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Impact of task-oriented training on balance in spastic hemiplegic cerebral palsied children

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Abstract

Introduction. A large majority of hemiplegic cerebral palsy children demonstrate poor balance, which leads to poor gait and impaired reaching movements as the maintenance of stability is critical to all movements. Various approaches and strategies are used to improve balance; task-oriented training is one of them. This study aimed to evaluate the effect of task-oriented training on balance in spastic hemiplegic cerebral palsied children.

Methods. Overall, 30 spastic hemiplegic cerebral palsy children who fulfilled the inclusion criteria were randomly allocated into 2 equal groups (control and study group). The control group received a selected therapeutic exercise program for 90 min. The study group received the same program for 60 min and task-oriented training for 30 min. The total treatment provided for both groups was 90 min/day, 3 days/week for 4 successive months. Baseline and post-treatment assessment of each child with regard to overall, anteroposterior, and mediolateral stability indices was performed by using the Biodex Balance System.

Results. Children in both groups showed significant improvements in post-treatment mean values of all measured variables when compared with the pre-treatment mean values ($p < 0.05$). Significant improvement was observed in favour of the study group when comparing the post-treatment mean values of both groups.

Conclusions. Task-oriented training is a useful tool that can be applied in improving balance in children with hemiplegic cerebral palsy.

Key words: cerebral palsy, balance, task-oriented training

Introduction

Cerebral palsy describes a group of permanent motor disorders of movement and posture resulting from prenatal, perinatal, or postnatal damage to the brain; these disorders are usually accompanied by disturbances of communication, perception, sensation, and cognition [1, 2]. Cerebral palsy occurs in 2–2.5 per 1000 live births, seems to be the most common cause of lifelong physical disability, and has an impact on the child, caregivers, and society [2, 3]. The incidence of cerebral palsy continues to rise owing to the large numbers of premature and high-risk infants who survive [4].

In cerebral palsy, 70–80% of children have spastic features like muscular hypertonicity; weakness, and increased deep tendon reflexes [5]; about 33% of children with cerebral palsy have hemiplegia [6].

Spastic hemiplegia is a type of cerebral palsy which affects one side of the body. Those children may present mixtures of asymmetry between the two sides of the body, spasticity, weakness, sensory loss, decrease of muscle volume in paretic side muscles, and considerable leg length discrepancy [7].

Balance plays an important role when performing all functional activities of daily living. Information from proprioception, visual, and sensory system are integrated to generate postural adjustments required for a given motor task. Poor balance is considered a major constraint for those activities [8, 9]. Hemiplegic cerebral palsied children have poor balance because of impaired development of their neural control mechanisms in addition to secondary musculoskeletal problems, such slow proprioception, muscle weakness, and spasticity, which all reduce the ability to shift the body weight symmetrically in repose to motion in order to keep balance [10, 11].

Modern theories of motor learning suggest that training is most effective when it is specific to the intended outcome and meaningful to the person [12, 13]. So, the practice of specific tasks and activities leads to a maximum improvement in function [14, 15]. With the development of the task-oriented training approach, practitioners have shifted their interest from traditional inhibition and facilitation techniques, minimizing deficits that patients suffer from, to a more dynamic task-oriented training, which improves function in all aspects of motor performance by concentrating on function, participation in activities, and quality of life [16].

Some authors concluded that task-oriented training was effective in improving mobility and balance among spastic diplegic children [17–19]. Others reported that task-oriented training was an effective and feasible strategy for improving the mobility function and postural stability of children with cerebral palsy [20, 21].

Despite these conclusions, relatively few studies have examined the effect of task-oriented training on improving balance in hemiplegic cerebral palsied children. Therefore, the aim of the current study was to determine the effect of a selected task-oriented training on balance in children with hemiplegic cerebral palsy.

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Subjects and methods

Design

The study was designed as a controlled trial that compared 2 groups. The control group included children who performed the selected therapeutic exercise program for 90 min. In the study group, children received the same program for 60 min in addition to 30 min of task-oriented training. The children were randomly assigned into these groups by a blinded and independent research assistant, who opened sealed envelopes that contained a computer-generated randomization card.

