THE EFFECTIVENESS OF SUIT THERAPY WITH DUAL TASK EXERCISES ON GROSS MOTOR FUNCTIONS AND WALKING IN CHILDREN WITH DIPLEGIC CEREBRAL PALSY

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Resumo

Background: Cerebral palsy (CP) is a non-progressive condition that affects movement and development due to early brain injury. Children with CP have difficulty with posture and daily activities. Long-term therapy is essential and must keep children engaged. Suit therapy is an emerging method that helps improve posture and movement through a specialized orthotic suit. The aim of this work was to detect the effect of suit therapy with dual task training on gross motor performance and walking abilities in children with diplegic cerebral palsy (SDCP). **Methods:** This prospective randomized controlled study was carried out on 30 children with clinical criteria of spastic diplegia. Children were subdivided into two equal groups: group A: received suit therapy as control groups and group B: received suit therapy in addition to dual task exercises.

Results: The study of 30 children with spastic diplegia showed significant post-treatment improvements in balance. Both groups were similar at baseline, except the experimental group had a higher mean weight. After treatment, the experimental group showed greater improvements in static and dynamic balance and PBS scores. Significant gains were seen in standing and Pediatric Balance Scale. (PBS) scores, but not in walking/running/jumping.

Conclusions: Dual task training significantly improved gross motor functions and walking than Suit therapy in children with SDCP, therefore, we can recommend them as basic protocols that should be included in the treatment plan for diplegic children.

Keywords: Suit Therapy, Dual Task Exercises, Motor Functions, Diplegic Cerebral Palsy

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Introduction

Cerebral palsy (CP) is a nonprogressive motor impairment syndrome caused by brain defects or lesions that occur in an immature brain before or during birth or within two years of birth [1].

It is accompanied by motor disorder; disturbances of sensation, cognition, perception, communication, and behaviour; and seizure disorder and affects overall development [2].

Accordingly, children with CP show reduced postural control when engaging in several activities such as sitting, standing, and walking and have limitations in performing the activities of daily living [3, 4].

Therapeutic approaches for CP include neurodevelopmental treatment, Vojta therapy, sensory integration therapy, and conductive education. Specific therapeutic strategies for CP may differ, but they all aim to improve the independence of children with CP [5].

Considering that the rehabilitation period of patients with CP is observed in a prolonged period it is important to induce the sustained participation of these children, making sure that the therapeutic interventions are interesting and easily performed [6]. For this we will use these treatment tools in our study.

Suit therapy is a relatively new and experimental form of therapy designed to help those with improve muscle tone, posture, and movements [7].

Suit therapy consists of an orthotic suit that includes a hat, knee pads, and specially designed therapeutic shoes, the suit also has rings that allow bungee cord-like ropes to be inserted and adjusted according to the child's height, once the child has the suit on and the elastic ropes are adjusted, it brings the body into proper alignment and helps improve abnormal muscle tone, in this way the suit assists in retraining the brain to recognize the new connected body movements [8].

The aim of this work was to detect the effect of suit therapy with dual task training on gross motor performance and walking abilities in children with diplegic cerebral palsy (SDCP).

Methodology

This prospective randomized controlled study was carried out on 30 children, aged from 6 to 12 years old, both sexes, with clinical criteria of spastic diplegia CP made by pediatricians or Pediatric neurologists, spasticity grades ranged from 1 to 2+ according to Modified, ashworth scale (MAS) and children who can sit on a chair with good balance and recognize and follow verbal orders and commands included in both testing and training techniques. The study was done after approval from the Ethical Committee, Kafr-Elsheikh University, Kafr-Elsheikh, Egypt. An informed written consent was obtained from the relatives of the patients.

Exclusion criteria were others with a permanent deformity (bony or soft tissue contractures), children have visual or auditory defects, current hospitalization for urgent medical reasons, severe mental retardation, children who underwent fewer than twelve regular sessions of physical therapy at their place were not included in the survey and children with history of epileptic seizure or any diagnosed cardiac or Orthopedic disability that may hinder assessment methods and treatment.

Randomization and blinding

An online randomization program (http://www.Randomizer.org) was used to generate a random list and each patient's code was kept in an opaque sealed envelope. Patients were randomly allocated with 1:1 allocation ratio into two equal groups in a parallel manner: group A: received suit therapy as control groups and group B: received suit therapy in addition to dual task exercises.

