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Effect of lumbar-pelvic control on functionality in children with spastic cerebral palsy

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ABSTRACT

Lack of pelvic control is a common functional impairment in children with spastic cerebral palsy (CP), so pelvic stability may be critical to improve controlled movements and activities in these children. The aim of this randomized controlled trial was to evaluate the effect of physical therapy programs combined with pelvic control exercises on controlled hip, knee, and ankle movements and gross motor functions in children with spastic CP. Thirty-two children diagnosed with spastic cerebral palsy at levels II and III on the gross motor functional classification system participated in this study. They were randomly and equally divided by a computerized program into control and study groups. The control group (eight boys and eight girls) received the designed therapy program for one hour. The study group (four boys and twelve girls) received lumbar-pelvic control exercises for 20 minutes in addition to 40 minutes of a physical therapy program. The program for both groups was applied three times per week for twelve weeks. After twelve weeks of treatment, the controlled movement, functional ability plus a joint range of motion of the hip, knee, and ankle were assessed by selective motor control scale, Peabody scales, and Kinovia software program, respectively. All statistical measures were performed through the Statistical Package for Social Studies (SPSS) version 20 for windows (SPSS, Inc., Chicago, IL). The results of our study showed a statistically significant improvement in median selective motor control, the Z score of Peabody scale, and the mean angle of hip, knee, and ankle range of motion after the treatment program in the study group compared with the control group ($p < 0.05$). Lumbar-pelvic control exercises are useful in improving the controlled movement and functional abilities in children with spastic diplegia CP when combined with a physical therapy program.

KEYWORDS

Cerebral Palsy; Spastic Diplegia; Pelvic Control; Motor Control; Functional Ability

1. INTRODUCTION

Cerebral palsy (CP) is a neurological disorder resulting from a non-progressive lesion of the immature central nervous system causing developmental disability in posture and movement (Rosenbaum et al., 2007). CP affects 2.11 per 1000 live births (Jonsson et al., 2019). CP may be classified according to a dominant neurological sign into: spastic, dyskinetic, or ataxic. However, the spastic CP might be hemiplegic, diplegic, tetraplegic, or paraplegic (Himmelmann et al., 2006). Lack of selective muscle control, muscle weakness, spasticity, poor postural responses, and abnormal agonist-antagonist co-contraction are the primary motor impairments in children with spastic CP, resulting in functional deficiencies (Palisano et al., 2008). The uncontrolled pelvic movements in those children could result from abnormal coordination between the lower extremity and trunk and inter-limb coordination of lower extremity which is due to the hamstring weakness or inadequate hamstring lengthening (Arnold et al., 2006), rectus spasticity and psoas contracture (Kay et al., 2002), or trunk muscle weakness (Bleck, 1987; O'Sullivan et al., 2007).

Selective motor control is the ability to isolate the activated muscles in a specific pattern requiring a voluntary movement. It is therefore affected by abnormal co activation of muscles that depends on descending pathways from the residual brainstem, increased interference of cortical representation, and changes in spinal cord excitability (Sanger et al., 2006; Staudt et al., 1989). The selective motor control is recently considered as a predictor of motor function in children with CP (Staudt et al., 1989).

The aim of this study is to evaluate the effect of pelvic control exercises on controlled movement of hip, knee, and ankle, and gross motor skills in children with spastic CP.

2. METHODS

2.1. Study Design and Subjects

This study was a randomized controlled trial. Thirty-two children were recruited from the outpatient clinic of the Faculty of Physical Therapy, Cairo University, with the following criteria: a) age between 4 -7 years, b) diagnosis of spastic diplegia CP, c) spasticity of grades 2 and 3 according to the modified Ashworth Scale (MAS), d) gross motor function classification system level II and III on GMFCS. The children who had perceptual disorders, either visual, hearing, or proprioceptive, fixed deformities in lower limbs, or a history of botulinum toxin injection before three months of the study were excluded. Children were randomly and equally allocated by a computerized program into control and study groups. The control group (eight boys and eight girls) received the designed therapy program for one hour. The study group (four boys and twelve girls) received lumbar - pelvic control exercises for 20 minutes in addition to 40 minutes of a physical therapy program. The program for both groups was applied three times per week for twelve weeks.

