

Effect of pelvic girdle stability training on functional sitting control in children with hypotonic cerebral palsy

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ABSTRACT

The aim of this research was to examine the impact of pelvic girdle stability training in children with hypotonic cerebral palsy on functional sitting control. Thirty children with hypotonic cerebral palsy in both sexes, with their ages ranging from two to four years were used in the study. There were fifteen children in the experimental group and fifteen children in the control group. The study group received pelvic girdle stability training program in addition to a selected program for upper limbs and trunk muscles strengthening exercises, while the control group received only the selected program for upper limbs and trunk muscles strengthening exercises. Results revealed significant difference of GMFM88 (sitting domain) ($P < 0.01$), stationary raw scores and stationary standard scores of PDMS-2 ($P < 0.05$) but no significant difference of age equivalent of PDMS-2 ($P > 0.05$). GMFM88, on the other hand, had a significant difference (sitting domain) ($P < 0.05$) but no significant difference of stationary raw scores, stationary standard scores and age equivalent of PDMS-2 ($P > 0.05$) in the control group. Paired t-test were conducted for comparison between pre and post treatment mean values of sitting domain and stationary scores in each group. From the obtained results of the present study, we conclude that pelvic girdle stability training program was more effective in generating core muscle activity for functional sitting control compared to traditional physical therapy of upper limbs and trunk muscles strengthening exercises in children with hypotonic cerebral palsy.

Keywords: Pelvic girdle stability, functional sitting control, hypotonic cerebral palsy.

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INTRODUCTION

The pelvic girdle is the bony structure, which attaches the legs to the body. It consists of the pelvis and the base of the spine (sacrum). Pelvic girdle stability is the ability of the surrounding core muscles to support this structure. The muscles involved are the bottom (gluteus), tummy (abdominal), thigh (quads and hamstrings) and the pelvic floor. This develops from an early age as a baby begins to roll and crawl (Cambridgeshire, 2018). Children with low muscle tone often present with weakness in the core muscles (neck and trunk muscles) and difficulties with maintaining a stable head and trunk posture in many activities. Core (trunk and neck) muscle strength and postural alignment and stability are closely linked, with different body positions and tasks requiring different degrees of muscle strength and coordination (Cignetti et al., 2013). Cerebral palsy is a heterogeneous group of

non-progressive motor disorders of developing brain is cerebral palsy. In fetal life or early infancy, this occurs from a lesion or developmental abnormality. Because of altered co-activation of trunk and hip muscles, children with hypotonic cerebral palsy frequently have issues with impaired trunk control and exhibit weak sitting postures against gravity (Dureja and Verma, 2018).

Neurological muscle tone is a representation of the capacity for periodic action of motor neurons since it is an inherent feature of the nervous system; voluntary control, exercise, or diet will not change it. The muscle's inherent ability to respond to stretch is true muscle tone (Bodensteiner, 2008). A child with hypotonia has muscles which are sluggish against an outside force to initiate contraction, and cannot sustain muscle contraction for as long as possible. In other words, even

though the outside force might still be present, the muscles "relax" faster (O'Sullivan and Schmitz, 2007).

Children with hypotonic cerebral palsy show difficulty in achieving static and dynamic trunk control in sitting due to faulty feedback mechanisms. As a result of this the postural control system is unable to generate appropriate muscular forces and integrate sensory information received from receptors present throughout the body; thus, leading to "Postural Dyscontrol" (Cheryl, 2006).

Depending on how the child is affected, treatment of hypotonia differs. A treatment plan will shape the overall health of the child and the desire to engage in therapies. Depending on the ability of the child, some children also work with physical therapists and may work for specific purposes, such as sitting upright or walking. Children with serious condition may need wheelchairs for mobility and, because joint dislocations are common, this condition makes the joints very loose (Roddick and Selner, 2016).

During functional balance and mobility tasks, pelvic stability refers to the ability to coordinate activity among the lower trunk and the proximal hip muscles in which the pelvis offers proximal dynamic stability to allow efficient mobility of the lower limb (Lee and Hodges, 2004).

The aim of this research was to evaluate the impact of pelvic girdle exercises in children with hypotonic cerebral palsy on functional sitting control.

It was hypothesized that pelvic girdle stability training in children with hypotonic cerebral palsy had no effect on functional sitting control.

