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A Study on Effectiveness of Ankle Foot Orthosis on Static Stability in Children with Spastic Diplegic Cerebral Palsy

Meher RN, Behera P* and Rout SK

Department of Prosthetics & Orthotics, CIRS, India

***Corresponding author:** Priyanka Behera, Associate Professor, Department of Prosthetics & Orthotics, Chakradhar Institute of Rehabilitation Sciences, Utkal University, Bhubaneswar, Odisha, India, Tel: 9776074291; Email: priyankalipi20@gmail.com

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Abstract

Background: Spastic cerebral palsy is the most common subtype of Cerebral Palsy in children that is characterized by muscle stiffness and tightness. This significantly affects an individual static balance and posture which can adversely affect his/er movement and cause mobility impairment.

Aim: The study aims to study the effect of Solid Ankle Foot Orthosis on static stability in children with spastic dialogic cerebral palsy.

Method: 30 subjects with spastic diaplegic CP between the ages 7-12 years participated in the study. The subjects were divided in to experimental group (provided with SAFO and Physical therapy) and control group (only physiotherapy). Human Balance System (Force Plate) was used to study the Postural parametres (Center of Pressure sway) and static balance (M-L stability, A-P stability). The pre-test data and post –test data was collected and analyzed using SPSS software.

Result: Difference of stability between experimental group and control group is 14.93 which is 44.52% of change. ($p \leq 0.03$ and $t=3.282$). The average change in mobility for experimental group was 42.13±18.2 & control group was 24.86±11.85. The average change in stability score of the experimental group was 42.53±19.57 & mean value of control group was 22.20±15.7. The mean difference between the experimental group and control group with reference to the path length of Cop was -67.50 which 30.94% of change is. The difference in average velocity of body sway between the experimental group and control group was -1.13, which is 30.87%of change. ($p \leq 0.000$ and $t= -4.106$).

Conclusion: The outcomes of the study shows a significant improvement in the static balance and posture of subject with the use of SAFO's in children with spastic cerebral palsy.

Keywords: Cerebral Palsy; Spastic; Diaplegic; Solid Ankle Foot Orthosis; Static Balance; Postural Control; Static Stability

Abbreviations: CP: Cerebral Palsy; AFO: Ankle-Foot Orthoses; KAFO: Knee-Ankle-Foot Orthoses; SAFO: Solid Ankle Foot Orthoses; Com: Center Of Mass; Cop: Center Of Pressure; GMFCS: Gross Motor Fuction Classification System.

Introduction

Cerebral palsy (CP) is a heterogeneous group of developmental motor disorders that affect movement and posture, resulting from a non-progressive injury to the

developing brain [1]. The prevalence of CP is approximately 2-3 per 1,000 live births globally [2,3] and it is the most common motor disability in childhood. Spastic cerebral palsy is the most prevalent subtype, accounting for approximately 70-80% of all cases [4]. Spastic types exhibit pyramidal involvement with upper motor neuron signs, weakness, hypertonia, hyperreflexia, clonus and positive Babinski [5]. It is characterized by increased muscle tone and stiffness, which can affect movement and cause mobility impairment.

In spite of the high occurrence and impact of spastic cerebral palsy, there is still much to be understood about its underlying mechanisms, optimal treatment options, and long-term outcomes. The etiology of spastic cerebral palsy is multifactorial, including both genetic and environmental factors. Recent research has focused on the role of brain plasticity and the interaction between the developing brain and the environment in the pathogenesis of spastic cerebral palsy [6]. The clinical manifestations of spastic cerebral palsy vary widely, from mild to severe impairment of motor function, coordination, and balance. These impairments affect the ability to perform daily activities, social participation, and academic achievement. Individuals with spastic cerebral palsy may also experience secondary complications, such as contractures, joint deformities, and pain, which further affect their quality of life and functional outcomes [4,7].

