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Wieloprofilowe usprawnianie dziecka z rozpoznanym zespołem dysmorficznym uwarunkowanym heterozygotyczną mutacją w genie ZMIZ1

Multi-profile rehabilitation of a child with diagnosed dysmorphic syndrome conditioned by heterozygous mutation in the ZMIZ1 gene

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Physiotherapy in patients after myocardial infarction


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Kosmetologia • Dermatologia • Medycyna Estetyczna
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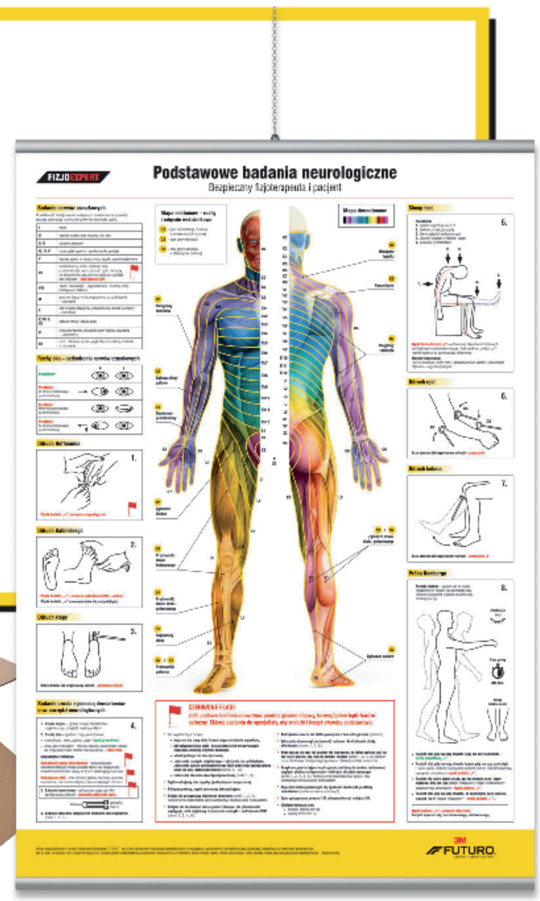

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Effect of Functional Trunk Training Program on Gait Harmony in Children with Spastic Diplegia: A Randomized Controlled Trial

功能性驱干训练计划对痉挛性双瘫儿童在步态协调上的影响：随机对照试验

Rasha Atef Saad El Metwally[1(A,B,C,E)], **Kamal El Sayed Shoukry**[2(A,D,E,F)], **Amira El Sayed El Bagalaty**[2(A,E,F)]

[1]Physical Therapy Department for Growth and Developmental Disorders in Children and its Surgery, Faculty of Physical Therapy, Cairo University, Egypt
[2]Department of Physical Therapy for Pediatrics, Faculty of Physical Therapy, Cairo University, Giza, Egypt

Abstract

Purpose. To determine the effect of functional trunk training on gait harmony in children with spastic diplegic CP by using the core stability and gait training program through strengthen the core area and the modified walker tool. Design. Single blind randomized controlled trial. Methods. Thirty children with CP spastic diplegia participated in this study with ages between four to seven years. They were randomly and equally divided into two groups (A and B), the control and study group respectively. Group A received selected physical therapy program for two hours aiming to improve functional gait ability while group B received the same as group A for only one hour plus the intervention program. The intervention program which is aiming to improve gait harmony consists of two fundamental parts. Firstly, core training and mobility exercises for half an hour. Secondly, gait training on different surfaces by using Modified walker for half an hour. Treatment was conducted for 3 times per week for a successive 3 months for both groups (control A & study B). Modified Ashworth scale (MAS) was used for sample selection. Gait harmony was measured by golden ratio equations which determine the spatiotemporal data from tracker motion analysis program version 5.0.6. Results. By using descriptive analysis to show mean ± standard deviation (SD) for all comparative variables, non-parametric test (chi square) to express the MAS values pretreatment for selection, paired t-test for measuring the pre and post treatment results within group and independent t-test between both groups (control and study) for measuring the results of Gross Motor Function Measure score (GMFM) for walking domain that showed a significant difference between both groups (A & B) post treatment. Usage of multivariate analysis (MANOVA) multivariate to determine the effect of independent variables (side, time and the intervention in both groups A&B) on the dependent variables equation (a, b, and the difference between both equations). There was a significant difference in the following: the proportion of stance/ swing phase time (equation a), the proportion of gait cycle/ stance phase time (equation b) and the difference between the values of both proportions (equation a and b) between both groups. Conclusion. It can be concluded that functional trunk training program in conjunction with a selected physical therapy program improved the gait harmony significantly in children with spastic diplegic CP. Which is obvious in gait harmony equations.