All patients were subjected to demographic data and clinical assessments (gross Motor Function which measured pre- and post-treatment using the Gross Motor Function Measure-88 (GMFM-88) and balance (assessed pre- and post-treatment using the Pediatric Balance Scale (PBS)).

Child Preparation

Therapist assignment to ensure consistency and treatment fidelity, all interventions, evaluations, and measurements at baseline and post-intervention were performed by the primary investigator (the same physical therapist). Parents or legal guardians of children who meet the inclusion criteria were provided with a detailed explanation of the treatment protocol in a language they understand. Informed consent was obtained through a signed consent form prior to participation. Demographic information and outcome measures for each participant were recorded on specially designed data collection forms.

GMFM-88 was used to assess the child's gross motor performance across five dimensions: lying and Rolling (17 items), sitting (20 items), crawling and Kneeling (14 items), standing (13 items), walking, running, and jumping (24 items). Each item was scored and interpreted according to the GMFM guidelines. Scores were expressed as a percentage of the maximum possible score for each dimension. The total GMFM score was the average of the percentage scores across the five dimensions. Partial administration was permitted based on each child's level of function [9].

Balance Evaluation of PBS, a modified version of the Berg Balance Scale, was used to evaluate functional balance. It included 14 items scored on a 5-point scale from 0 (lowest function) to 4 (highest function), with a maximum total score of 56. The scale was time-efficient (approximately 15 minutes) and required no specialized equipment [10].

Treatment Procedures

In Control Group, Children received suit therapy, which included: an orthotic suit with knee pads and specially designed therapeutic shoes. The suit is equipped with rings that allow the attachment of bungee cord-like elastic bands. These are adjusted based on the child's height to maintain correct body alignment. The test aims to improve abnormal muscle tone and facilitate neuroplastic changes by retraining the brain to recognize corrected movement patterns.

While wearing the suit, the child participates in structured therapeutic exercises in a clinical setting.

All treatment sessions lasted one-hour, conducted three times per week for a total duration of 12 weeks.

In group B, children received suit therapy combined with cognitive dual-task training, which included: performing the same physical exercises used in control group while simultaneously engaging in cognitive tasks, such as naming tasks (naming animals, familiar objects, or family members).

Auditory identification tasks: identifying sounds or voices (e.g., child, man, woman; sounds such as door closing, hand clap, cat meowing) presented via loudspeaker connected to a laptop.

Counting tasks: listening to a forward-counting sequence (e.g., counting from 1 to 10 with increments of 1) and recalling the digits afterward.

This dual-task approach was designed to challenge attention, memory, and auditory processing while promoting motor skill acquisition.

The traditional exercise program (given to both groups)

The training program of gross motor performance: all the tests in GMFM 88 was used as a treatment program and exercises such as basic rolling, sitting, crawling and walking.

The selected physical therapy program: neurodevelopmental approach (aimed to facilitate typical motor development and function and to prevent secondary impairments) [12] , approximation (aimed to control spasticity and stimulate the joint mechanoreceptors [12] ,stretching exercise aimed to maintain length and flexibility of shorten [13], strengthening exercise aimed to improve the functional ability [14] , spider suspension exercise for 30 minutes [15] , gait training activities aimed to improve balance [16] , balance training program aimed to improve balance [17]. The treatment protocol was repeated for 12 weeks.

Sample Size Calculation

Using G-power version 3.1.9.7 for windows and regarding t-test study, alpha level of 0.05, confidence interval 80% and effect size of 1.135 calculated from the previous study [18], the total sample size will be 28 children (fourteen in each group) [19] We will increase the number to be 30 children (Fifteen in each group) to avoid any drop out.

Statistical analysis

Statistical analysis was done by SPSS v26 (IBM Inc., Chicago, IL, USA). Shapiro-Wilks test and histograms were used to evaluate the normality of the distribution of data. Quantitative parametric variables were presented as mean and standard deviation (SD) and compared between the two groups utilizing unpaired Student's T- test. Quantitative non-parametric data were presented as median and interquartile range (IQR) and were analyzed by Mann-Whitney test. Qualitative variables were presented as frequency and percentage and were analyzed utilizing the Chi-square test or Fisher's exact test when appropriate. A two tailed P value < 0.05 was considered statistically significant.