MATERIALS AND METHODS

Participants

In this randomized control trial (RCT) study design, thirty children (19 males and 11 females) with hypotonic CP, with ages ranged from two to four years were included in the present study. The inclusion criteria were; participants had level (II) in gross motor function classification system (sit on the floor, but if both hands are free to manipulate objects, they can have trouble with balance. Without adult help, movements in and out of sitting are done. Children pull on a steady surface to stand. As preferred mobility methods, children crawl on hands and knees with a reciprocal pattern, cruise on furniture and walk with an assistive mobility system), they had mild to moderate degree of hypotonia (not floppy), their age ranged from 2 to 4 years. They were selected according to the inclusion from both sexes. They could understand and follow instructions. They could start pelvic bridge from crook lying position. They received traditional physical therapy since at least 6 months as determined from their medical files without focusing on pelvic core stability training. The exclusion criteria included children with seizures, structural scoliosis, contractures that could interfere with procedures of treatment, surgical procedures in the last 12 months, severe intellectual disability or significant perceptual disorders were excluded. They were recruited from the outpatient clinic of the physical therapy department, Fayum General Hospital. The current study started from February 2019 to September 2019.

They were assigned randomly into two groups. The study group consisted of 15 children (8 males and 7 females) who received pelvic girdle stability training program in addition to a selected program of upper limb and trunk control strengthening exercises.

Whereas, the control group consisted of 15 children (11 males and 4 females) and received the same selected program of upper limb and trunk control strengthening exercises given to the study group.

Materials

Evaluation

Functional sitting control was assessed using gross motor function classification system expanded and revised for classifying children gross motor abilities, gross motor function measure 88 scale was utilized to assess gross motor functions of sitting in the hypotonic CP children and peabody developmental motor scale -2(PDMS-2) which was used to assess stationary subtests.

The following tools were used during assessment through Peabody scale:

- (A) Chair
- (B) Pillow
- (C) Stopwatch

Treatment

The following tools were used during treatment:

- (A) Mat
- (B) Magnetic darts board
- (C) Therapeutic ball

Procedures

Evaluation

A) Gross motor function measure scale 88

The gross motor function measure (GMFM-88) scale examines the condition and changes in the condition of motor proficiency owing to therapeutic interventions (Styer-Acevedo, 2008).

I - Test administration and scoring: It enables the examiner to have a good awareness of the potential areas of vulnerability of the participant. Scoring is defined as follows 0: Does not initiate. 1: Initiates. 2: Partially Completes. 3: Completes. The scores are added together and the final score is presented as a percentage; thus, a slight shift over time can be observed (Eek and Beckung, 2008). Any item which has been excluded or the child is unwilling or unable to try shall be scored as 0. A maximum of three trials on each item are permitted for the child. In each dimension, percentage scores are calculated and averaged to obtain a total score ranging from 0 to 100. Higher scores suggest improved capability (Russel et al., 2002).

II - Interpretation: Sitting domain on the GMFM-88 has 20 number of items, and it contributes to the total score therefore a percent score was calculated for this domain [(child's score / maximum score) 100]. For sitting dimension, the sum of scores range from minimal 0 to maximal 60 (equals 3 × 20). By adding the percent scores for each dimension and dividing by five, the total score is obtained (Styer-Acevedo, 2008).

Validity: The construct validity was assessed by establishing the GMFM responsiveness to change over time in children with CP.

Reliability: Evidence of the reliability of measurements obtained with the GMFM had been established by several investigators for its

use with children with cerebral palsy or brain damage and for children with Down Syndrome (Lundkvist et al., 2009).

In this study, it was used only to examine gross motor developmental delay in sitting milestones for study and control groups of hypotonic cerebral palsy children by using sitting domains of GMFM-88.

B) Peabody developmental motor scale 2 (PDMS-2) (Folio and Fewell., 2000).

This part was performed in the following steps: I - Test administration, II - test scoring and III -Interpreting the results.

I - Test administration: The tests were administered in a quiet, comfortable, and non-distracting environment. Appropriate adaptive instructions were used for each participant.