Key words:

cerebral palsy, spastic diplegia, gait harmony, golden ratio, GMFM, MAS

摘要

目的。通过使用核心稳定和步态训练计划以加强核心区域和改良的助行器，来确定功能性躯干训练对痉挛性双瘫大脑瘫痪儿童的步态协调影响。设计。单盲随机对照试验。方法。30 名年龄在 4 至 7 岁间的痉挛性双瘫大脑瘫痪儿童参与研究，他们被随机平均分配至两组（A 和 B），分别为对照组和研究组。A 组接受持续 2 小时的选定物理治疗计划，以改善功能性步态能力，而 B 组接受与 A 相同却持续 1 小时的计划和干预计划。旨在改善步态协调的干预计划包含两个基本部分，首先进行半小时的核心训练和能动性运动。然后以改良的助行器在各种表面进行半小时的步态训练。两组（对照组 A 和研究组 B）均连续三个月每周进行 3 次 治疗。肌肉张力评估（MAS）用于样本选择。步态和谐通过从版本 5.0.6.的跟踪器运动分析程序决定时空数据的黄金比例方程式测量而得。结果。通过使用描述分析显示所有比较变量的均值±标准偏差（SD），使用非参数检验（卡方）来表示预处理的 MAS 值以供选择，配对 t 检验来测量组内治疗前后的结果，并以两组间的独立 t 检验（对照组和研究组）来测量步行领域的运动功能总评分（GMFM），结果显示治疗后两组（A 和 B）均有显著差异。使用多元分析（MANOVA）多元变量来确定自变量（A、B 组间的侧面、时间和干预）对因变量方程（a、b 和两个方程间的差异）的影响。结果在以下方面存在着显著差异：姿势/摆动期时间（方程 a）的比例、步态周期/姿势期时间（方程 b）及两组间两种比例值（方程 a 和 b）间的差异。结论。结论是功能性驱干训练计划结合选定的物理治疗计划可显著改善痉挛性双瘫大脑瘫痪儿童的步态协调性，在步态协调方程中很明显。

关键词：

脑瘫、痉挛性双瘫、步态协调、黄金比例、运动功能测量评分、肌肉张力评估

Introduction

Cerebral palsy (CP) is a group of neuromuscular disorders resulting from prenatal, perinatal, or postnatal central nervous system damage. Although it is non- progressive, the abnormal disorders may become more obvious when affected children get older [1].

CP, approximately 3 in 1000 live births, makes the most common cause of physical disability in children in developed countries [2].

Children with CP spastic diplegia have poor trunk control and abnormal muscle tone (spasticity) of unequal distribution between upper and lower extremities, lower limbs are commonly more affected. In addition, They suffer from abnormal postural reflexes, alignment of trunk and abnormal back geometry which affect sitting and standing postures, their quality of life and participation in activities of daily living [3].

Core stability is the ability to control the trunk motion and position over the pelvis. It permits the optimal production of force and motion to transfer to the distal segment of the body also it helps in maintaining a good posture and stable base for arms, legs, and head coordinated movement [4].

Prior to movement of extremity, the head, neck, and core muscles need to brace for gravitational field. Complex synergy among diaphragm, pelvic floor, abdominal wall and spine extensors is essential for stabilization of the lower thoracic and lumbar spine. The muscle synergy composed of concentric contraction between diaphragm and pelvic floor followed by eccentric contraction of the abdominal wall and spine extensors. This synergy helps to increase intra-abdominal pressure [5].

Trunk control is essential for proper gait control. It plays an important role in proactive balance control, in steering (moving the center of mass to a new direction) and in attenuation of gait-related oscillations to promote stability of the head. Furthermore, the trunk interacts with the lower limb movements to achieve efficient locomotion. Poor trunk control is a primary impairment in children, adolescents and adults with cerebral palsy and may affect activities of daily life [6].

Harmony is the ability to transfer the body symmetry into alternated, synchronized, symmetric, and rhythmic movements in intra limb, inter limb and lower-upper body coordination. It is important feature in saving the smoothed and efficient movements during walking [7].