Children with spastic diplegic cerebral palsy (CP) commonly experience problematic static balance and postural control. These impairments can significantly affect their ability to perform daily activities, walk efficiently, and participate in social and recreational activities [8]. Static balance refers to the ability to maintain an upright posture while standing still, while postural control involves the ability to maintain balance while performing dynamic activities such as walking and reaching [9]. In individuals with spastic diplegic CP, these abilities are often compromised due to increased muscle tone, weakness, and joint contractures. Studies have shown that individuals with spastic diplegic CP have reduced postural stability compared to typically developing individuals. This is often characterized by an increased sway of the center of mass and decreased muscle activation in the lower extremities during standing and walking. Additionally, individuals with spastic diplegic CP often exhibit a crouched gait pattern, which can further compromise postural control and balance [10]. Several interventions have been developed to address problematic static balance and postural control in spastic diplegic CP. These may include Physical therapy interventions and orthotic interventions such as ankle-foot orthoses (AFOs) or knee-ankle-foot orthoses (KAFOs), which can provide support and stability to the lower limb and improve alignment during standing and walking [11,12].

Postural control is a critical component of functional mobility in individuals with diplegic spastic cerebral palsy (CP). Solid ankle foot orthoses (SAFOs) are commonly used as an orthotic intervention to improve postural control in individuals with diplegic CP. SAFOs provide support and stability to the foot and ankle, which can improve alignment and control of the lower limb during standing and walking. The rigid structure of the SAFO restricts ankle plantarflexion and dorsiflexion, which can reduce ankle instability and improve balance in individuals with diplegic CP [13].

Static standing balance is traditionally measured either by the duration of maintaining the balance and/or by the postural stability. The postural stability is defined as the ability to maintain and control the body's Center of Mass (CoM) within the base of support to prevent falls and complete desired movements [14]. Among the various methods used to measure the postural stability during quiet standing, the motion of center of pressure (CoP) derived from the ground reaction force is one of the most common parameters [15,16]. In this study COM and COP deviation have been utilized to understand the effect of SAFO on the Postural stability and balance in subjects with spasic diaplegic cerebral palsy.

Spastic diaplegic CP is a common presentation among children Aisen ML, et al. [17] and studying the use of SAFO for improving static balance and postural control in children with spastic diplegic CP is of significant importance due to the high prevalence of this condition in childhood, the significant motor impairments experienced by this population, and the limited evidence regarding the effectiveness of SAFO in improving these specific impairments in children. Thus the present study aims to investigate the effect of Solid Ankle Foot Orthosis on static balance among children with spastic diaplegic cerebral palsy.

Methodology

In the present study total number of 30 participants having spastic diaplegic cerebral palsy (Figure 1) of GMFCS(Gross Motor fuction classification system) I, II ,III, Palisano R, et al. [18] were selected by convenient sampling technic with the age range between 7-12 years. Out of the 30 subjects 22 male and 8 female participants. Subject with bilateral involvement and those who were able to walk independently or with support were considered for this study. Another important inclusion criterion was that subjects must have undergone therapeutic interventions before being considered for the study. Subjects having any other orthotic involvement and spinal deformities were not considered for the study. There was no drop out during the study. The study was carried out at Swami Vivekananda National Institute of Rehabilitation Training and research, Cuttack which is a pioneer Institute

in the field of rehabilitation of person with disabilities. The study was carries out for a period of 12 months.

Pre-Test Post-Test Experimental Study Design was utilized to study the Postural Parametres (COP, sway) and static balance (Anterior-Posterior stability and Mediolateral stability) using HUMAC balance and tilt system. The subject was divided into two groups (control group and experimental group) with 15 subjects in each group and the pre-test data regarding the static stability were collected using Humac balance system. The control group underwent only physical therapy and the experimental Group underwent physical therapy as well as was fitted with Solid Ankle Foot Orthosis (SAFO). After the fitment of orthoses, training for standing stability was given to the subjects. Then both the exercise group and orthotic group patients are called after 4week. Then intervention data (Post-test) regarding standing stability was collected using Humac balance system (Figure 2)

Figure 1: Subject with spastic diaplegia.

