COMBINED EFFECT OF TASK-SPECIFIC TRAINING AND DYNAMIC ORTHOTIC APPROACH ON GAIT PERFORMANCE IN CHILDREN WITH UNILATERAL CEREBRAL PALSY

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Abstract

Objectives: Integration between different treatment methods will benefit patients. We aimed to evaluate the effect of adding dynamic ankle-foot orthosis while carrying a task-specific training based-program to improve gait performance in children with unilateral cerebral palsy (CP).

Methods: Thirty-six patients were included in this study from 7-9 years. They were assigned randomly into two equal groups: experimental and control groups. Both groups received selected task-specific training-based programs, including lower limb strengthening exercises and treadmill gait training without body support. In comparison, the experimental group used dynamic ankle-foot orthosis. The intervention program was performed three times per week for 12 successive weeks for a total of 36 hours. All children were evaluated through a 6-minute walk test (6MWT), a 10-meter walk test (10MWT), and the modified pediatric version of the Wisconsin gait scale (WGS). Measured variables were recorded twice: pre-and post-treatment.

Results: Significant improvement was noticed in both groups; the post-treatment improvements were significantly greater in favor of the experimental group concerning results of 6MWT, 10MWT, and the modified pediatric version of WGS as P=.0001.

Conclusions: Integration between the task-specific training based-program and dynamic ankle-foot orthosis improves gait performance in children with unilateral CP.

Keywords: Unilateral cerebral palsy. Task-specific training. Dynamic ankle-foot orthosis. Gait Performance

Introduction

Unilateral spastic cerebral palsy represents one of the most common neuromuscular impairments resulting from brain insults in which one side of the body is affected with functional limitations in both upper and lower extremities[1].

Significant functional limitations often cause gait deficits, making it hard for those with brain insult to move about indoors [1]. Community access demands the ability to walk, manage uneven surfaces, curbs, and elevations [2].

Sensorimotor impairments, including muscle weakness, proprioceptive deficits, muscle tone disturbances, and stereotyped movement overlapping with a normal gait, are combined with a high risk of falling [2,3]. Many rehabilitation methods were developed, but the overlap between impairment and gait pattern still has yet to be fully understood [4,5].

Gait patterns of hemiparetics are distinguished by being stereotyped with diminished weight bearing on the affected lower limb. Being the foot flat while contacting the floor is a typical stance phase kinematics disturbance. Overactivity or shortening calf muscles during the swing phase decrease the ankle's dorsiflexion, causing the foot to be flat during heel strike. Additionally, the increased spasticity permits only the lateral border of the foot to contact the ground primarily, giving the equinovarus placement of the foot [6, 7].

Studies have shown that strengthening exercises while seated position leads to maladjusted consequences on gait [8, 9]. Furthermore, Kim et al. (2001) stated that intervention targeted an increase in strength, not leading to significant changes in walking. [10]

Task-specific training programs help patients to obtain suitable control strategies and combine functional movements in an actual situation to improve motor control [11]. Patients are put in a situation where weak muscles normally function [12]. Two major approaches found in the literature for task-specific training improve the gait. The first approach is Treadmill training. The second is a wide variety of functional mobility tasks with intensive practice. Mobility tasks can be attained through endurance components and functional training [13].

Several studies showed that having more functioning muscle strengthening, such as in task-specific training, may lead to a more significant effect on gait [8, 10]. Different gait patterns have improved in hemiparetics following combined specific strengthening exercises with a task-specific training program [14].

Lowe et al. (2015) suggested that treadmill training is a safe, efficient, and clinically practical treatment for ambulant children with developmental delays. A high-intensity protocol along with typical PT treatment could be utilized to assist those children in improving their functional gross motor skills in 6 weeks or less [15].

Ankle foot orthosis (AFOs) can be either non-articulated or articulated, depending on the biomechanical design [16]. Relatively to design, splinting can be either unpowered or powered assistive devices; a powered AFO is desirable to interact with residual musculoskeletal structures [17]. Concerning treatment position, Menotti et al. (2014) concluded that using AFO results in lower energy costs, improvements of spatial, temporal, and kinematic parameters and higher comfort levels [18].

There is a lack of knowledge regarding the integration of different methods of treatment which need attention for the benefit of our patients seeking pediatric rehabilitation. So, this controlled randomized trial (CRT) aims to examine the integrated impact of task-specific training through treadmill and dynamic ankle-foot orthosis on selected spatiotemporal gait parameters in children with unilateral CP.

Material and Methods

Study design

The present RCT was carried out after approval by the local ethical committee at the Faculty of Physical Therapy, Cairo University (No: P.T.REC/012/002627), and the ethical principles of the Declarations Helsinki were followed. Thirty-six children with one-sided cerebral palsy of both sexes ranging from 7 – 9 years were selected. The parents of each participant signed an informal consent form.