GMFM is the scale that assesses and measures changes over time in gross motor function in children from birth to 16 years. It has 88 items arranged in five sections or dimensions of lying and rolling, sitting, crawling and kneeling, standing and walking, running and jumping. Change in each dimension as well as total score is calculated in percentage scores. The GMFM measures achievement of motor function but not the quality of performance [8].

Researchers have noted that the proportion between stance and swing phase is close to Φ, an irrational number (about 1.618034) already known in ancient Greece as "golden ratio". This number has been related to the problem reported by Euclid in III century BC to cut a given straight line so that the proportion between the shorter part to the longer one is the same as the longer part to the whole [9].

In children with CP spastic diplegia, there is poor and abnormal movement of trunk was detected even after training programs because those children gain improvement in lower limbs reciprocation before developing proper trunk control. The purpose of the study was to determine the effect of functional training program of both trunk and pelvis to improve gait harmony in children with spastic diplegic CP. This program based on improving core stability and gait pattern in a modified walker.

Materials and methods

Study Design

This study was an experimental study randomized, single-blind study that was performed at the Outpatient Clinic of the Faculty of Physical Therapy, Cairo University. Data collection and treatment application of both groups, started in March 2017 and finished in January 2018.

Participants

Thirty children diagnosed as spastic diplegic CP participated in this study. Their ages ranged from 4-7 years. Children were included if they met the following criteria:

1. the degree of spasticity ranged from grade 1 to 2 according to MAS,
2. they could follow the instructions during testing and training,
3. they could stand holding on with one hand,
4. they could walk holding on according to GMFCS (level II & III),
5. they could walk between parallel bars with forward flexed posture.

Children were excluded if they fulfill the following criteria:

1. they have any visual or auditory problems,
2. they have any structural deformities in hip and knee joints or bone,
3. they were controlled by medications that affect muscle tone or motor functions.

Randomization

Written informed consents were obtained from children parents or caregiver after explaining the nature, purpose and benefits of the study. They were informed about their right to withdraw or refuse at any time, and the confidentiality of any obtained information. The children included in this study were classified randomly into two groups through using cone method of equal numbers, group A (control group) and group B (study group). Each group included fifteen children.

Instrumentations

A) For evaluation:

1. Video gait analysis by using [10]:

- Digital camera with three-point stand with modifiable length.
- Hard ware: computer
- Software: tracker motion analysis system version 5.0.6.

• Memory card for saving videos and transferring data from the camera to the computer.

Spatiotemporal gait parameters that include gait cycle time, stance phase time, and swing phase time were measured for all enrolled subjects before and after treatment program. After that, the gait harmony was calculated using the irrational number (Golden Ratio ϕ =1.62) for right and left limb in both groups (A & B)[11].

2. Gross Motor Function Measurement scale (GMFM):

The domain that was measured is E. Walking, running, and jumping (total dimension E/72) × 100 =%

B) For treatment:

Tools used for core training program:

• Mat, balls with different sizes (gymnastics and medicine) and rolls with different size.

The modified walker device [12] formed of fig. (1):

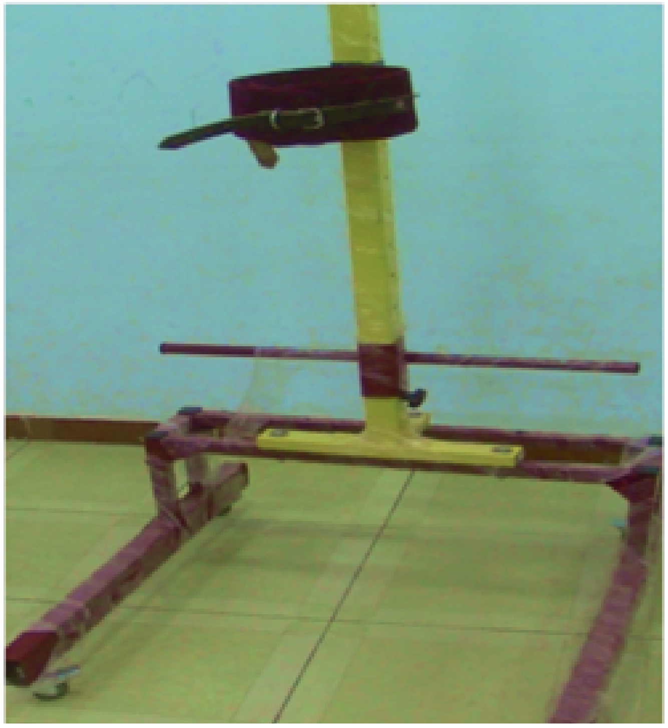

Fig. 1. The modified walker device

• Posterior vertical bar with one belt.
• Belt moderately flexible, padded for comfortable use and adjustable height and width.
• U shaped base, and wheels with brakes for easily moving the device and safety.
• Base permit for walking on different tools.
• The belt could be used as a pelvic belt for prevention of the pelvis from over rotation, over posterior or anterior tilt or as a thoracic belt rapped under axilla to reduce the forward, lateral bending and rotation of the upper trunk.
• The belt width customized according to the child's age.