Results

The study of 30 children with spastic diplegia (mean age 8.9 ± 1.7 years) showed significant post-treatment improvements in balance. Pre-treatment, static and dynamic balance measures (surface area ellipse and path length) were higher, and PBS scores were lower (Standing: 73.9, Walking/Running/Jumping: 67.8, Total: 85.3). Post-treatment, static and dynamic balance measures decreased, while PBS scores improved (Standing: 75.8, Walking/Running/Jumping: 71.2, Total: 87.6), indicating enhanced balance performance. Table 1

Data are presented as mean ± SD or frequency (%). BMI: Body Mass Index., PBS: Pediatric Balance Scale. GMFM: Gross Motor Function Measure. PBS: Pediatric Balance Scale. GMFM: Gross Motor Function Measure.

There were no significant differences between the control and experimental groups in terms of age, gender, height, BMI, gestational age, birth weight, or pre-treatment balance and PBS scores. The only significant difference was a higher mean weight in the experimental group (p = 0.0191). Overall, both groups were comparable at baseline across all balance and PBS measures. Table 2

Data are presented as mean ± SD or frequency (%). BMI: Body Mass Index, PBS: Pediatric Balance Scale, GMFM: Gross Motor Function Measure. [t]: Independent t-test; [X]: Chi-square test, [MWU]: Mann–Whitney U test. *Statistically significant at p < 0.05.

Post-treatment, the experimental group showed significantly greater improvements in all balance parameters compared to the control group. Static and dynamic balance measures were notably better (p < 0.05), with

Table 1. Demographic characteristics, pre-treatment of (PBS), (GMFM) and post-treatment of (PBS) and (GMFM) scores results of all participants.

			N = 30
Demographic characteristics	**Age (years)**		8.9 ± 1.7
	Sex	**Male**	19 (63%)
		Female	11 (37%)
	Height (cm)		121.2 ± 11.4
	Weight (kg)		24.6 ± 4.7
	BMI (kg/m²)		16.8 ± 2.7
	Gestational age (weeks)		34.3 ± 4.9
	Birth weight (kg)		2.3 ± 0.9
Pre-treatment (PBS)	Static balance – surface area ellipse (cm²)		110.4 ± 11.6
	Static balance – length (cm)		31.6 ± 5.8
	Dynamic balance – surface area ellipse (cm²)		101.2 ± 12.8
	Dynamic balance – length (cm)		20.1 ± 2.8
Pre-treatment (GMFM) Scores	Dimension D (standing)		73.9 ± 2.7
	Dimension E (walking/running/jumping)		67.8 ± 4.3
	Total Score		85.3 ± 2.8
Post-treatment (PBS)	Static balance – surface area ellipse (cm²)		79.2 ± 21.1
	Static balance – length (cm)		21.7 ± 8.4
	Dynamic balance – surface area ellipse (cm²)		77.5 ± 14.1
	Dynamic balance – length (cm)		13.3 ± 3.8
Post-treatment (GMFM) scores	Dimension D (standing)		75.8 ± 4.4
	Dimension E (walking/running/jumping)		71.2 ± 4.3
	Total Score		87.6 ± 3.4

lower surface area ellipse and path length values. PBS scores also improved significantly in the experimental group for dimension D (standing) and total score ($p < 0.001$), though dimension E (walking/running/jumping) showed no significant difference between groups. Table 3

Data are presented as mean ± SD or frequency (%). PBS: Pediatric Balance Scale, GMFM: Gross Motor Function Measure. [t]: Independent t-test. *Statistically significant at $p < 0.05$.

Discussion

CP is a nonprogressive impairment or lesion occurring in immature brains and is a neurodevelopmental disorder that causes permanent impairment to movement and postural development and brings about activity limitation [20]. CP mostly causes problems such as abnormal muscular tone as in spasticity, muscular weakness, coordination disorder, and ataxia, and also restricts complex movement such as loss of selective movement and impairment of coordination and balance [21]. Such impairments of the postural control and balancing abilities of children with CP limit the activities of daily living depending on the body functionality and lead to activity constraints and social participation restrictions. Accordingly, for intervention of children with CP, not only should the improvement in the level of bodily impairment be taken into account, but also enhancement of the functional level and activity participation should be considered [22].

Various intervention methods such as progressive resistance exercises, strength exercises, and so on for the improvement of the body functionality of children with CP have been reported that they have reported a positive effect on balance and postural control ability when external focus exercises are completed using a tool such as a balance pad. However, interventions for which only the body functions were considered have limitations in performing functional tasks in daily living, and for this reason, studies have been announced that the physical abilities of individuals and connected activities of complex task performance in daily living as important perspectives [23].