Figure 2: Patient with SAFO on HUMAC balance machine.

Statistical Analysis

The pre-test and post-test data were statistically analyzed using SPSS statistical software version 23. The data was analysed using the inependent t-test to compare the static stability in the control group and experimental group. The p-value of less than 0.05 was considered significant.

Results

To find out the static balance and stability three tests has been performed; they are a) Stability b) Mobility c) COP. This COP provides an output results as i) Stability Score ii) Path length iii) Average velocity. All the data were test through an independent paired t-test to compare the difference of stability in both the groups, mobility in both the groups & COP in terms of stability score, path length, and average velocity.

Change in Stability

The mean change of stability in the experimental group was 33.53 ± 16.47 and in the control group was 18.60±7.4 as shown in the Figure 3. Difference of stability between experimental group and control group is 14.93 which are 44.52% of change. ($p \leq 0.03$ and $t=3.282$). It means that 44.52% of more stability is gain by the use of the SAFO along with balance training in compare with only therapeutic intervention in subjects with spastic diaplegic CP.

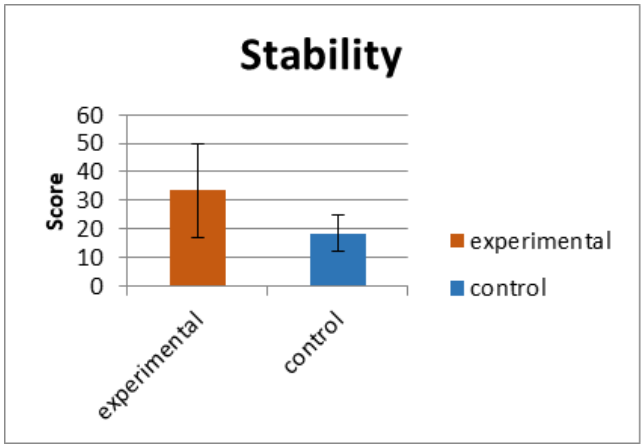

Figure 3: Stability in both the group.

Change in Mobility

The average change in mobility for experimental group was 42.13±18.2 & control group was 24.86±11.85 as shown in (Figure 4). The mean difference between experimental group and control group in terms of change in mobility was 17.26 which are 41.82% of change. ($p \leq 0.05$ and $t=3.078$). This indicates a 41.82% of more mobility is gain by the use of the SAFO along with balance training in compare with subject who underwent only therapeutic intervention.

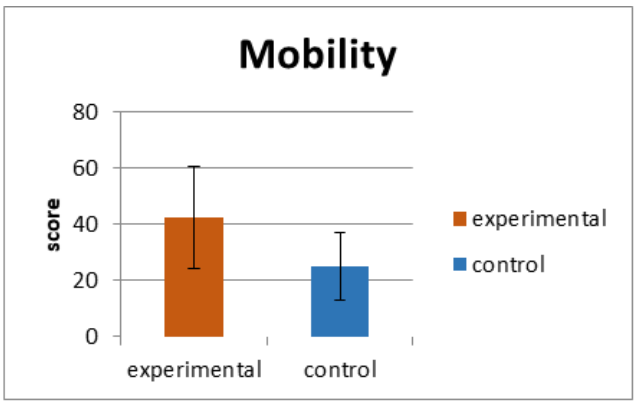

Figure 4: Mobility in both the groups.

Change in Stability Score

The average change in stability score of the experimental group was 42.53±19.57 & mean value of control group was 22.20±15.7 (Figure 5). The mean difference between experimental group and control group in terms of stability score was 20.33 which are 47.80% of change. (p≤0.04 and t=3.146). This implies that 47.80% of more stability in terms of the path of COP was gained by the use of the SAFO along with balance training in comparison with the control group subjected to only therapeutic intervention.