Stable /Unstable surfaces:

• Stepper, separator, wedges, gravity bars, balance beam, toys car and spring wedges.

Interventions

Control group (A): fifteen children CP spastic diplegia were included in this group; they received a selected physical therapy treatment aiming to improve gait abilities for 2 hours, 3 times / day, for 3 successive months.

Study group (B): fifteen children with spastic diplegia were included in this group; they received the same selected physical therapy treatment for one hour in addition to intervention program directed toward improving the gait harmony formed of:

Core stability training program for half an hour.

Gait training program with modified walker for half an hour on different surfaces.

The intervention was conducted for 3times /day, for 3 successive months.

Treatment procedures for study and control groups:

Children in both groups received a designed physical therapy program directed toward improving walking abilities and gait harmony for three times per week for three successive months, it included the following:

Neurodevelopmental technique (NDT) [13]:

NDT practice model view the desired outcomes of intervention that include improvement of functional abilities and activities participation. An intervention plan based on enhancing levels of motor development which is valued by individuals.

Functional training program

Closed kinetic chain movements

Closed chain (CC) movements refers to movement of the body on the limbs when the distal segment of the limb is supported on stable surface:

– Exercise 1: upper limb weight bearing from sitting position.

Child position: sitting on high bench facing in front of the table, one upper limb supported on other table at the level of the hip with slight flexion of elbow joint.

Therapist position: beside the child`s supporting arm for support and control the movement.

Order: ask the child to take small forward step and to reach the object on the table.

– Exercise 2: upper limb weight bearing at standing position.

Child position: standing facing bench in front with one arm supported at the height that allow elbow to be in slight flexion.

Therapist position: behind the child, holding both knees to control knee and ankle movement.

Order: ask the child to reach up into the object forward.

– Exercise 3: up and down squatting.

Child position: standing with trunk against the wall.

Therapist position: sitting in front of the child with his feet over the child's feet for support and his hands grasping the child's knees to control movement down.

Order: ask the child to descend slowly till 90 of knee flexion and return slowly while maintaining the trunk erect.

Modified chain

Modified chain (MC) can be defined as the distal segment of the limbs maintains contact with a surface and either the distal segment and surface move together.

– Exercise 4: single limb stance with the other limb supported on small ball moving it in different directions.

Child position: standing, one foot on fixed surface (i.e. gravity bar) and the other foot on medicine ball.
Therapist position: sit behind the child with one hand holds the stance limb and the other hand on movable foot to control foot movement on ball.
Order: ask the child to move medicine ball at different directions.
– Exercise 5: standing on mechanical stepper for lower limb reciprocal movement.
Child position: standing on mechanical stepper, holding on if needed.
Therapist position: back to child, both hands around the hips, thumb make forward pressure over ischial tuberosity, and fingers make outward movement on both thighs.
Order: make reciprocal movement for lower limbs, trunk erect above mechanical stepper.
– Exercise 6: walking forward while pushing toys car for improving the trunk extension.
Child position: stride standing, holding toys car forward.
Therapist position: beside the child with one hand on car bar to control the car movement and the other hand free steady for any abnormal movement.
Order: ask the child to push a car forward while maintaining the trunk erect.

Open chain
The limbs move selectively and free in space.
– Exercise 7: take high step forward.
Child position: standing holding on if needed.
Therapist position: back to child, foot of therapist on foot of the supporting limb of the child, one hand makes locking for knee, the other hand stimulate limb for elevation, teach then make actively, fade assistance if needed.
Order: ask the child to touch bench/ step forward with child's toes then return, repeat on opposite side. (N.B: avoid hyperextension of the trunk, hip hiking, and lateral bending of the trunk and rotation of the trunk or pelvis).

Gait training
– Exercise 8: walking holding bars closed environment.
– Exercise 9: walking holding sticks for reciprocal movement upper and lower limbs.
– Exercise 10: walking on balance beam.