For all subtests, entry/start point, basal level and ceiling level were used. The time required to administer the selected subtest comprising the gross motor composites (stationary) in (PDMS-2) was 20 to 30 min. Item administration begins at the maximum item to examine gross motor developmental delay in sitting milestones (stationary subtest item 19) (entry point). The child should receive a score of 2 on the first three consecutive items to go forward. If on each of the first three items administered, starting from the entry point, the child scored 0 or 1. We tested backward until the child scored 2 on the three items in a row (basal level). If the basal was established, more difficult items were administered gradually by the examiner until a ceiling was established. When the child scored 0 on each of three items on a raw item, the ceiling is defined (ceiling level). A child was given a maximum of 3 trials for each item before scoring. Each item was given a score of 0, 1 or 2. The child's total raw score for each subtest was computed by adding the total score for all items in the subtest.

II - Test scoring: The PDMS are based on scoring each item as 2, 1 or 0. The general criteria for scoring item were as follows:

2 The child carried out the item on the basis of the criteria defined for mastery.

1 The performance of the child indicates a strong similarity to the criteria for item mastery, but it did not entirely fulfill the criteria.

0 The child was unable or unwilling to try the item, or the attempt did not demonstrate that the skill had emerged.

III - Interpreting the results: Rawscore, age equivalents, and standard scores for the subtests were calculated. From the raw scores calculated from each subtest, the age equivalent and standard scores are obtained from the norms tables (Table C) provided in the manual.

For treatment

Participants of the study group received pelvic girdle stability training program for 30 minutes. In addition they were received a selected program of upper limb and trunk control strengthening exercises that were applied for 30 min. Sessions were carried out three times per week for three months. The pelvic girdle stability training program (Cambridgeshire, 2018) included the following:

Pelvic bridge: Child was in crook lying position. She was stimulated or guided to lift the pelvis from the mat and hold it for 3 s. This was repeated 20 times (Figure 1).

One leg bridge: Child was in crook lying position with one leg crossing over the other leg. She stimulated or instructed to lift the pelvis off the mat, held it 3 seconds and repeated 10 times. This was repeated on her other leg (Figure 2).



Figure 1. The therapist stabilizes the pelvis of the child.



Figure 2. The therapist stabilizes the pelvis on the side of bridging.

Clam exercise for gluteus medius: The child was lying with both hips and knees flexed to 90° on the side. He/she stimulated or instructed to abduct the top hip against the gravity, held it 3 second and repeated 10 times. This was repeated on his/her other leg (Figure 3).

Hip abductor strength training: Child was in crook lying position with hip abducted. The therapist placed his hands on lateral aspect of both child knees. Then he/she stimulated or instructed his/her to adduct both leg. This was repeated 20 times (Figure 4).

Leg lift: Laid the child on his tummy with his legs straight. Instructed or stimulated to lift one leg with the knee straight just off the floor. Held this position for 3 s and repeated 10 times. This was repeated on the other leg (Figure 5).

4 point kneeling arm lift: The child was put the on his/her hands and knees with his knees under hips and hands under shoulders. He/she was facilitated him by magnetic dart to lift one arm forward



Figure 3. The therapist stabilizes the foot on the other one.



Figure 5. The therapist stabilizes the pelvis with used a pillow under the pelvis.



Figure 4. The therapist stabilizes both knees in abduction position.



Figure 6. The child substitutes his/her trunk during functional movement.

in line with his shoulder to reach it. Held this position for 3 s and repeated 10 times. This was repeated on his other arm (Figure 6).

Participants of control group received a selected program of upper limb and trunk control strengthening exercises that were applied for a session of 60 min three times a week for 3 months. The selected program included the following:

a) Weight bearing on both hand

Performed in a prone position by weight bearing on both hand and sustained for 30 to 60 s and repeated 5 times.

b) Push up exercise

Performed in a prone position by raising the upper body using the arm and repeated 5 to 10 times.

c) Sitting up exercise

Trunk flexion was the act of bending at the hip to sit up from a lying position and repeated (20) times.

d) Righting reaction exercise

Position therapist hands with his thumbs and pointer finger supporting the child on his pelvis. The child was encouraged to righting reaction on the ball.

e) Tummy time on therapy ball

A prone position was performed in on therapy ball. Encouraged the child to raising head on the ball and sustain as much as he can and repeated for 5 min (Figure 7).

f) Quadruped positioning

Encouraged the child to raising his body on his hands and knees and held for 5 min (Figure 8).



Figure 7. The therapist stabilizes the lower trunk with leaning the child forward.



Figure 8. The child has difficulty to maintain his quadruped position without substitution.