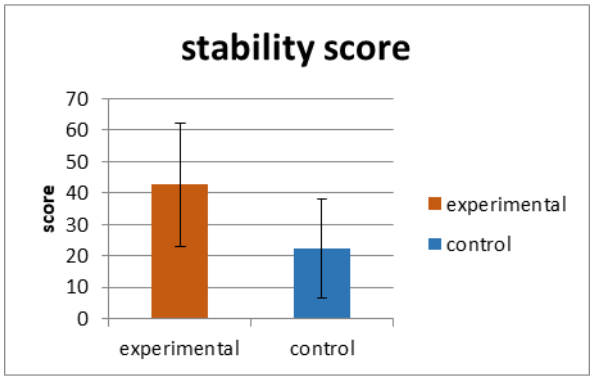

Figure 5: Stability score in both the group.

Change in Path Length

The average change in path length of COP was documented as shown in (Figure 6). The mean value of the experimental group was 219.86±27.66 and mean value of control group is 287.80±57.66. The mean difference between the experimental group and control group with reference to the path length of Cop was -67.50 which 30.94% of change is. (p≤0.000 and t= -4.117). It means a 30.94% of less path length travels of COP have been reported by the use of the SAFO along with balance training in compare with the only therapeutic intervention. This connotes that by the use of SAFO the subject's body COP sways less whereas in therapeutic group the body's COP sway is more.

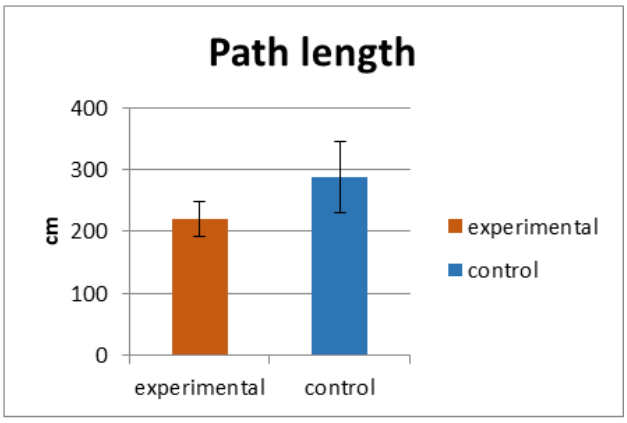

Figure 6: Path length travel in both the group.

Change in Average Velocity

The change in average velocity of the sway of body's COP is shown in (figure 7). The mean value of the experimental group was 3.66±0.46 and the mean for the control group was 4.79±.96. The difference in average velocity of body sway between the experimental group and control group was -1.13, which is 30.87%of change. (p≤0.000 and t= -4.106). It signifies a 30.87% less average velocity of COP sway by the use of the SAFO along with balance training in compare with control group. Therefore this implies that by the use of SAFO, the average velocity of body COP sway improved.

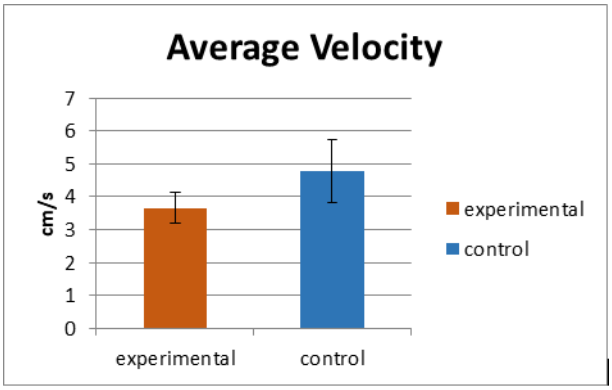

Figure 7: Average velocity of COP sway in both the groups.