Base of support (BOS) changing for improving static and dynamic balance through:
1. Manipulate BOS through
– Work for modified chain (MC) movement then open chain movements (OC).
– More body segments compose the base → fewer segments compose the base.
– Movement of one body segment of the base→ multiple segments of the base are manipulated at the same time using assistive device (e.g.: sticks, stand bar).
– The surface that the child use for weight bearing are going to change from stable → less stable→ mobile.
2. Decrease BOS by moving the COM over a smaller space like (shifting from ring sitting→ bench-sitting→ standing, or shifting from quadruped → kneeling→ half kneel → standing.
3. Transitional activities:
– Sit to stand
– Stand to sit
– Up and down in squats
– Loading/terminal stance weight shifts in standing.
– Cruising → reaching across space toward a stable object.
– Standing to balance → taking a step → multiple steps.
4. Combine movements:
– Sit to stand with stepping.
– Sit to stand holding an object.
– Walking and stooping to pick an object up.
– Walking and changing directions.
The repetition of each exercise depends on the child participation and endurance.

Treatment procedures for study group only
Children in the study group received the same designed physical therapy program for 3 times per week for three months, in addition to intervention program directed toward improving the gait stability, harmony and symmetry.
These sessions were completed within an average of 12-14week span. Actual total therapy sessions took 2 hours (one hour for the designed physical therapy program and 1 hour for intervention program directed toward improving the gait harmony. Sessions were under the supervision of the therapist that ensure the performance of the child properly as much as they can.

Core training program [14]
Supine position
Starting position: the child will lie on his back on mat with hips and knees bent to 90 degrees over a physio ball.
Therapist position: sit at the side of the child at pelvis level, support one hand on the legs and the other hand on both ASIS to prevent elevation of the pelvis.
Order: slowly and with control, ask the child to rotate knees to one side keeping hips in contact with the floor; engage obliques to pull knees back to center and repeat on the opposite side; Repeat 5-10 times on each side.
Starting position: the child will lie on his back on mat with hips and knees bent to 45 degrees and his feet flat on the medicine ball.
Therapist position: sit at the side of the child at pelvis level, support one hand on feet and the other under the buttocks to guide the motion.
Order: ask the child to raise his pelvis about 2 to 3 inches' maximum off the floor. Hold this position for 3 – 5 seconds; slowly bring his pelvis back to start. Repeat 5-10 times.
Starting position: the child will lie facing upward on mat with knees straight, feet resting on physio ball, arms at sides.
Therapist position: sit at the side of the child at pelvis level, support one hand on feet and the other under the buttocks to guide the motion.
Order: contract your abdomen then slowly lift your pelvis off the floor until trunk and thigh on the same line; hold for 3-5 seconds; slowly return to starting position. Repeat 5-10 times.

Sitting position

Starting position: the child will sit on physio ball against wall with feet planted.

Therapist position: sitting in front of the child close to him and hold a medicine ball.

Order: ask the child to take the ball and move it side to side. Repeat 5-10 times.

Starting position: the child will sit on physio ball with his spine straight against wall, knees at 90 degrees and his hands on his hips. His feet should be shoulder width apart.

Therapist position: sitting in front of the child close to him, one hand supports the uprising limb at pelvis level.

Order: ask the child to slowly raising the right knee into hip flexion and hold for a 3 -5 second count; keeping hips level then bring knee down to starting position; repeat on opposite side. Repeat 5-10 times.

Gait training program with modified walker for half an hour on different surfaces

1. The therapist puts the child at modified walker,
2. Adjust the belt on the child.
3. Ask the child to walk while moving the pelvis forward with trunk erect till pelvis lined on the supported foot and hands free.
4. Ask the child to weight shift his body on supported limb and raise the other for swing phase through single limb support, the child continued the progression of the pelvis till hip hyper extended and the stance limb heel elevation.
5. With the same steps ask the child to walk at stepper, separator, treadmill and on spring wedges

Outcome measures

1. Modified Ashwarth Scale (MAS) for the children selection pretreatment for measuring the muscle tone [15].
2. GMFM for walking domain pre and post treatment within each group by using paired t-test and between both groups (control and study) by using independent t-test.
3. Golden ratio ϕ (the irrational number = 1.62) was done by calculating equation (a) that denotes the proportion of stance to swing phase period and equation (b) that denotes the proportion of gait cycle to stance phase period. The result of both proportions should meet the irrational number ($\phi = 1.62$). These results demonstrate gaining of gait harmony. Gait harmony was evaluated by measuring the equation (a) and equation (b) pre and post treatment for both lower limbs in both control and study groups and the difference between both equations (a & b).