Sampling

G-Power 3.1.9.4 software (Windows version) was utilized to establish sample size as follows: it was estimated by assuming the statistical test within two groups. Assuming α=0.05 and a power of 95%, a sample size of 36 children would be needed.

Participants

Thirty-six participants, ages seven to nine, with cerebral palsy of spastic hemiparesis (infantile type) taken part in this controlled randomized trial. They were recruited from the outpatient clinic, Faculty of Physical Therapy, Cairo University. Grades of individual manual muscle testing were 4 or less. Based on the Modified Ashworth Scale, the level of spasticity ranged from grade 1 to grade 2. During testing and training, all children could stand and walk independently. They could also understand and follow verbal commands and instructions. Children with fixed deformities, like those with major cognitive, perceptual, visual, and auditory disorders, were not allowed to join.

Participants were allocated randomly into two groups, a control group (A) and an experimental group (B). A block randomization technique was used. Each group consisted of eighteen participants.

Both groups received selected task-specific training-based programs, including lower limb exercises and treadmill gait training without body support. Also, group B was given the same task-specific training program as group A except that; treadmill training was applied to participants while wearing the dynamic ankle-foot orthosis. The treatment session lasted one hour and was performed three times per week for twelve successive weeks. Absence for more than two successive sessions means exclusion from the study. The assessment protocols were applied twice: pre-and post-treatment.

Procedures

Evaluation

6-minute walk test (6MWT): The American Thoracic Society developed (6MWT) in 2002 to assess endurance and aerobic capacity by measuring the distance covered within 6 minutes as an outcome in performance capacity. A stopwatch, a distance scale measuring distance covered, a 30-meter walkway, and two-colored cones to mark the covered distance were required to determine the outcome. The participant was instructed to walk barefoot through the walkway for 6 minutes and was allowed to slow down, stop, and rest as necessary. Walking was back and forth around the cones. Examiner read the standardized encouragement rules during the test.

10-meter walk test (10MWT): It is a performance outcome used to assess walking speed using a short distance by dividing the distance determined in meters over the time spent in seconds. Stopwatch and clear walkway with set distance at zero and ten meters. The participant was asked to walk on the walkway at a comfortable or usual speed. The time was started when the toes passed the zero-set mark, and it was stopped when the toes passed the ten-set mark. The test was applied for three trials, and their average was calculated.

The modified pediatric version of the Wisconsin gait scale (WGS): It consisted of four subscales and evaluated 14 gait parameters during consecutive gait cycles, and it was video recorded. It is a new, affordable, easy-to-use tool for gait performance assessment in children with unilateral CP [19].

The participant was assessed based on video material acquired during trials. For this aim, two video cameras were situated at two different places and simultaneously recorded. The camera concerning the record of the frontal plane view was set in the middle of the delineated route, at a distance of two meters from the path walked by the child. The camera recording the sagittal plane view was aligned with the path walked. The sum of scores of all 14 parameters represented the total score with a minimum score of 14 and a maximum of 45, a lower score corresponding to improvement in gait parameters.

Treatment

The treatment program was directed toward proprioceptive training, correcting abnormal patterns, improving gait patterns, and preventing the development of contractures [13].

Depending upon task-specific training, the rehabilitation program applied for both groups was selected. High repetitions were applied for specific functions as well as strengthening exercises. Strengthening exercises were applied using weights for hip flexors, extensors, abductors, knee extensors and flexors, ankle dorsi-flexors, and planter flexors. Functional exercises were applied in the form of sit-to-stand exercises, stoop and recovery exercises, treadmill training, and up/downstairs training.

Criteria for treadmill training included no body weight support, 20 – 30 minutes per session according to child tolerance, without any resistance applied by a treadmill, without inclination (flat surface), and through using colorful footprints.

Dynamic AFO was fitted for experimental group (B) participants before joining the treadmill training protocol. Standard-sized dynamic AFO was fabricated from thermoplastic material with metal hinges on the sides. It was aimed to correct ankle position while stepping on the treadmill while hinges allow ankle motion.

Stretching exercises for hip flexors, adductors, knee flexors, and ankle planter-flexors were performed according to the child's tolerance with 30 seconds stretch and 30 seconds rest.

Statistical Analysis

Statistical Package for Social Sciences (SPSS 22) for Windows was utilized to look at the data. Statistics were used to show the mean and standard deviation of the collected data on the baseline characteristics. The Chi-square test and the independent t-test were chosen to compare characteristics at the start. Parametric and non-parametric tests were utilized to compare changes in 6MWT results, 10MWT results, and the modified pediatric version of WGS results, respectively. The between-groups comparison in each assessment, an unpaired t-test, and a Mann-Whitney U test were used. Statistical significance was considered when p-value <0.05.