RESULTS

Data obtained from both groups pre and post treatment regarding functional sitting control have been analyzed and compared statistically.

The findings of all variables between the study and control groups before treatment were statistically non-significant ($p > 0.05$).

For comparison of the average age among the two groups, descriptive statistics and t-test were carried out.

In order to compare the sex distribution among the two groups, the Chi square test was carried out.

For comparison among pre and post-treatment average values of the sitting domain and stationary scores in each group, the paired t test was performed.

General characteristics of the subjects

Table 1 shows general characteristics of the children in both groups including sex and age, 6 males (31.58%) and 3 female (27.30%) were from 21 to 30 months of age, 8 males (42.10%) and 4 females (36.35%) were from 31 to 40 months of age and 5 males (26.32%) and 4 females (36.35%) were from 41 to 50 months of age.

Comparison between study and control groups pre and post treatment

Comparing the mean values of GMFM in both study and control groups

As is seen in Table 2, a comparison between the average pretreatment values in both groups (study and control) were 37.84 ± 6.11 and 38.31 ± 6.50 , respectively, which is non-statistically significant ($P > 0.05$). Comparing the mean values post treatment in both groups, they were 43.76 ± 6.7 and 40.3 ± 6.4 , respectively. Mean value equals 3.46, which is statistically significant ($P < 0.01$).

Comparing the stationary mean values (raw scores) in both study and control groups pre and post treatment

As shown from Table 3, the comparison between the mean values pretreatment in both groups (study and control) were 25.06 ± 0.7 and 25.86 ± 1.41 , respectively, which is non-statistically significant ($P > 0.05$). Comparing the mean values post treatment in both group, they were 29.46 ± 1.4 and 26.40 ± 1.37 , respectively. Mean value equals 3.06, which is statistically significant ($P < 0.05$). The percentages of change of raw scores in both study and control groups were 11.59 and 3.1%, respectively.

Comparing the mean values of stationary (standard score) in both study and control groups:

As is seen in Table 4, the comparison between the mean values pretreatment in both groups (study and control) were 1.35 ± 0.7 and 1.8 ± 0.94 , respectively, which is non-statistically significant ($P > 0.05$). Comparing the mean values post treatment in both groups, they were 2.6 ± 1.4 and 1.66 ± 0.7 , respectively. Mean value equals 0.94, which is statistically significant ($P < 0.05$). The percentages of change of standard score in both study and control groups were 92.59 and -7.7%, respectively.

Table 1. Distribution of age and sex of subjects.

Age Month	Males		Females		Total	
	N	%	N	%	N	%
21-30	6	31.58	3	27.30	9	30
31-40	8	42.10	4	36.35	12	40
41-50	5	26.32	4	36.35	9	30
Total	19	100	11	100	30	100

Table 2. Comparison between the mean values of GMFM in both study and control groups pre and post treatment.

		GMFM					
		Study group	Control group	MD	t	P	Sig
Pre	Mean ± SD	37.84 ± 6.1	38.31 ± 6.5	0.47	0.89	P > 0.01	NS
Post	Mean ± SD	43.76 ± 6.7	40.3 ± 6.4	3.46	2.11	P < 0.01	S
Percent of change		15.6%	5.1 %				

Mean ± SD: Mean ± Standard Deviation; P: Probability value; t: Paired t value; MD: Mean Difference; NS: Non Significant; S: Significant.

Table 4. Comparison between the mean values of stationary (standard score) in both study and control groups pre and post treatment.

		Standard score					
		Study group	Control group	MD	t	P	Sig
Pre	Mean ± SD	1.35 ± 0.7	1.8 ± 0.94	0.45	-0.28	P > 0.05	NS
Post	Mean ± SD	2.6 ± 1.4	1.66 ± 0.7	0.94	15.54	P < 0.05	S
Percent of change		92.59%	-7.7 %				

Mean ± SD: Mean ± Standard Deviation; P: Probability value; t: paired t value; MD: Mean Difference; NS: Non Significant; S: significant.

Table 5. Comparison between the mean values of age equivalent of the stationary subtests of PDMS-2 in both study and control groups pre and post treatment.