ϕ = stance/swing = 1.62------------------(a)

ϕ = gait cycle/stance = 1.62------------------(b)

$\phi = (1+\sqrt{5})/2$ = GC/(Stance phase) = stance/swing = 1.67

Statistical analysis

Results were expressed by using descriptive analysis to show mean ± standard deviation (SD) for all comparative variables, non-parametric test (chi square) to express the MAS values pretreatment for selection, paired t-test for measuring the pre and post treatment results within group and independent t-test between both groups (control and study) for measuring the results of walking domain (GMFM). Usage of multivariate analysis (MANOVA) multivariate to determine the effect of independent variables (side, time and the intervention in both groups A&B) on the dependent variables equation (a, b, and the difference between both equations). Statistical Package for Social Sciences (SPSS) computer program (version 20 windows) was used for data analysis. P value ≤ 0.05 was considered significant.

Results

Both groups were similar at baseline ($p>0.05$) regarding age and GMFM for walking domain as shown in table [1], and regarding to MAS as shown in table [2]. The total sample was thirty children randomly assigned into two groups, there was no statistically significant differences between groups as in table [1] and [2].

Table 1. Mean age for group A and B

Items	Group A Mean ± SD	Group B Mean ± SD	P-value	S
Age (years)	5.79 ± 0.99	5.83 ± 0.9	0.45	NS
GMFM for walking	11.56±2.43	12.59±1.85	0.2	NS

SD: standard deviation, S: significance, NS: non-significant

Table 2. descriptive analysis of non-parametric tests (Mann whitney) for Modified Ashwarth Scale (MAS) to both groups pretreatment for selection

MAS (Modified Ashwarth Scale)	Group A frequency	Group B frequency	Mann-Whitney	p-value	S
1	6	5	107.5	0.826	NS
1+	5	5			
2	4	5			

SD: standard deviation, S: significance, NS: non-significant

The descriptive statistics of GMFM variable measured pre and post-treatment were presented in table [3] and their inferential statistics regarding paired and unpaired t-test were presented in table [3]. There was a significant difference in independent t-test post treatment between both groups (A & B) for GMFM walking domain. There was a significant difference in the paired t-test between pre and post treatment in group A (control group). The percentage of improvement was 25.6%. There was a significant difference in the paired t-test between pre and post treatment for group B (study group). The percentage of improvement was 45.51%. between groups.

Table 3. Descriptive and Inferential statistics of GMFM for walking domain variables measured within group (pre and post treatment for group A and B) and between groups for post treatment

Items	Group A (study)		Group B (control)		P-value within group (A)	P-value within group (B)	P-value between group (post)
	pre	post	pre	post			
GMFM	11.56 ± 2.43	14.53 ± 2.39	12.59 ± 1.85	18.32 ± 1.83	0.0001	0.0001	0.0001

The descriptive analysis for both equations (a, b, and the difference between a & b) which denotes the proportion between stance and swing phase time and the proportion between gait cycle and stance phase time respectively and the difference between both equations (a & b) showed in table [4].

Table 4. Descriptive statistics of equation (a) and equation (b) for Mean and SD

Item	Group A (control group)				Group B (study group)			
	Pre		Post		Pre		Post	
	Right	Left	Right	Left	Right	Left	Right	Left
Stance/swing phase time	17.27 ± 4.6	14.12 ± 3.5	11.7 ± 1.6	11.3 ± 2.7	19.35 ± 3.63	14.5 ± 3.3	4.39 ± 1.7	6.44 ± 2.9
Gait cycle/stance phase time	1.22 ± 0.19	1.19 ± 0.17	1.33 ± 0.17	1.35 ± 0.17	1.18 ± 0.21	1.19 ± 0.18	1.39 ± 0.17	1.33 ± 0.18
Difference between (a & b) equations	16.05 ± 4.7	13.3 ± 3.5	10.39 ± 1.6	10.05 ± 2.9	18.1 ± 3.6	12.7 ± 3.4	3.18 ± 1.9	5.4 ± 3.1

– Equation (a): the percentage of improvement at the right limb in group A (control group) was 32.25%, and at the left limb was 19.97%. the percentage of improvement at the right limb in group B (study group) was 77.3% and at the left limb was 55.5%.
– Equation (b): the percentage of improvement at the right limb in group (A) was 8.27% and at the left limb was 11.85%. the percentage of improvement at the right limb in group (B) was 15.1% and at the left limb was 10.5%.
– Difference between (a & b) equations: the percentage of improvement at the right limb in group (A) was 35.26% and at the left limb was 24.44%. the percentage of improvement at the right limb in group (B) was 82.4% and at the left limb was 57.48%.