Participants

Overall, 30 children were assigned to 2 equal groups. They were recruited from the outpatient clinic of the Faculty of Physical Therapy, Delta University for Science and Technology, Mansoura, Egypt and met the following inclusion criteria: (1) diagnosis of spastic hemiplegic cerebral palsy; (2) age of 5–8 years; (3) the degree of spasticity in the affected lower extremity between grade 1 and 1+ in accordance with the Modified Ashworth scale [22]; (4) the level of gross motor function between I and II in accordance with the Gross Motor Function Classification System (GMFCS) [23]; (5) ability to understand and follow instructions; (6) no serious or recurring medical complications. The exclusion criteria were as follows: (1) any orthopaedic conditions or fixed deformities interfering with balance; (2) visual, auditory, vestibular, or perceptual deficits; (3) seizures or epilepsy; (4) having received botulinum toxin injections or other spasticity medications; (5) surgical interventions for the lower extremity musculature during the period of the study. The procedure, purpose, and all details of the study were explained to the parents and their children.

Measurement tools

1. Modified Ashworth scale was used to measure the degree of spasticity [22].
2. GMFCS was applied to classify the severity of functional limitation/disability in children with cerebral palsy [23].
3. Biodex Balance System SD (Biodex Medical Systems Inc., Shirley, USA) is a valid and reliable balance assessment tool [24]. It consists of a support handle, platform, display, and printer. It has a static mode and 12 levels of the dynamic platform tilt (12 is the most stable and 1 is the least stable). The balance system was used to assess the changes in the reactive postural balance control in the participating children of the 2 groups in the standing position pre- and post-training (overall stability index, anteroposterior stability index, and mediolateral stability index).
4. A height and weight scale (SH-8024) was applied to measure the children's height and weight.

Measurement procedures

The participants (in both groups) underwent baseline and post-treatment assessments (at the end of 4 months of training). The evaluation with the Biodex Balance System was performed at the stability level of 8 on the basis of the pilot study that involved 15 children.

At first, the following parameters were taken and fed to the device: the child's weight, height, age, and stability level (platform firmness). Children whose weight was less than 20 kg and height less than 100 cm were excluded.

Each child in both groups (control and study) was asked to stand on the centre of the locked platform within the device while grasping the handrails. The display screen was adjusted so that the participants could look straight at it. Then, each child was asked to attain a centred position in a very slightly unstable platform by shifting their feet position until it was easy to keep the cursor (representing the centre of the platform) in the centre of the screen while standing in a relaxed upright position. Once the child was adjusted in the centre of the platform and the cursor was in the centre of the display target, the participant was asked to maintain their feet position till stabilizing the platform.

The test started after introducing feet angles and heel coordinates into the Biodex system. Then, the platform was adjusted to an unstable state (level 8), and the child was instructed to focus on the visual feedback screen directly in front of them, with both arms at the sides of the body, without grasping the handrails. The subjects attempted to maintain the cursor in the middle of the bull's eye on the screen. The device allowed each child to perform the test in 3 trails of 30 min each. The mean of the 3 trails was determined by the Biodex system and a printout report was obtained, including information on the overall stability index, mediolateral stability index, and anteroposterior stability index.

Treatment procedures

The children in both groups received a selected therapeutic exercise program; those in the control group received the program for 90 min whereas the study group subjects received the same program only for 60 min in addition to 30 min of task-oriented training. The selected therapeutic exercise program was conducted for 3 days/week on non-consecutive days and included the following items with clear instructions to the children:

1. Stand with feet together, with the therapist sitting behind the child and manually locking the child's knees, then slowly tilting them to each side, forwards, and backwards.
2. Stand with the therapist behind the child, guiding them to shift their body weight forwards and then backwards alternately.
3. Stand on a balance board, which is a flat board with a fulcrum attached to its underside (17.5 inch length × 13.5 inch width × 4 inch height), with the feet separated apart, trying to keep the body balanced.
4. Stand, with the therapist manually locking the child's knees; then try to stoop and recover.
5. From standing position: equilibrium, righting, and protective reactions training was performed.
6. Gait training (closed environment) was conducted in the form of forward, backward, and sideways walking between parallel bars. Obstacles including rolls and wedges with totally different diameters were placed between parallel bars and the children were instructed to walk between the bars holding the objects.
7. Gait training (open environment) was performed with obstacles including rolls and wedges with totally different diameters placed in the course. The child was instructed to walk without any assistance through the course with the obstacles.
8. Strengthening exercises for back, hip, and knee extensors muscles were done against the therapist's manual resistance.
9. Passive stretching exercises were applied for all tight muscles, including hamstrings and calf muscles in the lower limb and elbow flexors, wrist flexors, and forearm pronators in the upper limb [25].