The parents of selected children signed written informed consent after clarifying the study's purpose, instructions, and steps. The Ethics Committee of the Faculty of Physiotherapy, Cairo University, approved this study (NO.P.T.REC|012|003019).

2.2. Measurements

2.2.1. Modified Ashworth Scale

The modified Ashworth scale is a valid, simple, and quick test for assessing the resistance to passive movement by moving the limb passively through its full range of movement. According to the degree of resistance experienced, the degree of spasticity is scored from 0 to 4 (Sarathy et al., 2019).

2.2.2. Gross Motor Function Classification System (GMFCS)

GMFCS is classified into five-level according to the child's gross motor abilities, need for assistive devices or wheeled mobility, and limitations of functions (Moreno-De-Luca et al., 2012).

2.2.3. Selective Motor Control (SMC)

The selective motor control scale (SMC) is valid in measuring the strength of isolated muscle groups for children with CP (Fetters et al., 2004). The scale grades the selectivity of muscle groups as follows: grade 0 – no ability/only patterned movement observed, grade 1 – partial ability/partially isolated movements, and grade 2 – full ability/completely isolated movements (Sarathy et al., 2019).

2.2.4. Kinovea Computer Program (KCP)

The hip, knee, and ankle range of movement was evaluated using the Kinovea computer program (KCP). It is an accessible, fast, and low-cost modality for analyzing the joint movements of the body during activities (Abbas & Abdulhassan, 2013). The hip, knee or ankle joints' movement was captured by a digital camera exported into KCP to be analyzed and saved (Elwardany et al., 2015).

2.2.5. Peabody Developmental Motor Scales (PDMS-2)

Peabody Developmental Motor Scales (PDMS-2) is one of the standardized tests for patients with motor problems from birth to 72 months (about 6 years) of developmental age to assess their motor skills (Folio; Fewell, 2000). Items of PDMS were showed precisely with specific verbal cues (Van Waelvelde et al., 2007). Gross items are categorized into reflexes, stationary, and locomotion. PDMS-2 scoring system is a three-grading scale (0, 1, 2) that gives age-equivalent data (Palisano et al., 1995).

2.3. Interventions

2.3.1. The Physical Therapy Programs

The children in the control group received a specific physiotherapy program for one hour, while the children in the study group received 40 minutes focused on; a) stretching exercises of the Achilles tendon, hamstring, hip flexors and adductors of both lower limbs, b) strengthening of back muscles through two-handed push-up exercises, stopping and recovery exercises, c) facilitation of balance from different positions (kneeling, half kneeling and standing position) on the mat then on balance board, standing on both legs then on a single leg, and d) gait training; forward, side and backward walking and walking on the stepper.

2.3.2. Lumbar-pelvic Control Exercises

The children in the study group received the pelvic control exercises with a physical therapy program that included the following exercises (Tyler et al., 2014; Dubey et al., 2018): pelvic bridge, dynamic stability bridge, circuit exercise, advanced lateral hip and gluteal strengthening exercises, and all 4's Clockwise and Counterclockwise circles with hip in extension. The exercises start from passive to active to achieve the oriented task.

2.4. Data Analysis

All statistical measures were performed through the Statistical Package for Social Sciences (SPSS) version 20 for Windows (SPSS, Inc., Chicago, IL). Data obtained from both groups pre- and post-treatment regarding functional ability and selective movement were statistically analyzed and compared using paired and unpaired T- test to detect the significance level within and between groups, respectively. The Mann–Whitney U test was conducted to compare SMC between control and study groups, and Wilcoxon Signed Ranks was conducted to compare SMC between pre- and post-treatment in each group. The significance level for all statistical tests was set at $p < 0.05$.

3. RESULTS

A total of 32 children with spastic diplegic cerebral palsy were randomly assigned to control and study groups. There were no statistically significant differences between their age, weight, height, and body mass index (BMI) ($p > 0.05$) (Table 1).