Dual-task training is an intervention of performing two or more complex tasks differently in nature that frequently take place in daily life, and it is a method of training wherein a different task is additionally performed when a basic task was performed, two or more tasks are performed concurrently. When dual-task training is undertaken by combining cognitive and motor tasks, a cognitive-motor interference effect appears [24].

As dual-task training can elicit Behavioral modalities by encouraging two motor tasks to be performed simultaneously, it has greater significance if the trainee has a cognitive disorder and motor disturbance, such as CP. However, there is still insufficient research on applying dual-task training in children with CP [25].

This study was conducted to investigate the effect of suit therapy combined with dual task training on gross motor performance and walking abilities in children with spastic diplegia. A total of 30 children aged 6 to 12 years, diagnosed with SDCP, were enrolled and randomly assigned into two equal groups: control group which received suit therapy alone and experimental group which received suit therapy in addition to dual task exercises.

In our study, the post-treatment assessment using the PBS showed notable improvements in balance parameters. The mean surface area ellipse during static balance decreased to 79.2 ± 21.1 cm2 (range: 32–116), and the mean path length was reduced to 21.7 ± 8.4 cm (range: 3–37). During dynamic balance tasks, the mean surface area ellipse was 77.5 ± 14.1 cm2 (range: 51–111), while the mean path length decreased to 13.3 ± 3.8 cm (range: 5–21). In agreement with Mohamed et al. [26] who found that the PBS is a reliable tool for assessing functional balance in children with SDCP, and improvements in balance parameters have been observed following treatment.

Further, Abd-Elmonem et al. [27] showed that children with spastic SDCP have shown significant improvements in balance parameters after specific treatment interventions, particularly when assessed using the PBS.

Based on the results, the post-treatment evaluation using the PBS demonstrated improvements in both standing and dynamic movement tasks. The mean score for Dimension D (Standing) increased to 75.8 ± 4.4 (range: 67–84), and Dimension E (Walking/Running/Jumping) reached 71.2 ± 4.3 (range: 63–81). The total PBS score improved to 87.6 ± 3.4 (range: 82–94).

In alignment with our results, Kolezoi et al. [28] declared that the PBS has been shown to be effective in demonstrating improvements in both standing and dynamic movement tasks after treatment in children with SDCP.

Moreover, Abd-Elfattah et al. [29] recorded that PBS have shown that interventions like core stability training and Pilates exercises can lead to significant improvements in balance, standing, and gait parameters in children with SDCP.

Table 2. Comparison between control and experimental groups regarding demographic characteristics, pre-treatment (PBS) and pre-treatment (GMFM) scores (N = 30).

			Control group (n = 15)	Experimental group (n = 15)	P
Demographic characteristics	**Age (years)**		8.3 ± 1.4	9.5 ± 1.8	0.0934 [t]
	Gender	**Male**	8 (53%)	11 (73%)	0.2712 [X]
		Female	7 (47%)	4 (27%)	
	Height (cm)		119.7 ± 12.5	122.7 ± 10.4	0.4906 [t]
	Weight (kg)		22.7 ± 4.2	26.6 ± 4.5	**0.0191* [t]**
	BMI (kg/m²)		15.9 ± 2.2	17.8 ± 3.0	0.0536 [t]
	Gestational age (weeks)		34.4 ± 4.8	34.3 ± 5.2	0.9426 [t]
	Birth weight (kg)		2.3 ± 0.9	2.3 ± 1.0	0.8639 [t]
Pre-treatment (PBS) scores	Static balance – surface area ellipse (cm²)		109.6 ± 10.8	111.2 ± 12.3	0.7262 [t]
	Static balance – length (cm)		32.2 ± 6.1	31.1 ± 5.5	0.6567 [t]
	Dynamic balance – surface area ellipse (cm²)		96.9 ± 12.1	105.5 ± 12.1	0.1271 [t]
	Dynamic balance – length (cm)		19.9 ± 2.5	20.4 ± 3.2	0.6632 [MWU]
Pre-treatment (GMFM) scores	Dimension D (standing)		73.4 ± 2.4	74.5 ± 2.8	0.2825 [t]
	Dimension E (walking/running/jumping)		69.3 ± 4.1	66.4 ± 4.2	0.0538 [t]
	Total Score		84.5 ± 2.6	86.1 ± 2.8	0.1328 [t]

Table 3. Comparison between control and experimental groups regarding post-treatment (PBS) and post-treatment GMFM scores.