		Age equivalent in months					
		Study group	Control group	MD	t-value	P	Sig
Pre	Mean ± SD	6.26 ± 1.09	7.86 ± 1.6	1.60	- 1.77	P > 0.05	NS
Post	Mean ± SD	6.46 ± 2.30	5.93 ± 1.6	0.53	2.13	P > 0.05	NS
Percent of change		3.1 %	- 24.5 %		2.13	P > 0.05	NS

Mean ± SD: Mean ± Standard Deviation; P: Probability value; t: paired t value; MD: Mean Difference; NS: Non Significant; S: significant.

Comparing the mean values of age equivalent in months of the stationary subtests of PDMS-2 in both study and control groups

As shown from Table 5, the comparison between the mean values pretreatment in both groups were 6.26 ± 1.09 and 7.86 ± 1.6 , respectively, which is non-statistically significant ($P > 0.05$). Comparing the mean values post treatment in both groups, they were 6.46 ± 2.30 and 5.93 ± 1.6 , respectively. Mean value equals

0.53, which is statistically significant ($P < 0.05$). The percentages of change of age equivalent in months in both study and control groups were 3.1 and -24.5%, respectively.

DISCUSSION

The present research was conducted to examine the impact of pelvic girdle stability training in children with

hypotonic cerebral palsy on functional sitting control. Thirty children with hypotonic cerebral palsy were chosen with age range from two to four years from the outpatient clinic of the physical therapy department, Fayum General Hospital, to participate in this search and they were allocated at random to two classes with equal numbers.

All children in both groups were assessed before starting the treatment program by two tests: a) GMFM-88 which was used to assess sitting domain and b) PDMS-2 that was used to assess stationary subtests including the variables of raw score, standard score and age equivalent in months. All the general characteristics of the children in both groups before starting of treatment revealed non-significant differences ($p > 0.05$). The variables of GMFM-88 and PDMS-2 indicated non-significant differences ($p > 0.05$), which demonstrated the homogeneity between the children in both groups before starting of the treatment. The pretreatment results revealed that children in both groups showed lower mean values in both GMFM-88 and PDMS-2 variables that were attributed to the characteristics of the hypotonia in CP children, which supported the predetermined inclusive criteria of those children.

Choosing the age of the children who participated in this study between two and four years is supported by Azzam (2014), who reported that children are able to perform to assignments at this age and obey simple one-stage orders. Simultaneously, with verbal prompting, they may consciously execute reach and grasp/release activities.

All children were selected with mild to moderate degree of hypotonia (not floppy) and they sat on the floor, but when both hands were free to manipulate objects, they found it difficult to balance. Choosing the GMFM-88 for the assessment of hypotonic cerebral palsied children comes in agreement with Tustin et al. (2015), who emphasized the effectiveness of GMFM in assessment of motor abilities due to its high reliability and validity. Assessments of stationary subtests of PDMS2 were applied in the current study to assess the ability of the child to maintain control of the body inside its center of gravity and maintain balance in the sitting position (Folio and Fewell, 2000). The stationary subtest was used to examine gross motor developmental delay in sitting milestones for children in both study and control groups. Item administration begins at the maximum item to examine gross motor developmental delay in sitting milestones (stationary subtest item 19).

The pretreatment results of all children in both study and control groups revealed lower mean values of all variables than normal standards which is attributed to hypotonicity and poor functional sitting control that indicated weak core muscles and inadequate trunk stability. McGill (2003) stated that the term core was utilized to refer to the trunk or, more precisely, to the body's lumbo-pelvic region. Miyake (2013) reported that the core stability region is like a box in which its anterior

portion is formed by the abdominal muscles, the spine muscles and the gluteal muscles form its posterior part, the diaphragm muscles form its roof, and its floor is formed by the pelvic girdle muscles.

Zazulak et al. (2007) stabilize the central part of the body as the core muscles contract normally, providing a powerful support base, which in turn helps children to create controlled arms movements. For effective motor skill development, this is an important component. The pretreatment results of the current study indicated that hypotonic CP children have difficulty to crawl and sit, which come in agreement with Strubhar et al. (2007), who reported that hypotonic CP children have difficulties learning to independently roll, sit, crawl, and walk. On the other hand, Levitt (2013) reported that a common characteristic of most hypotonic children is the absence of all or some the normal postural mechanisms. She added that hypotonicity is also not necessarily correlated with strength of voluntary motion but seems more associated with the postural mechanisms.