Table 1. General characteristics of the participants in both groups (control and study group)

	Mean ±SD		MD	p
	Control group	**Study group**		
Age (years)	5.43 ± 1.09	5.53 ± 1.04	-0.1	0.8
Weight (kg)	22.86 ± 3.33	24.23 ± 2.65	-1.37	0.22
Height (cm)	115.73 ± 8.19	118.26 ± 7.13	-2.53	0.37
BMI (kg/m²)	17.23 ± 0.95	17.34 ± 1.42	-0.11	0.82

SD: standard deviation; p: Probability value; BMI: body mass index; MD: mean difference

Table 2 shows the difference in selective motor control values between the control and study groups (before and after treatment). The SMC scale grades showed a statistically significant difference between the control and study groups in the hip, knee, and ankle joints after the treatment program (Table 2).

Table 2. The difference in selective motor control values between the control and study groups

		Control group	Study group	p
Hip	**Pre**	1	1	0.31
	Post	1	2	0.0001*
	Z- value	-1	-3.6	
	P-value	0.31	0.0001*	
Knee	**pre**	1	1	0.15
	post	1	2	0.001*
	Z- value	-1	-2.82	
	P-value	0.31	0.005*	
Ankle	**pre**	1	1	1
	post	1	2	0.001*
	Z- value	0	-2.82	
	P-value	1	0.005*	

*: significant

Regarding the active range of motion, it was significantly increased before and after treatment in both groups ($p < 0.05$) (Table 3).

Table 3. The mean values of the range of motion of the hip, knee and ankle joints of the participants in both groups

		Control group	Study group	MD	P value
Hip flexion	**Pre**	30.86 ± 9.47	36.06 ± 9.21	-5.2	0.13
	Post	33.13±9	40.73±9.28	-7.6*	0.03
	MD	-2.27*	-4.67*		
	P-value	0.0001	0.0001		
Knee extension	**Pre**	57.73 ± 12.2	55.6 ± 10.85	2.13	0.61
	Post	62.26±12.66	71.33±10.8	-9.07*	0.04
	MD	-4.53	-15.73		
	P-value	0.0001 *	0.0001 *		
Ankle dorsiflexion	**Pre**	12.26 ± 1.62	11.6 ± 2.52	0.66	0.39
	Post	15 ± 2.07	17.46±3.15	-2.46	0.01*
	MD	-2.74	-5.86		
	P-value	0.0001*	0.0001*		

*: significant; MD: mean difference; *P-value:* Probability value

Regarding functional abilities, standard scores on the Peabody scale improved significantly after the treatment program in the control and study groups ($p < 0.05$), with a mean difference of -0.47 and -1.54. Age equivalent and Z-scores were significantly improved in the study group than in the control group (Table 4).

Table 4. The mean difference in Peabody scores of participants in both groups

		Control group	Study group	MD	p value
Sum standard score	**Pre**	3.86 ± 1	3.66±0.9	0.2	0.03*
	Post	4.33±0.81	5.2±1.26	-0.87	
	MD	-0.47	-1.54		
	P-value	0.01	0.0001		
Age equivalent	**Pre**	21.16±1.09	20.63±2.06	0.53	0.02*
	Post	21.93±0.88	23.43±2.25	-1.5	
	MD	-0.77	-2.8		
	P-value	0.0001	0.0001		
Quotient	**Pre**	42.33±1.67	43.2±2.42	-0.87	0.0001*
	Post	43.46±0.83	46.6± 2	-5.61	
	MD	-1.13	-3.4		
	P-value	0.009	0.0001		
Z score	**Pre**	4.2±0.5	4.17±0.75	0.03	0.0001*
	Post	4.13±0.48	3.48±0.15	4.93	
	MD	0.07	0.69		
	P-value	0.01	0.003		

*: significant; MD: mean difference; P-value: Probability value

4. DISCUSSION

The children with spastic CP have a reduced ability to regulate and coordinate the isolated movements, which interferes the flexor and extensor synergies of the lower extremity during functional tasks as walking (Voorman et al., 2007).