Discussion

Static standing balance and postural control is an important component which facilitates for upright and independent walking. Although the stable postural control is automatically maintained in healthy children, it is often a challenging goal for children with CP. The results of the present study show

significant improvement in static balance as observed from the analysis of the stability, mobility & body COP sway data. The study thus provides a better understanding of the effect of SAFO on balance & stability among this population and may help us to enrich our approaches for children with CP. Although, previous studies have measured static balance and postural stability using net body sway but most of them have been done on healthy children and adult. There is a dearth of literature regarding postural balance in subject with CP using the force platform and thus this contribute in improving our insight about the same [1,2].

In the present study Stability test measures a person's ability to stabilize and balance at a particular location around their neutral position and Mobility test is used to test an individual's ability to hold their Center of Pressure on moving target that circles around a patient's neutral balance point. In the present study, it was observed that stability score improved considerably after the use of SAFOs and the mobility score indicated that with the use of SAFOs the subject's mobility score improved considerably. The stability score is different from stability. This stability score is a modality of COP which defines how effectively the subjects maintain his/her center of gravity (CG) in the center position in all the four quadrants. This parameter display the subjects' Mediolateral and Anterior-Posterior weight distribution. The more the subject maintains his/her CG centrally; the better is the individuals' stability score. In the present study it was observed that the stability score improved by 47.8% after the use of SAFOs which is a major achievement of the subject.

The COP body sway showed a significant difference between the experimental group & control group. The findings of the study is in agreed with the findings of the Cherng RJ, et al. [19].where they studied standing balance in seven children with spastic diplegic CP under normal and altered sensory environments. Similarly, they found that there was no significant difference in stance stability, as measured by center of pressure sway area, between children with spastic diplegic CP and matched control individuals when provided with normal fixed foot support.

The finding of our study, showed significant reduction in average velocity, which means that the displacement of the COP has decreased after the use of SAFO and thus stability has improved. This finding is in accordance with the finding of Rose J, et al. [20] which reported wider range and higher speed of CoP displacement in children with CP, compared to their control group. It was observed that SAFO was effective in controlling stability, mobility & COP and resulted in improved static balance. It also shows that by the use of SAFO the body COP sway travels less whereas in control group the body COP sway travels more area. The mean difference in path length of CoP was found to -67.93 (t= -4.117 & p=0.000) which indicates a significant reduction in the values of path length. Therefore, more the area travels less the stability & less the area travels more the stability. So, it was accomplished that by the use of SAFO, the COP sway reduced in subjects with spastic diaplegic cerebral palsy.

In a study by Park ES, et al. [21], the use of SAFOs significantly improved static and dynamic balance in children with spastic diplegic CP compared to barefoot conditions. Another study by Barreto AB, et al. [22] found that the use of SAFOs improved postural stability during standing and walking in individuals with diplegic CP. The outcome of the study suggests that the use of SAFOs along with physical therapy has a statistically significant effect on static balance and posture in subjects with spastic diaplegic CP. Therefore, the present study is in line with the previous literatures and proves that SAFOs used along with physical therapy improves static balance and provides better postural control in comparison to subject undergoing only physical therapy.

The benefits of SAFOs for postural control in diplegic CP may be due to improved proprioception and increased sensory feedback from the foot and ankle. The SAFO provides a stable base of support, which allows the individual to more accurately sense their body position and make adjustments to maintain balance. It is important to note that the use of SAFOs for postural control should be individualized based on the specific needs and functional goals of each individual with diplegic CP.

Conclusion

Static balance and postural control is a major concern in children with spastic diaplegic CP with not only affects they ability to stand and walk independently but also interferes significantly in their ability to participate in daily activities, social and recreational activities due to increased risk of falls and injuries. SAFOs are an effective orthotic intervention for improving the static balance and postural control when used along with physical therapy in children with spastic diaplegic cerebral palsy. The Orthosis was found to be successful in controlling the foot-equines and resulted in stable, natural and satisfactory, achievement of independent standing as well as the postural balance. However, future studies with objective outcomes and modern instrumentation are encouraged to provide valid and applicable evidence to support clinical practice. As the present study deals with static standing balance, dynamic balance and gait analysis may be performed for better outcomes.

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