The individual pre-treatment results of children in both groups showed difficulties and variability in time for maintaining a stable head position and trunk posture during functional sitting positions, which are consistent with the results of Grates (2013), who reported that children with hypotonic cerebral palsy may have some strength with antigravity movement but cannot sustain. The pre-treatment findings of the current research are in accordance with Cignetti et al. (2013), who reported that children with low muscle tone often present with weakness in the core muscles and difficulties with maintaining a stable head and trunk posture in many activities.

Children in both the study and control groups received the same selected program of upper limbs and trunk control strengthening exercises to improve functional sitting control. The time of this type of treatment for both study and control groups were 30 and 60 min, respectively. In addition children in the study group received pelvic girdle stability training program for extra 30 min per each session. Treatment sessions for both groups were carried out three times per week for three months.

At the completion of the period of treatment, post treatment evaluation was done in the same sequential manner as in the initial assessment routine. The post treatment mean values of the study group indicated significant improvement in the measuring variables including the mean values of sitting domain of the GMFM-88, raw scores and standard scores of the stationary subtests of PDMS-2, as compared with corresponding pretreatment mean values. However the post treatment mean value of age equivalent in months revealed non-significant improvement as compared with corresponding pre-treatment mean value. Researchers are interested in core stability exercises to improve the balance of children with disabilities (Hodges and

Richardson, 1997).

The results of the current study indicated the effectiveness of using pelvic girdle stability exercises for improvement of functional sitting balance in hypotonic CP children. Depending on their functions, the core muscles may be divided into two groups: Internal oblique, transversus abdominis, quadratus lumborum and psoas major and minor are the deep core muscles; and rectus abdominis and external oblique muscles, which are not directly related to the spine, are superficial core muscles. They connect to the pelvis, ribs or leg and function as dynamic muscles as well as a global stabilizer (Escamilla et al., 2010).

The stability training involves the abdomen muscles and pelvic muscles, which maintain postural alignment and allow movements of extremities. Postural control is mainly for motion and depends on these muscles for stability and endurance (Briggs et al., 2004). Strength, endurance, balance and the related activity of the back, abdominal and pelvic muscles are components of core stability. (Liemohn et al, 2005). It was reported that the core muscles act like one block to keep the body stable during static state and with extremity motion (Zazulak et al., 2007).

The improvement in post treatment results of the study group may be due to increase strength of both abdominal and back muscles. Focus was applied on selective muscle strengthening such as bridging the pelvis, strengthening adductor and abductor hip and kneeling arm lift. It was mentioned that reinforcing the trunk's deep muscles would stabilize the trunk and ready the lower extremity for movement. The spine is stabilized by the transverse abdominal muscle, external and internal and rectus abdominus, and supports the motion of lower extremity. Furthermore, the spine is supported and the dynamic equilibrium is maintained by multifidus and transverse abdominal muscles. Internal abdominal pressure and thoraco-lumbar fascia tension will rise as the transverse abdominal muscles contract; this will stabilize the region (Kibler et al., 2006).

In order to reinforce the muscles around the abdominal, lumbar and pelvic regions, pelvic girdle stability exercises are widely used, as the muscles of these regions play a significant role in preserving posture stability and enabling the legs and arms to move against gravity. The pelvic girdle stability exercises enable children of the study group to: a) have a stable base to enable controlled movement of trunk, b) balance and maintain posture and c) have a steady base for the development of hand skills (Ryerson et al., 2008).

Gracies et al. (2010) reported that the core stability program encourages body control, which activates the feed forward system in order to achieve limb postural activity. The coordination between the trunk and the upper extremities can be integrated by functional motions, which allow the body to move within the available range of motion without respect to the

beginning position. The post treatment results of the study group are attributed to the improvement in trunk stabilization. Unayik and Kahiyan (2011) reported that engagement in performing a core stability program can lead to (a) enhanced length tension relationship of the muscles of the upper and lower limbs originating from the girdles, that in turn are connected to the spine, (b) enhanced phasic spinal muscle contraction, and (c) Reduced limitation and enhanced degree of freedom, resulting in smoother movements that are more suitable and more purposeful.

The post treatment mean value of the sitting domain of the GMFM-88 in the control group revealed significant improvement as compared with the pretreatment value. However, the post treatment mean values of raw scores, standard scores and age equivalent (in months) subtests of PDMS-2 showed non-significant improvement.