Item	*Within groups* Group A (control group)				Group B (study group)			
	Pre vs. Post		Right vs. Left		Pre vs. Post		Right vs. Left	
	Right	Left	Right	Left	Right	Left	Right	Left
Stance/swing phase time	0.000*	0.000	0.01	0.57	0.000	0.000	0.002	0.02
Gait cycle/stance phase time	0.086	0.03	0.95	0.4	0.000	0.000	0.86	0.4
Difference between (a & b) equations	0.000	0.000	0.016	0.54	0.000	0.000	0.002	0.017

Group A vs. Group B	*Between groups* Pre		Post	
	Right	Left	Right	Left
Stance/swing phase time	0.18	0.76	0.000	0.000
Gait cycle/stance phase time	0.63	0.49	0.37	0.85
Difference between (a & b) equations	0.04	0.75	0.000	0.000

– Group A:
*equation a: there was a significant difference pre and post treatment for both limbs (right and left). also there was a significant difference of right versus left limb pre-treatment and non-significant difference post treatment.
*equation b: there was a non significant difference of right limb pre and post treatment and a significant difference of the left one. there was a non significant difference of right versus left limb pre and post treatment.
*difference between a & b: there was a significant difference pre and post treatment for both limbs (right and left). there was a significant difference for right versus left limb pre treatment and non significant difference post treatment.
– Group B:
*Equation a: there was a significant difference pre and post treatment for both limbs (right and left) and a significant difference for right versus left pre and post treatment.
*Equation b: there was a significant difference pre and post treatment for both limbs and a non significant difference for right versus left limb pre and post treatment.
* Difference between a & b: there was a significant difference pre and post treatment for both limbs and for right versus left limb pre and post treatment.
– Between both groups (A and B):
for equation a and b, the results revealed non significant difference pre-treatment and significant difference post treatment for equation (a) and non significant difference for equation b. for the difference between both equations, there was a significant difference at right limb pre-treatment while left limb with non significant difference. there was a significant difference post treatment for both limbs.

Discussion

There is a consistent pattern of disorganization in children with CP spastic diplegia with respect to muscle activation patterns at both sitting and standing positions while postural perturbation occur. These children also seem to retain immature postural response characteristics seen in typically developing children of younger ages [16].

Trunk control plays a significant role in the human body mobility as it involves the selective movements of the trunk, head, and extremities which helps in acquiring stabilization and free movements. Upright functional activity is affected by impairments in postural muscle function that has a negative effect on the participation in various activities. So the directed treatment to improve trunk and hip muscle activation may increase functional ability [17].

The present study was conducted to determine the effect of functional trunk training program on gait harmony in children with CP spastic diplegia.

The results of the current study revealed a significant difference in the post treatment values of GMFM for walking domain ($p < 0.05$) and a significant difference within the groups pre and post treatment. Also the results showed the impact of the independent variables (side, time, and intervention) on the proportion between stance and swing phase time (equation a), gait cycle and stance phase time (equation b) and the difference between both equations (a & b).

The results of this study after the suggested period of treatment demonstrated the rate of improvement in the study group higher than the control group in the dependent variables (1) GMFM of walking domain, (2) gait harmony and symmetry equations. We gained a significant difference in measuring the relation between equation (a & b) so that the intervention program at both groups had lower impact effect on this item. It may be revealed to the absence of double limb support value that not inserted in equation (a) but included within gait cycle whole time in equation (b).

Our results are consistent with those of previous studies reporting deteriorated gait function and altered gait pattern in children with spastic diplegic CP [18]. When comparing them with normal development children, the percentages of right and left double-limb support during stance phase were higher in CP spastic diplegia [19]. It may be revealed to reduce hip adduction in the stance phase increases the internal abduction moment of the support limb and weakness of the hip abductor muscles [20. 21].

