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Effect of Weighted Vest on Gross Motor Function and Balance in Children with Spastic Cerebral Palsy

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ABSTRACT

Background: High muscle tension in children with CP causes unstable posture and mobility. The weighted vest was used as an intervention tool that provides weight resistance while applying the exercise program to children with disabilities.
Purpose: The study was conducted to examine the impact of the weighted vest on gross motor functions as well as balance abilities in children suffering from spastic diplegia. **Patients and Methods:** Thirty children, ranging in age from four to seven, suffering from spastic diplegia were involved in this study. They were divided into two equal groups utilizing random assignment. The participated children in both groups were given designed physiotherapy program. The study group was given the same physiotherapy program while wearing the weighted vest. The treatment program for the two groups was conducted for 3 times a week for 3 consecutive months. The gross motor function and balance of all participated children in both groups were measured by gross motor function measure (GMFM) as well as pediatric balance scale (PBS) respectively. **Results:** There was significant improvement in both groups in the gross motor function as well as balance abilities post-treatment. When comparing post-treatment for both groups, the results showed a significant improvement favoring the study group. **Conclusion:** This prospective study demonstrated beneficial effects of three months of physical therapy exercises, while wearing the weighted vest on gross motor abilities and balance in children with diplegia.
Keywords: Balance, Diplegia, Motor function, Weighted vest.

INTRODUCTION

Cerebral palsy (CP) is chronic non-progressive encephalopathy that is the most prevalent reason of motor impairment in childhood. It also refers to a heterogeneous group of neurological conditions that progress with central motor dysfunction affecting movements and posture. The fundamental pathophysiological mechanism involves the occurrence of brain injury during the prenatal and neonatal stages of development **(1)**. Diplegia represents the most commonly observed form of spastic CP. The condition is distinguished by a prominent pyramidal motor syndrome primarily affecting the lower extremities. Perinatal hypoxic-ischemic insult often leads to the development of injuries in the white matter located around the lateral ventricles of the brain, a condition known as periventricular leukomalacia **(2)**.

Children with spastic diplegic CP often exhibit a greater degree of impairment in the lower extremities compared to other regions of the body. This typically manifests as challenges in maintaining an upright posture of the trunk due to the inherent instability caused by a high center of mass and a limited base of support **(3)**. It was demonstrated that children with spastic diplegic CP had worse trunk control and maintaining balance than typically developing children. Impaired trunk control directly causes problems with functional tasks, such as activities of daily living **(4)**. Abnormal gait patterns are common in children with spastic diplegia due to problems with balance, muscle weakness, spasticity, as well as skeletal deformities **(5)**. The observed patterns are distinguished by restricted movement in the lumbar spine, pelvis, as well as hip joints, and exhibit asymmetrical pelvic movement throughout walking **(6)**.

Wearing weighted vest with sandbags was utilized to enhance strength, stability and mobility in children with developmental disabilities **(7)**. Weighted vest provides deep compression sensation and resistance. Also, it improves concentration, and promotes changes in daily life movements in children with autism and CP **(8)**.

Limited studies are available on the effectiveness of using weighted vests in patients with CP, but these studies are insufficient to provide an effective basis for use as an effective intervention method in clinical practice **(9, 10)**. Therefore, the effect of wearing weighted vest equivalent to 10% of a child's body weight, on the gross motor functions as well as balance of children with spastic diplegia was studied.

PATIENTS AND METHODS

Study design: This prospective randomized clinical trial was done at the Outpatient Clinic of the Faculty of Physical Therapy, Deraya University from November 2022 to September 2023.

Sample size: The sample size was computed using G*POWER statistical (G*power version 3.1), with a power of 80%, an α-level of 0.05, as well as an effective size of 1.1. In order to conduct this study, we needed 15 participants in each group.

30 children, from both genders, with spastic diplegic CP were involved in the study. They were selected from the Physiotherapy Outpatient Clinic, Faculty of Physical Therapy, Deraya University. They were aged from four to

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seven. Children were involved in the study if they had (1) A spasticity ranging from 1 to 1+ based on the Modified Ashworth Scale (MAS), (2) A performance level of I or II according to the Gross Motor Function Classification System (GMFCS) and (3) The ability to recognize and follow verbal assessments and treatment guidelines.