In the current study, the program of upper limbs and trunk control strengthening exercises was used only for the control group to improve functional sitting control. A set of mechanisms for postural response, comprising of a) anticipatory postural responses that stimulate the muscles of the trunk and neck in preparation for a shift in body posture, regulate staying upright and keeping the head and trunk stable while moving the arms. b) Balance responses that modify the alignment of the various body segments in order to retain posture. c) Postural stabilization mechanism which retains for a long period of time the erect trunk posture. This program of treatment can be an effective therapeutic exercise to strengthen only superficial core muscles. However the pelvic girdle stability exercises applied for the study group can help the deep core muscle to work together with the superficial core muscles and decrease the rate of asymmetry. This was emphasized by Escamilla et al. (2010) who stated that core exercises on Swiss ball was more successful than the traditional sit-up in generating core muscle activity.

Comparing the post-treatment mean values of sitting domain of GMFM-88 in both study and control groups revealed significant differences. The percentage of improvement was 5.92 and 1.99, respectively. The post-treatment percentage of improvement of raw scores and standard scores in the study group showed significant increase than the control group that revealed the efficacy of pelvic girdle stability training which encouraged the children to facilitate their functional sitting control. These results are consistent with Shankar and Chaurasia (2012), who reported that after conducting core stabilization exercise on the Swiss ball, there was an enhancement in trunk endurance.

Post treatment mean values of age equivalent (in months) in both the study and control groups were 6.46 and 5.93, respectively, with mean difference equals to 0.53 which is statistically non-significant. It was observed that the post treatment mean values of age equivalent in both groups were decreased as compared with

corresponding pre-treatment mean values. These results may suggest that however children with hypotonic cerebral palsy revealed significant improvement in the GMFM-88 and in both raw scores and standard scores at the end of treatment in the study group, they may need a more than three months of treatment to improve their age equivalent in respect to the normal standards.

In respect of the study group, the focus was on the pelvic girdle stability training program to improve core stability and encourage functional activities of daily living and independency. Numerous studies have confirmed the effect of core stability on improvement of functional activities of children with motor disabilities. The results of the current study come in agreement with Cholewicki and VanVliet (2002), who stated that the trunk muscle activity pattern and strength for functional movements were enhanced by core stability exercises. The results of this research are compatible with the results of Akuthota et al. (2008), who reported that core stability exercises are becoming common in different populations to improve spinal stability and quality of life.

Au et al. (2014) reported that the core stability exercise program is effective in improving motor proficiency among children with developmental coordination disorder. The findings of this research agree with Ghaeeni et al. (2015), who suggested that intra-abdominal pressure rises through contraction of core muscles, providing body stability and stiffness. Hsu et al. (2018) mentioned that the central part of the body can be stabilized by core muscle contraction, providing a solid support base that, in turn, allows children to generate controlled arms movements. For effective motor skill development, this is an important component. The findings of this research come in accordance with Ali (2019), who indicated that the core stability program is strongly advised to be used in the treatment program for cerebral palsied children, which revealed weak functional sitting control to improve balance.

During treatment, parents of the majority of children in the study group informed us that their children became more stable and more independent in the functional sitting position. This positive change indicated that the applied pelvic girdle stability training program training program encouraged those children to be engaged in functional activities of their daily living from sitting position including playing activities.

The results of the current study disagree with Okada et al. (2011), who claimed that there no significant relation among core stability and functional movement. Limitation of the current study was indicated by decreasing of the post treatment mean values of age equivalent (in months) in both groups, which may be attributed to their irregular attendance, short predetermined period of treatment, lack of enhancement of child practicing of functional sitting position at home by their parents, and probably by their poor medical prognosis. In line with that Roddick and Selner (2016) reported that, depending on their ability,

some children often work with physical therapists; they can work with particular purposes, such as sitting upright.

Finally, it can be concluded that there are statistically significant differences in mean values of sitting domain of GMFM-88 and stationary subtests of PDMS-2 including both raw scores and standard scores in favor of the study group. These results imply that pelvic girdle stability training can be used to enhance functional sitting control in children with hypotonic cerebral palsy

CONCLUSION

Accordingly, from the results of the present study it could be concluded that pelvic girdle stability training can be used to improve functional sitting control in children with hypotonic cerebral palsy.

Ethical considerations

The research was accepted by the ethical committee of the faculty of Physical Therapy Faculty, University of Cairo, Egypt. As well as a written consent form children's parents was obtained before starting the study.

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