Results

Forty children with spastic unilateral cerebral palsy were initially assessed for eligibility. Group A (n= 19) was programmed for task-specific training, whereas group B (n= 19) used dynamic ankle-foot orthosis while trained in treadmill training. Of groups A and B, one withdrew from each group (due to absence for more than two consecutive sessions) (Figure 1).

Table 1 summarizes baseline characteristics at entry, including age, weight, height, frequency distributions of gender, affected side, and spasticity grading. There were no significant differences between both groups (p>0.05) (Table 1).

As shown in Table 2 and the following twelve weeks of application of the interventions, significant statistical differences (p<0.05) were noticed in gait performance outcomes, including 6MWT, 10MWT, and mWGS when comparing mean values within each group (Table 2).

Also, there were significant statistical differences when comparing mean values between groups concerning post-treatment results (p<0.05). Interaction between variables was studied as no significant difference was observed.

Discussion

A child's poor motor development is linked to their motor areas being less

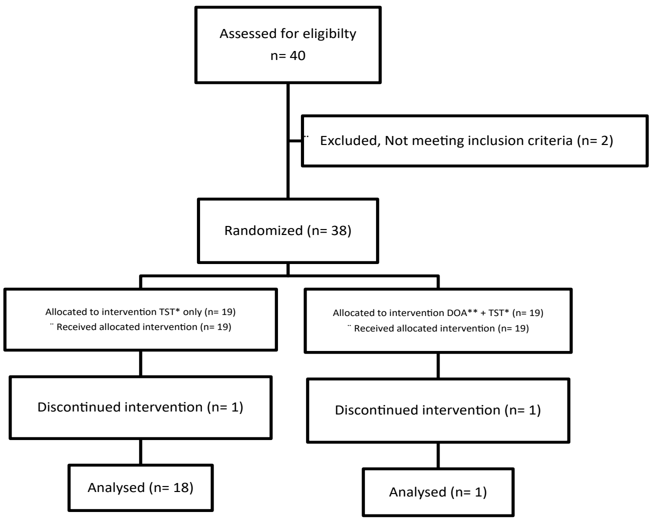

Figure 1: CONSORT flow diagram.

Note: *: Task-Specific Training; **: Dynamic Orthotic Approach.

Table 1: Baseline characteristics.

Item		**Group (A)**	**Group (B)**
Age (year)	Mean ± SD	8.6±1.8	8.73±1.83
Weight (Kg.)		30.07±4.67	31.2±4.74
Height (meter)		1.36±0.046	1.37±0.042
Frequency distribution of gender	Boys	10	9
	Girls	8	9
Frequency distribution of affected side	Rt. Side	11	10
	Lt. side	7	8
Frequency distribution of spasticity grading	Grade 1	7	6
	Grade 1⁺	5	6
	Grade 2	6	6

Table 2: Within and between group's comparisons for measured variables.

Variable	Group (A)		Group (B)		p-value
	Pre-	Post-	Pre-	Post-	
6MWT (meter)	443.11±36.63	492±25.13	453±33.2	564.67±60.06	0.000
p-value *	0.000		0.000		
10MWT (m/s)	1.46±0.1	1.6±0.09	1.51±0.13	1.9±0.09	0.000
p-value *	0.000		0.000		
mWGS	23.67±1.08	22.78±0.8	23.44±1.1	19.94±0.99	0.000
p-value *	0.000		0.000		

6MWT: 6-minute walking test, 10MWT: 10-meter walking test, m/s: meter/second,
mWGS: the modified pediatric version of Wisconsin gait scale, *: within-group comparison,**: between groups comparison, and p-value<0.05: Significant difference.

excited [20]. Neurophysiological tests have shown that the excitability of the cortex changes all over in children with brain diseases. This is evident even when the brain lesion is unilateral [21]. Postural problems arose because of disturbed tonus and muscle weakness. These problems affect motor development, resulting in difficulties doing essential functions like sitting, standing, and walking [22]. There is no cure for the brain lesion, but rehabilitation can minimize the manifestations of such conditions [23]. Muscle weakness is an essential clinical biomarker in children with unilateral CP and is engaged within the normal development of sensorimotor functions [24].

Children with unilateral CP often substitute muscle weakness by over-using the intact or less affected limb instead of using the paretic limb. Muscle strength may be decreased over time if not properly treated, leading to atrophy and joint contracture [25], which is attributed to the never-learned-to-use effect and the underutilization of the hemiparetic limb. This effect and underutilization suppress the traditional development of cortical plasticity, and this, moreover, inhibits functional use and worsens associated muscle weakness [26]. Following motor learning principles, task-specific training programs involve more practice of functional activities of daily living [27].