Exclusion criteria: Children having hearing and visual disorders, fixed spinal deformities, lower and upper limbs osteoporosis, rickets and history of co-morbid medical disorders (Tuberous sclerosis) or psychiatric disorder were excluded from the study.

The participants were randomly assigned into two groups (control and study). The control group involved fifteen spastic diplegic CP children who were given the designed physiotherapy program. The study group involved fifteen spastic diplegic CP children who were given the same physiotherapy program while wearing a pocketed weighted vest (10% of child body weight). The treatment program was carried-out for both groups for three times per week, each season for one hour for consecutive three months.

Randomization: The assignment was concealed by placing it in opaque sealed envelopes that were numbered sequentially. Until data analysis was finished, an external, independent researcher was blind of the group allocation as they opened the envelopes. Furthermore, the independent researcher had no prior knowledge of the treatment method and never interacted with the subjects.

Procedures for evaluation: All children were evaluated by using the weight and height scale, the GMFM and PBS.

1. Weight and height Scale: A universal weight and height scale was utilized to evaluate the weight as well as height of all participants in both groups.

2. Gross Motor Function Measure: It was a practical system that was used by rehabilitation team in the clinic. The GMFM was utilized to measure the gross motor abilities of children, document their developmental changes over a period of time, and provide carers with valuable information regarding the advancements achieved during the rehabilitation process [11]. The five dimensions that make up this scale are as follows: 1) lying down or rolling, 2) sitting, 3) crawling or kneeling, 4) standing, as well as 5) walking, running, or jumping. In the current study the participated children were assessed for their standing and walking abilities only.

3. Pediatric Balance Scale: It is a modification of the Perg Balance Scale (PBS) was utilized to evaluate balance abilities for all participated children in both groups. The balance measure was designed specifically for children from two to seven years old having mild-to-moderate motor impairments, in addition to those diagnosed with CP. The scale encompasses a range of tasks from timed sitting balance to single-leg standing [12]. All participants in both groups were evaluated for their balance pre- and post-treatment program.

Intervention:

Both groups were given the designed physiotherapy program for three times per week, each session lasting 1 hour for three successive months. The control group was given a designed physiotherapy program that included: 1) Physical activities involving walking, such as going forward, backward, side to side, or crossing an obstacle course. 2) Getting up and down stairs. 3) Stepping forward, backward, as well as side to side upon block. 4. Standing exercises involving reaching in various directions and picking up an object. 5. Sit to stand from a chair. 6) Single-leg standing. 7) kicking a ball.

The study group received the previously mentioned designed physiotherapy program while wearing a weighted vest. The X-small (chest size of 56–64 cm) as well as small (chest size of 66–74 cm) sizes of the pocketed weighted vest (Hongik Trading, HSI3228) were used for participated children in study group [13]. The vest had eight pockets with eight sandbags distributed by four pockets anterior and four pockets posterior. The weights of sandbags were equal to 10% of child's weight. Sandbags were equally distributed in eight pockets. The placement of the pockets on the anterior chest was sufficiently elevated to avoid placing the weights on the child's hips or legs during the sitting position. The posterior pockets were established between the scapulae, specifically located below the scapular boundaries, in order to provide support for the weight from the shoulder girdle [14].

Ethical consideration: With the number P.T.REC/012/003971, The Ethical Committee of the Faculty of Physical Therapy, Cairo University in Egypt provided their approval to the study's protocol. Before beginning the study procedures, parents or legal guardians signed a written consent forms for participation of their children. The Helsinki Declaration was followed throughout the study's conduct.

Statistical analysis

The independent t-test was used to compare the individual's characteristics among the groups. The Chi-squared test was used to compare the gender distribution of every group. To verify that the data were normally distributed, the Shapiro-Wilk test was employed. Between-group comparisons of GMFM as well as PBS were analyzed using the unpaired t-test. Within-group comparisons, outcomes were analyzed using paired t-tests. A p-value ≤ 0.05 has been set as the level of significance. We used IBM SPSS statistics for Windows version 25, from IBM (Chicago, IL, USA) to conduct all of our statistical tests.

RESULTS

Children characteristics: Table (1) presented the children characteristics of control as well as study groups. There was no statistical difference among groups in age, weight, height in addition to gender distribution ($p > 0.05$).