The children in the study group received the previous physical therapy program, in addition to 30-min task-oriented training. The total treatment time was 90 min, for 3 sessions/week. The following activities were used:

1. Sit-to-stand from various chair heights. The children were instructed to flex hip and move trunk forward until the shoulders were vertically above the knee joints, and finally to stand up as many times as possible without any external assistance or use of the hands.
2. Standing and reaching in different directions for objects located beyond arm's length. The children were asked to reach out in different directions (forward, sideward, and cross body), at different distances from their body (near, far), and at different heights from their body (above head, at shoulder level, below shoulder level).
3. Stepping forwards, backwards, and sideways onto blocks of various heights. The block height was 0.17 m for all children and was increased as the complexity increased, reaching 0.30 m.
4. Heel raising and lowering while maintaining in a standing position against the child's body weight.
5. Walking activities: walking forwards, backwards, sideways, and through obstacle course including steppers of various heights. The stepper height was 0.10 m for all children and was increased as the complexity increased, reaching 0.25 m.
6. Walking up and down stairs. The children were instructed to safely go up the stairs, turn around on the top step, and come all the way down until both feet landed on the bottom step, at the self-selected speed, placing only one foot on each step (step-over-step).

Each task lasted 5 min for each treatment session. Progressions included:

1. Increasing the number of repetitions completed within 5 min.
2. Increasing the complexity of the exercise performed, such as increasing the distance reached in standing, reducing the height of the chair during sit-to-stand, and increasing the height of the blocks and stairs.

Sample size

To avoid a type II error, a preliminary power analysis [power (1 – α error p) = 0.8, $\alpha = 0.05$, effect size = 0.982] determined a sample size of 14 for each group in the study. The effect size was calculated in accordance with a pilot study involving 10 participants (4 in the study group and 6 in the control group), with the consideration of overall stability as a primary outcome.

Data analysis

The statistical analysis was conducted by using the SPSS package software, version 25 for Windows (SPSS, Inc., Chicago, USA). The data were not normally distributed as shown by the Shapiro-Wilk test (non-parametric data). Additionally, testing for the homogeneity of variance revealed a significant difference ($p < 0.05$). Quantitative descriptive statistics included mean and standard deviation for demographic data (age, weight, height), overall stability index, anteroposterior stability index, and mediolateral stability index. Qualitative descriptive statistics included number (percentage) for gender, spasticity grades, and GMFCS level. Wilcoxon test was used to compare the pre- and post-treatment values within each group for quantitative variables. Mann-Whitney test served to compare the study group and the control group with regard to quantitative variables. Chi-square test was applied to compare the study group and the control group as for qualitative variables. All statistical analyses results were significant at the level of probability ($p \leq 0.05$).

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the ethical committee at the Faculty of Physical Therapy, Cairo University.

Informed consent

Informed consent has been obtained from the parents of all individuals included in this study.

Results

The statistical analysis revealed no significant differences ($p > 0.05$) in demographic data (age, weight, and height) between the study and control groups, as presented in Table 1.

In the statistical analysis, no significant differences were observed ($p > 0.05$) in the pre-treatment overall stability index, anteroposterior stability index, or mediolateral stability index between the study group and the control group. There were, however, significant differences ($p < 0.05$) between pre- and post-treatment values of the overall stability index, anteroposterior stability index, and mediolateral stability index within each group, as presented in Table 2.

Table 1. Demographic data in the study and control groups

Items		Study group	Control group	p	Significance
Age (years)		6.41 ± 0.75	6.27 ± 0.72	0.575	NS
Weight (kg)		25.27 ± 3.16	24.60 ± 2.95	0.269	NS
Height (cm)		124.00 ± 6.34	123.00 ± 4.30	0.771	NS
Gender	Boys	7 (46.67%)	6 (40.00%)	0.713	NS
	Girls	8 (53.33%)	9 (60.00%)		
Spasticity grade	1	9 (60.00%)	10 (66.67%)	0.794	NS
	1+	6 (40.00%)	5 (33.33%)		
GMFCS level	I	8 (53.33%)	9 (60.00%)	0.824	NS
	II	7 (46.67%)	6 (40.00%)		