The significant improvement of walking domain and gait harmony (equation a & b) may be attributed to the concentration of the training program on strengthening the trunk and abdominal muscles (core area) in addition to use the benefits of group muscles core training in functional gait training with maintaining the correct posture and controlling the compensatory movements during the gait cycle that comes in agreement with Chung et al. [22] who studied core training that might improve the stability of the lower trunk and pelvis and result in increased the ability of static balance, dynamic balance, and weight support bilaterally. Milot et al. [23] who stated that the group muscle training and functional strengthening program might lead to a greater carryover effect and impact on gait. The significant improvement of walking domains noticed in the children's ability to walk with one hand held instead of two handheld and walking cruising 10 steps instead of 5 with partial improvement in the ability to walk independently forward with wide base and narrow base.

The usage of modified walker device for functional gait training in children with CP spastic diplegia and studying the effect of this training on spatiotemporal parameters of the gait cycle to gain gait harmony comes in agreement with Booth et al., [24] that provides greater evidence confirm that functional gait training in children and young adults with CP is a safe treatment intervention to target improvement of gross motor function, walking endurance, spatiotemporal gait parameters, and functional mobility. The modified walker device used as a modification to passive stander device that studied by Kecskemethy et al. [25] who demonstrated the positive effect of it on the modulation of muscle tone, reduce contractures risk, more rapid gross motor development, improved interaction with one's environment also the mechanical loads importance for obtaining and maintaining bone mineralization.

The functional gait training helps in acquiring gross motor progression and that comes in agreement with Mills et al., [26] who stated that functional movement is the ability to produce and maintain a balance between mobility and stability along the kinetic chain while performing fundamental patterns with accuracy and efficiency. Muscular strength, endurance, coordination, balance and movement efficiency are components necessary to achieve functional movement, which is integral to perform gross motor skills.

Walking with modified walker using thoracic belt reduces the forward head tilting that produce benefit result on the vestibular system which plays an important role in controlling locomotion. Vestibular system detects the head angle with respect to gravity that hypothesized that during complex movement like walking the postural control is controlled by controlling of gaze which is called "top down mode" [27].

Our hypothesis of the significant improvement of the equation (a and b) was using modified walker that helps the child to generate a propulsive force to keep the body in motion by finding the COM of the body anterior to the supporting foot by the end of stance phase and the usage of it helps the body to be erect that may increase the energy that is generated by the plantar flexor groups as mentioned by Gage et al. [28] who stated that two-dimensional kinetic data have revealed that approximately 85% of the energy for normal walking comes from the plantar flexors of the ankle and 15% from the flexors of the hip and transferring it to the trunk to provide support and forward progression as mentioned by Meinders et al. [29] who stated that the conceptual frameworks regarding plantar flexors function are (1) restraining the forward movement of the trunk over the ankle joint, (2) accelerating the leg into swing phase and (3) actively propels the trunk upward and forward.In the current study, the training program included the usage of unstable surfaces for gait training which stimulate the three senses of the body (somatosensory- visual and vestibular senses) which have a critical role to improve the ability to modify how walking is, that comes in agreement with [30] who assumed that the sensory information from the limbs contributes to appropriate stepping frequency as the duration of the step cycle.

The results of the study may have revealed to the concentration of the training on the second determinant of gait (stance limb progression), which has complete responsibility for supporting body weight on a single limb support while maintaining whole-body stability (balance), and restraining forward momentum as mentioned by Perry & Burnfield [31] gait involves the displacement of body weight in a desired direction, utilizing a coordinated effort between the joints of the trunk and extremities and the muscles that control or produce these motion. The stability of the weight-bearing foot throughout the stance phase is one of the four priorities that the author mentioned. [32] showed that gait cycle has three basic tasks. firstly, the acceptance of the body weight, then transfer all the weight onto a single limb support and then provide limb advancement when unloaded. The motion of individual involved joints must be functional and their movements choreographed with each other in a seamless, well-timed manner.

Our results may be attributed to the interaction of the traditional program with our intervention. It comes in agreement with Begnoche & Pitetti, [33] who stated that a combination of traditional physical therapy and gait training using unstable surfaces is shown to improve motor skills in children with CP.

From the previous discussion of the results of this study, it can be suggested that adding of core stability training program and functional gait training using modified walker device to the selected physical therapy program improve the functional walking abilities and gait harmony of the children with spastic diplegia.

Conclusion

The results of this study provided evidence of the combination of functional trunk training program in addition to the designed physical therapy training program to improve the walking abilities and gait harmony that appears in proportion of stance phase time to swing phase time and gait cycle to stance phase time.

Adres do korespondencji / Corresponding author

Rasha Atef Saad El Metwally

E-mail: rashaatefsaad@gmail.com

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