Table (1): general characteristics of children

	Control group	Study group		
	mean ± SD	**mean ± SD**	**t- value**	**p-value**
Age (years)	5.67 ± 1.17	5.53 ± 1.13	0.31	0.75
Weight (kg)	16.47 ± 1.77	17.13 ± 2.07	-0.94	0.35
Height (cm)	111.60 ± 7.36	110.26 ± 8.68	0.45	0.65
Sex, n (%)				
Girls	7 (47%)	8 (53%)	(χ^2 = 0.13)	0.71
Boys	8 (53%)	7 (47%)		

SD, standard deviation; χ^2, Chi squared value; p-value probability value.

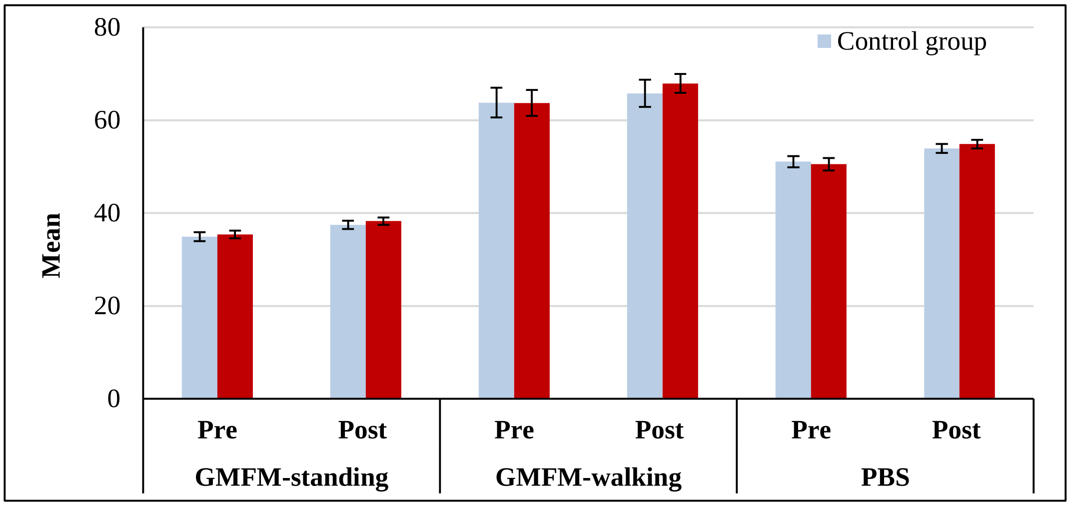
Impact of treatment on GMFM and PBS:

- **Within group comparison:** In both groups, there was a significant improvement in standing, walking in addition to balance ($p < 0.001$) (Table 2, figure 1).
- **Between groups comparison:** Pre-treatment, both groups showed no significant difference ($p > 0.05$). Standing, walking, as well as balance were significantly enhanced in the study group after treatment in comparison with the control group ($p < 0.05$) (Table 2, figure 1).

Table (2): Mean values of GMFM and PBS before as well as after treatment of control and study groups

	Control group	Study group			
	Mean ± SD	**Mean ± SD**	**MD**	**t- value**	**p value**
GMFM-standing					
Pretreatment	34.93 ± 0.96	35.40 ± 0.83	-0.47	-1.42	0.16
Post treatment	37.46 ± 0.92	38.27 ± 0.79	-0.81	-2.55	0.01
MD	-2.53	-2.87			
% of change	7.24	8.11			
t- value	-11.76	-12.12			
	p = 0.001	***p = 0.001***			
GMFM-walking					
Before treatment	63.80 ± 3.19	63.73 ± 2.79	0.07	0.06	0.95
After treatment	65.80 ± 2.91	67.93 ± 2.05	-2.13	-2.32	0.02
MD	-2	-4.2			
% of change	3.13	6.59			
t- value	-14.49	-8.10			
	p = 0.001	***p = 0.001***			
PBS					
Before treatment	51.07 ± 1.22	50.53 ± 1.35	0.54	1.13	0.26
After treatment	53.93 ± 0.96	54.86 ± 0.92	-0.93	-2.72	0.01
MD	-2.86	-4.33			
% of change	5.60	8.57			
t- value	-12.12	-15.08			
	p = 0.001	***p = 0.001***			

SD, standard deviation; MD, mean difference; p-value, probability value



GMFM, gross motor function measure; PBS, pediatric balance Scale

Fig. (1): Mean values of GMFM and PBS pre- as well as post-treatment of control and study groups.