Recently, both task-specific training and dynamic ankle-foot orthoses have been added to physical therapy programs for children with CP as it relies on high repetitions of functional exercises and allows anatomical structuring. Recently, a combination of both methods has been studied. We investigated in the current study the effect of task-specific training through a treadmill in conjunction with dynamic ankle-foot orthosis on gait performance in children with hemiparesis.

The results of the present study demonstrated an improvement in gait performance in both groups. Significance was apparent when comparing pre-and post-treatment results of either group A (task-specific training only) or group B (task-specific training in conjunction with dynamic AFO) and when comparing post-treatment results of both groups in favor of group B.

Clinical assessment of gait instead of several modern techniques may be helpful in our professionality as these modern techniques are much more complicated and expensive, so it will not be possible to be available in many clinical settings. Also, clinical evaluation gives an actual view of the functional abilities, especially in chronic cases with CP. So, we used 6-MWT, 10-MWT, and the modified pediatric version of WGS for assessment.

It was confirmed that the practice of task-specific activities leads to optimal improvement in functional movement in children with brain disorders [28, 29]. It has been observed that task-specific training improves basic abilities assessed by gross motor function measures further as functional balance [30, 31], muscle strength, and walking ability in children with brain insults [32].

Based on motor learning theory and clinical pieces of evidence, overall intensive strengthening was recently developed and has presented evidence of remarkable improvements in muscle strength and functional activities in children with unilateral CP [33]. One of the foremost commonly stated objectives in rehabilitating patients with neurologic problems is the recovery of walking ability [34, 35]. Although there is no consensus on the most effective methods to train walking efficiently and independently, evidence exists that task-specific training can have profound effects on gait outcomes [36].

Recent studies have highlighted the advantages of treadmill training. Grecco et al. (2013) characterize the positive effects of gait training on a treadmill compared to over-ground training on static and functional balance [22]. Through a rhythmic pattern, treadmill training is beneficial to postural control by allowing many repetitions of steps, thereby increasing control between agonists and antagonists and improving functional balance. Studies demonstrate effective results from treadmill training on cardiorespiratory fitness, endurance, gross motor function, and walking abilities [37].

Central pattern generators are activated within the neural structure at the lumbar level because of treadmill training [38]. These generators represent neural activations able to form motor patterns, resulting in rhythmic and automatic strides, permitting the training of biomechanical components involved within different phases of postural control and balance [39, 40]. Activating those generators and automatic reciprocation mechanisms is crucial for improving gait through treadmill training, as patients with brain lesions utilize different postural strategies from those without neurologic disorders [41].

Marchese et al. (2000) suggested that repetitive multiple sensory stimulations may help activate important mechanisms that improve the motor learning process. By treadmill training, motor training may promote proprioceptive feedback, resulting in adjustments for adequate functional performance [42].

Based on the analysis of systematic reviews, the Cochrane overview noted moderate-quality evidence that 20 hours of task-specific training as a minimum is needed to get a satisfactory impact [43]. So, using a training program lasted for 36 hours.

Orthoses are commonly used to correct the position and improve function and quality of movement [44]. It is proved that the obtained results from the application of braces can be due to altered sensory input from cutaneous and muscle receptors [45].

Dynamic AFO is an articulated orthosis used to improve body motion to allow optimal functioning [46]. It provides subtalar stabilization while facilitating free ankle dorsiflexion and plantar-flexion. Thus, dynamic AFO is practical to obtain proper body alignment [47].

From our point of view, dynamic AFO helps realign the ankle joint and promotes ankle movement, improving gait performance, especially following the designed task-specific training program. On the other hand, clinical gait assessment revealed a significant effect instead of the highly sophisticated gait lab analysis, which may be unavailable in all clinical settings and the need for highly expert specialists.

Limitations of this study included a limited age range of selected participants, few specific exercises, and only one type of cerebral palsy was investigated. Randomization does not ensure variation in results as it does not recognize gender variations and severity distribution between groups. It was difficult to follow up on children, which was considered a limitation.

Conclusion

The selected task-specific training program, in conjunction with the dynamic AFO used in this trial, is beneficial in improving gait performance in children with unilateral CP when participating in physical therapy programs.

Future researches could be applied to larger sample sizes, different measured parameters, different types of CP, and different types of orthoses. Also, a follow-up assessment is recommended.

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Conflict of Interests

The authors declare no conflict of interest regarding the publication of this paper.

Ethical Approval

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Authors Contributions

All authors conceived and designed the study, conducted research, provided research materials, and collected and organized data. ETM analyzed and interpreted data. IMMI and ETM wrote the initial and final draft of the article and provided logistic support. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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