NS – non-significant, GMFCS – Gross Motor Function Classification System

Table 2. Comparison of overall stability, anteroposterior stability, and mediolateral stability indices for the study and control groups

Items		Study group	Control group	*p*	Significance
Overall stability index	Pre-treatment	2.33 ± 0.12	2.31 ± 0.09	0.776	NS
	Post-treatment	1.38 ± 0.07	1.59 ± 0.11	0.0001	S
	Improvement	40.77%	31.17%		
Anteroposterior stability index	Pre-treatment	2.38 ± 0.09	2.41 ± 0.08	0.367	NS
	Post-treatment	1.50 ± 0.08	1.89 ± 0.26	0.0001	S
	Improvement	36.97%	21.58%		
Mediolateral stability index	Pre-treatment	2.90 ± 0.30	2.94 ± 0.36	0.436	NS
	Post-treatment	2.09 ± 0.11	2.34 ± 0.20	0.0001	S
	Improvement	27.93%	20.40%		

NS – non-significant, S – significant

Discussion

Cerebral palsied children lack dissociated movement as a result of decreased motor control, spasticity, and muscle weakness [26]. Poor posture and abnormal shifting of body weight may occur owing to the development of contractures following spasticity, muscle weakness, and pelvic asymmetry [27]. So, children with cerebral palsy should be trained on how to effectively utilize motor control strategies in addition to direct tasks which allow the children to receive more information from the environment and enable them to perform more delicate activities, in order to diminish the effects of the musculoskeletal and neuromuscular system impairments and permit functional adjustment [28].

Therefore, this study was conducted to determine the effects of task-oriented training on balance in children with spastic hemiplegic cerebral palsy. The results of the study showed improvement in overall stability and anteroposterior and mediolateral indices in both groups. Additionally, a significant difference was observed in favour of the study group when comparing the post-treatment mean values. These results support the efficacy of task-oriented training as compared with conventional treatment for improving balance in children with hemiplegic cerebral palsy.

The task-oriented training resulted in the overall stability index improved by 40.77%, anteroposterior index improved by 36.97%, and mediolateral stability index improved by 27.93% in spastic hemiplegic cerebral palsied children. The findings are in agreement with other reports stating that task-oriented training is highly recommended for children with spastic hemiplegic cerebral palsy who suffer from balance problems [21]. Our results are also supported by research presenting a significant positive effect on balance among cerebral palsied children who conformed to a training program including functional mobility exercises, such as sit-to-stand, step-up, and walking downstairs [29, 30].

The findings in the study group may be attributed to the effect of task-oriented training, which focuses on improving performance of functional tasks through repetitions, practice, and increased complexity. This focus is on training of functional tasks rather than on impairment. The outcomes may also be explained by the fact that the task-oriented training included functional activities increasing the children's ability to transfer their centre of mass from a larger to a smaller base of support, as well as challenging the muscular system and the equilibrium system.

The observations in this study may result from the effect of the task-oriented training added to the selected therapeutic exercise program in performance and balance in children with cerebral palsy, which is in accordance with Han and Chung [31], who conducted a study to inquire about the effects of task-oriented training on balance in children with cerebral palsy. The results obtained in the study group are in line with the findings of Kumar and Ostwal [32], who reported that task-oriented training was beneficial in improving balance in children with diplegic cerebral palsy after evaluating all patients with the Pediatric Balance Scale.

The results in the control group may be attributed to the effect of the conventional physical therapy program (based on the neurodevelopmental basis), which was directed toward facilitating normal patterns of postural control (righting and equilibrium reactions) and developing a greater variety of normal movement patterns, particularly in the trunk and lower extremities, as proved by Ottenbacher et al. [33].

The post-treatment improvement in the results of the control group are in agreement with other studies which found that exercises and rehabilitation programs increased general physical capacity and functional independence in children with cerebral palsy [34].

Limitations

In terms of the study limitations, there was no follow-up period, so the long-term effect of the training in children with hemiplegic cerebral palsy cannot be detected.

Conclusions

The results of this study suggest that task-oriented training is effective in improving balance in children with spastic hemiplegic cerebral palsy.

Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors state no conflict of interest.

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