DISCUSSION

Children with CP often have poor static balance owing to a variety of factors, like muscle weakness or spasticity, impaired coordination and diminished proprioception. They exhibit an altered gait pattern in comparison with normally developing children, which can be attributed to the shifting of the center of mass in both the anteroposterior and mediolateral directions. This displacement disrupts the dynamic balance in these children [(13)].

Problems with balance are significant obstacle for children with spastic diplegic CP, resulting in challenges related to achieve and sustain stability. The presence of impaired postural control and balance in those children can significantly hinder their abilities to engage in daily activities, resulting in limitations in their activity levels and social participation [(15)]**.**

In the current study, the selected age of the sample ranged from 4 to 7 years as this age is a critical time for intervention in children with spastic diplegia. During this time, children are still developing rapidly and are likely to make gains in motor functions. A prior study detected that children with diplegic CP who received intensive therapy between the ages of 4 and 7 were more likely to walk independently than those who received therapy at a younger or older age. The study also found that the children who received therapy at this age had better balance and coordination [(16)].

Based on results of this study, it was concluded that the wearing of the weighted vest during the treatment by the designed physiotherapy program was more effective in enhancing children’s balance as well as gross motor function than the treatment by the designed physiotherapy program only in the control group. The current study results come in accordance with the results of **Kwon** [(13)]**,** who found improvement by training using a weight vest on the large movement function, performance and balance abilities of children with CP (n=12) reflected on GMFM-88 scores. The justification of his results was that, deep compression stimulation via weighted vest can be used as an intervention to reduce the insignificant hyperactivity of sensory dysregulation disorders and to improve functional concentration for targeted activities. The present study is in agreement with the work of **Samsir *et al.*** [(16)] who detected that CP children's muscle strength and mobility improved across all GMFM dimensions after 6 months of guided exercise therapy utilizing weighted vest and ankle strap. Diffusion magnetic resonance imaging (dMRI) revealed in their study an increase in connectivity between the brain's corticospinal tract and the children's upper and lower limbs, suggesting that the improvement occurred simultaneously with the increase in connectivity. **Giray *et al.*** [(17)] support the findings of this study, confirming that the custom-made lycra suit known as the dynamic elastomeric fabric orthosis vest yields prompt enhancement in sitting balance and gross manual dexterity for individuals. The intervention not only enhances posture and balance during seated activities but also demonstrates comparable effectiveness when worn for 2-hours during therapy, as opposed to the traditional 6-hour usage. This is particularly beneficial for children diagnosed with CP, as it complements therapy efforts aimed at enhancing sitting balance.

The results of this study regarding gross motor function come in contradiction with the outcomes of **Scholtes *et al.*** [(7)] who discussed the effect of weighted vest on functional walking ability in CP children aged from 6 to 13 years. Muscle strength increased in school-aged, ambulatory children who had CP after a 12-week functional resistance exercise program utilizing a weighted vest, although functional walking activity did not. The explanation of this difference between two studies may be due to the older age range on their study.

The study done by **Alriksson *et al.*** [18] attributed the rationale of effectiveness of weighted vest to several factors. Firstly, working against resistive loads may increase proprioception and re-alignment. Secondly, the added weight of the suit can help stimulate muscles that may assist in improving posture and alignment, and make it easier for the child to move. Thirdly, it helps the patient to participate actively in motor performance.

Another study reported that the added weight of the suit can help to stretch the muscles and reduce spasticity. This can make it easier for the child to move and participate in activities. Also, this can help to improve his balance and coordination, and make it less likely to fall. Finally, the added weight of the suit can help to apply pressure to areas of the body that are in pain. As a result, the child may experience less pain and be able to move more freely [19].

CONCLUSION

According to the aims and results of this study, additional weight can provide children with more stability, which in turn was reflected on improving their motor abilities and balance. Moreover, the added weight may give children experience to be stable and move more freely. Therefore, the weighted vest may be helpful during the physical therapy exercises to promote functional independence and balance. Pediatric physical therapy clinics may incorporate the use of the weighted vest into their rehabilitation program because it is an efficient, applicable, and non-invasive approach for rehabilitation.

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