The asymmetrical and restricted pelvic movements are the primary disorders in spastic cerebral palsy children that affect the effective muscle contraction and neuromuscular control of lower trunk and lower limb muscles (Zwambag et al., 2014; Park et al., 2015). The range of motion of the hip, knee, and ankle joints and the motor quotient of the Peabody scale are improved after physical therapy program, which facilitates postural control and increases spinal stability through strengthening trunk muscle. The more postural stability, the more ability to isolate joint motion during standing and walking via allowing the generated energy to transfer from large to small body parts (Sharma & Kaur, 2017; Ali, 2019).

The lumbo-pelvic control as proximal control allows effective kinetic control of lower extremities (Sharma & Kaur, 2017), which affords dynamic control during daily functional activities such as transfers, walking on the even floor, and climbing upstairs (Dubey et al., 2018). The pelvic stability training provides good proprioception stimulation for muscle and joints of the lower limbs in hence imrove intrarsegmental control that might increase the strength of the lower limb muscles. John et al. (2005); Willson et al. (2005) concluded that antagonist muscle strength increases andagonist muscle spasticity decreases during closed chain activities. Park et al. (2015) also found that improving hip muscle strength after pelvic exercises, particularly pelvic tilt exercises, had effects on postural stability and walking speed by creating force coupling between the trunk flexors (rectus abdominus and obliquus externus abdominis) and hip extensors (gluteus maximus and hamstrings). Kim & Seo (2015) studied the effect of pelvic stability training on muscle strength by EMG after 6-weeks. They found a significant decrease in the excessive hip flexor activation, extensor spinae, rectus femoris, and semitendinosus muscles and a significant increase in hip extensor activation and gluteus maximus activation.

The results of the current study showed statistically significant improvement in the hip, knee, and ankle ROM (range of motion) ($p < 0.05$) after pelvic stability training, which may be due to improvement in muscular selectivity and normal co-contraction of the lower trunk and proximal hip muscles. These results are consistent with those of Khanal et al. (2013), who found that ROM increased when following a specific PNF program that focused on pelvic exercises that increased muscle length and thus neuromuscular efficiency of the pelvic and lower leg muscles. The ROM of hip, knee, and ankle might be increased significantly in children of the study group as more strength of lower limb muscles improving functional ability mainly for stationary tasks during standing (Park et al., 2015). Hindle et al. (2012) explained that the physiological increase of ROM might be due to autogenic inhibition, reciprocal inhibition, and stress relaxation. Also, the lumbopelvic exercises could improve mechanical coordination of the gluteus medius and the gluteus maximus muscles that are essential for the coordination of the lumbo-pelvic region and the lower limb, specifically the gluteus medius muscle transmit the forces from the thoracolumbar region to the knee (Powers, 2010).

Significant increase of stability and mobility scores on Peabody scale in children of study group after pelvic control exercise come in agreement with Wu et al. (2016) who studied the effect of applying pelvis assistance force during overground gait training for children with CP. They found a significant increase in step length, step height, muscle activation of hip abductors and self-selected walking speed. The pelvic stabilization during a closed kinematic chain activity such as standing and walking influences the excellent positioning of the pelvis that depends on neuromuscular control, the integrity of the osteo-ligamental system, proper interaction between muscles and fascia, and good alignment of the joints of lower limbs (Park et al., 2012). Children with CP show inert anterior pelvic tilt due to contracture of the iliopsoas muscle and weakness of the trunk flexors and hip extensors so that pelvic stabilization might potentiate active force-coupling between the hip flexors and low-back extensors (Baptista-Maresh, 1990). Furthermore, pelvic stabilization improves the pelvis's symmetrical positioning, stimulating a more excellent stretch over the hip joint by resisting the excessive anterior pelvic tilt that enhances postural control during functional activities.

5. CONCLUSIONS

Lumbar-pelvic control exercises are useful in improving the controlled movement and functional abilities in children with spastic diplegic CP when combined with a physical therapy program.

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All authors have critically reviewed and approved the final draft and are responsible for the content of the manuscript.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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