with stroke. However, the AFOs used in those studies differed in type and also not hinged AFOs.

The results of this study revealed that GRAFO was superior to solid AFO in improving balance in children with diplegic CP. This may be due to the immediate effect of GRAFO in regaining the proper alignment of leg and foot during standing position, through pushing the tibia posteriorly and moving the line of gravity backward to pass through the knee joint resulting in decreased knee flexion moment and crouching while assuming standing position.

This comes in agreement with *Rogozinski* et al., who reported that The FRAFO applies GRF directly into the anterior compartment of the knee joint and increases extension. Therefore, it can improve the knee joint angle in the sagittal plane improving knee extension.

Also, the results of this study is parallel with *Woollacott* et al., who reported that the crouched position may decrease the ability of children with CP to recover postural control. According to their results, using a FRAFO to minimize the crouch position may improve postural control and balance in children with spastic diplegic CP.

Although the AFOs provide neutral position of the ankle joint while assuming standing position, they provide more limitation to the normal movement of the ankle dorsiflexion/ plantar flexion and also subtalar joint movements of inversion and eversion needed for the ankle strategy contributing to balance control. But this may be compensated by more proximal control of balance at the hip joint. The GRAFO augmented balance control through hip strategy by proper alignment of the knee joint in extension and decreasing crouch while standing.

Preference of these proximal strategies to control static standing balance in the children with CP was also noted in the report of *Ferdjallah*, et al., [21]who suggested that poor ankle control in children with CP may be likely to result in an increase in the contributions of proximal strategies

to maintain postural stability.

There are some potential limitations of this study; firstly the long lasting effect of orthoses on balance weren't evaluated. Secondly evaluating the overall balance without detecting the excursion of COP different planes. Therefore, future researches would be beneficial to assess the long lasting effect of different types of orthoses on balance in these children with diplegic CP.

CONCLUSION

From the obtained results it can be concluded that; GRAFO was superior to solid AFO in improving the overall balance in children with spastic diplegic CP through maintaining the proper alignment of the ankle and foot besides decreasing the knee flexion and crouching while assuming standing posture augmenting the proximal strategy for posture control and balance in these children.

CONFLICT OF INTEREST

The authors declare no conflict of interest regarding this study.

AUTHOR CONTRIBUTIONS

All authors contributed in collecting and analyzing data. All authors participated in writing every part of this study. All authors read and approved the final version.

REFERENCES

Abel MF, Juhl CL and Damiano DL. 1998:Gaitassesment of fixed ankle-foot orthoses in children with spastic diplegia. Arch Phys Med Rehabil;79:126-33.

Bjornson KF, Schmale GA, Adamczyk-Foster A, Mc Laughlin J. 2006:The effect of dynamic ankle foot orthoses on function in children with cerebral palsy. Journal of Pediatric Orthopaedics. 26(6):773

Bohannon RW and Smith MB 1987:Inter-Reliability of Modified Ashworth Scale of Muscle Spasticity. J. Physical Therapy, Vol.:67 (2), PP.:206-208.

Bowker P, Brader D, Pratt D, Condie D, Wallace A. 1993: Biomechanical basis of orthotic management: Butterworth-Heinemann Ltd.

Burtner PA, Woollacott MH, Qualls C. 1999: Stance balance control with orthoses in a group of children with spastic cerebral palsy. Dev Med Child Neurol;41:748-57.

Carmick J. 1995:Managingequinus in a child with cerebral palsy: merits of hinged ankle-foot orthoses. Dev Med Child Neurol;37:1006-19.

Chen CL, Yeung KT, Wang CH, Chu HT, Yeh CY.1999: Anterior ankle-foot orthosis effects on postural stability in hemiplegic patients. Arch Phys Med Rehabil;80:1587-92.

Ferdjallah M, Harris GF, Smith P and Wertsch JJ. 2002:Analysis of postural control synergies during quiet standing in healthy children and children with cerebral palsy. ClinBiomech, 17(3): 203–210.

Ferdjallah M, Harris GF, Smith P, Wertsch JJ. 2002:Analysis of postural control synergies during quiet standing in healthy children and children with cerebral palsy. ClinBiomech (Bristol, Avon);17:203-10.

Knutosn L and Clark D.1991:Orthotic devices for ambulation in children with cerebral palsy and myelomeningocele. Phys Ter;71:947-60.

Lucareli PRG, Lima MO, Lucarelli JGA and Lima FPS. 2007:Changes in joint kinematics in children with cerebral palsy while walking with and without a floor reaction ankle-foot orthosis. Clinics; 62(1): 63–68.

Lucareli PRG, Lima MO, Lucarelli JGA, Lima FPS. 2007Changes in joint kinematics in children with cerebral palsy while walking with and without a floor reaction ankle-foot orthosis. Clinics. 62(1):63-8.

Niam and Anderson 1999: balance and physical impairments after stroke. Arch. Phys. Med. Rehabil, 80, PP 1227-1233.

Pohl M, Mehrholz J. 2006: Immediate effects of an individually designed functional ankle-foot orthosis on stance and gait in hemiparetic patients. Clin Rehabil;20:324-30.

Rha D, Kim DJ and Park ES. 2010:Effect of hinged ankle-foot orthoses on standing balance control in children with bilateral spastic cerebral palsy. Yonsei Med J ;51(5): 746.

Rogozinski BM, David JR, Davis RB, Jameson GG, Blackhurst DW. 2009:The efficacy of the

floor-reaction ankle foot orthosis in children with cerebral palsy. The Journal of Bone & Joint Surgery. 91(10):2440-7.

Rosenbaum PL, Paneth N, Leviton A, Goldsteini M, et al.,2006:A report: the definition and classification of cerebral palsy, April. Dev Med Child Neurol 109 (Suppl.): 8–14.

Sanger, T.D., Delgado, M.R., Debrah D., et al., 2003: Task Focus on Childhood Motor Disorders Classification and Definitions of Disorders causing Hypertonia in childhood. Pediatrics; 111 (1): 89- 97.

Tong-Wai R., Wester R., and Shevel M., 2006:A clinical and etiologic profile of spastic diplegia. Pediatric Neurology;34(3):212-218.

Woollacott MH and Shumway-Cook A. 2005:Postural dysfunction during standing and walking in children with cerebral palsy: what are the underlying problems and what new therapies might improve balance? Neural Plasticity; 12(2-3): 211.

World Health Organization 2001: International classification of functioning, disability and health. Geneva: WHO, 2001.