		Control group (n = 15)	Experimental group (n = 15)	P
Post-treatment (PBS) scores	Static balance – surface Area ellipse	96.1 ± 10.9	62.3 ± 13.9	**<0.0001* [t]**
	Static balance – length (cm)	27.6 ± 6.1	15.9 ± 6.0	**0.0002* [t]**
	Dynamic balance – surface area ellipse	84.5 ± 11.9	70.4 ± 12.5	**0.0195* [t]**
	Dynamic balance – length (cm)	15.5 ± 3.1	11.1 ± 3.2	**0.004* [t]**
Post-treatment (GMFM) scores	Dimension D (standing)	72.7 ± 3.1	78.9 ± 3.3	**<0.0001* [t]**
	Dimension E(walking/running/jumping)	70.5 ± 4.1	71.9 ± 4.4	0.377 [t]
	Total Score	85.4 ± 2.5	89.8 ± 2.7	**0.0006* [t]**

Regarding the results, post-treatment comparisons revealed statistically significant differences between the control and experimental groups across all balance parameters. The mean static balance surface area ellipse was 96.1 ± 10.9 cm² in the control group and 62.3 ± 13.9 cm² in the experimental group ($p < 0.0001$). Static balance length averaged 27.6 ± 6.1 cm in the control group and 15.9 ± 6.0 cm in the experimental group ($p = 0.0002$). For dynamic balance, the surface area ellipse was 84.5 ± 11.9 cm² in the control group and 70.4 ± 12.5 cm² in the experimental group ($p = 0.0195$), while dynamic balance length was 15.5 ± 3.1 cm and 11.1 ± 3.2 cm in the control and experimental groups, respectively ($p = 0.004$).

These findings are in accordance with AMIRA et al. [30] who notified that Dual-task training may offer more significant improvements in overall functional balance and gait compared to suit therapy alone.

Also, Lee et al. [24] found that the use of dual-task training is an efficient clinical intervention technique for improving static & dynamic balance, as well as their gross motor function in children with spastic diplegia CP.

Additionally, our results supported by Fritz et al. [31] who stated that dual task training improves the ability to perform 2 tasks spontaneously and improves spatiotemporal measures of the gait, it also improves the independence level, decreases the risk of fall, enhances gait and improves cognition.

Following the intervention, significant differences were observed between the groups in certain PBS dimensions. The mean score for Dimension D (Standing) was 72.7 ± 3.1 in the control group and 78.9 ± 3.3 in the experimental group ($p < 0.0001$). For Dimension E (Walking/Running/Jumping), the control group scored 70.5 ± 4.1 and the experimental group scored 71.9 ± 4.4 ($p = 0.377$), indicating no significant difference. The total PBS score was significantly higher in the experimental group (89.8 ± 2.7) compared to the control group (85.4 ± 2.5), with a p-value of 0.0006. These outcomes agreed with Ghai et al. [32] who demonstrated that in SDCP , both Thera Suit therapy and dual-task exercises can improve balance, but they may do so through different mechanisms. While both interventions can lead to significant improvements in balance, dual-task training might offer more specific benefits for functional activities requiring coordination and attention.

Moreover, Okur et al. [33] informed that Dual-task therapy and suit therapy, including Thera Suit, are both used in treating SDCP, but they address different aspects of motor function. Dual-task therapy focuses on improving balance and gain by training individuals to perform two tasks simultaneously, which is particularly beneficial for children with cognitive and motor impairments. Suit therapy, on the other hand, aims to improve alignment, strength, and overall motor control using a specialized suit and exercise protocols. While both have shown positive effects, research suggests that dual-task training may offer more significant gains in functionality and motor skills, especially when combined with conventional physiotherapy.

Limitations of the study were relatively small sample size inevitably lowered the statistical power of the analysis, single-centre study makes the results less generalizable, the study lacked the comparison of suit therapy combined with dual task exercises with other protocols of gross motor performance and walking abilities in children with spastic diplegia and the follow up period was short [34].

Conclusions

Dual task training significantly improved gross motor functions and walking than Suit therapy in children with SDCP, therefore, we can recommend them as basic protocols that should be included in the treatment plan for diplegic children.

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