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Effect of core stability exercise on postural stability in children with Down syndrome

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ABSTRACT

*Down syndrome is one of the commonest causes of developmental delay in children. Postural stability problems often exist with Down syndrome. To investigate the effect of core stability exercises on postural stability in children with down syndrome. Thirty children (21 boys and 9 girls) with down syndrome, with ages ranged from 6 to 10 years were participated in this study. They were assigned randomlyinto study and control group. Study group received core stability exercises and conventional physical therapy program while control group received Conventional physical therapy program. The duration of treatment was 8 weeks. Postural stability was evaluated pre and post treatment by Biodex *Balance System. There was a significant decrease in anteroposterior, mediolateral, and overall stability indices of the study group compared with control group post treatment (p < 0.001). Both groups showed a significant decrease in anteroposterior, mediolateral, and overall stability indices post treatment compared with pre treatment (p < 0.001). Eight weeks of core stability exercises is effective in improving postural stabilityand balance of children with Down syndrome. Core stability exercises should be considered as important part of the rehabilitation program for childrenwith Down syndrome.*

Key words: core stability, Down syndrome, postural stability, balance

INTRODUCTION

Postural stability is defined as the ability to maintain or control the center of mass in relation to the base of support to prevent falls and complete desired movements [1,2].The ability to maintain a posture, such as balancing in a standing or sitting position, is operationally defined as static balance. The ability to maintain postural control during other movements, such as when reaching for an object or walking, is operationally defined as dynamic balance. Both static and dynamic postural control are thought to be important and necessary motor abilities [2,3]. Postural control requires two different processes: the sensory organizational process, in which multimodal sensory systems, including the visual, somatosensory and vestibular systems, are involved and integrated within the central nervous system; and the motor adjustment process, involved in executing coordinated and properly scaled musculoskeletal responses [4,5].

Down syndrome is one of the most common developmental disabilities. It is estimated that approximately 6000 children with Down syndrome are born annually in the United States resulting in an estimated birth prevalence of 14 per 10000 live births [6]. Children with Down syndrome often demonstrate deficits in muscular strength, muscular endurance, and motor skill development [7,8,9]. Children with Down syndrome showed delay in the acquisition of both postural and voluntary components of motor control compared with that of the developmentally normal child [10,11]. Gait and postural disorders are common with Down syndrome limiting the patients’ quality of life [10,12].

Balance problem in children with Down syndrome manifests as them having a wide support base, frequent falling, difficulty in everyday activities like walking without assistance, going downstairs, and moving in a dark environment [13].Healthy people control their upright posture with small oscillatory movements, namely postural sway, made in segments of the body. A posture controlled in stable stance requires that the center of body mass is balanced within the support frames of the soles. Compared to normal subjects, individuals with Down syndrome have been characterized by greater postural sway in quiet stance which were represented as a feature of instable postural control [13,14].Children with Down syndrome also found an increase in frequency oscillation both in the anterior-posterior and medio-lateral directions [13,15). Their balance deficit may be linked to an inadequately developed postural control system that does not adequately adjust its responses to the changing levels of postural task requirements [16].

Previous research shows significant correlation between muscle weakness and balance disorders [17]. Muscle weakness may be responsible for balance problems in children with Down syndrome that reduces their balance in standing and increases their risk of falling [18]. The preservation of muscle strength at a satisfactory level is necessary for the activities of daily living [19].

In recent years, the core stability exercises are of interest to researchers in the field of improving the balance functions of children with disabilities [20]. The term core has been used to refer to the trunk or more specifically the lumbo-pelvic region of the body [21]. Core stability area is like a box that abdominal muscles form its anterior section, muscles of the spine and gluteal muscles form its posterior section, diaphragm muscle forms its roof, and pelvic girdle muscles form its floor [22].

The stability of the lumbo-pelvic region is crucial to provide a foundation for movement of the upper and lower extremities, to support loads, and to protect the spinal cord and nerve roots (23). The core muscles stabilize the spine and trunk during movements such as jumping, running, and throwing [24]. Previous studies revealed that trunk muscle fatigue led to decreased dynamic stability of the trunk and loss of balance control [25,26].

The Core stability may help to improve dynamic balance and muscle coordination between lower and upper extremities, as well as reducing injury risk and muscle imbalances [25]. Core stability exercises have a positive effect on reducing pain, activating deep abdominal muscles, elevating the stability of lumbar spine and improving physical function in patients [27,28]. Core strength training is widely used in improving performance [29, 30], reducing the risk of injuries in athletes, increasing physical fitness in healthy individuals [31], and rehabilitation of patients with a low back pain [32]

The purpose of this study was to investigate the effect of core stability exercises on postural stability in children with down syndrome. We hypotheses that adding core stability exercises to physical therapy program for children with Down syndrome may improve their postural stability that in turn improve their movement ability and quality of life.

MATERIALS AND METHODS

Participants

In this experimental design study, thirty children (21boys and 9girls) with Down syndrome, with ages ranged from 6 to 10 years were participated in this study. The inclusion criteria were; a confirmed diagnosis of Down syndrome by a pediatric neurologist, having no neurological or mobility disorders, independent standing and walking abilities, functional hearing and vision, and understanding of instructions which were necessary for the training and assessment procedures. The exclusion criteria included a history of congenital heart defects and orthopaedic surgery in the past year and sever mental retardation. They were recruited from the out-patient clinic of faculty of physical therapy, Cairo university, and from national institute for neuro-motor system, Egypt. outpatient clinic of national institute. Intelligence quotient (IQ) of the participants with down syndrome was evaluated by a clinical psychologist using the Leiter International Performance Scale- Revised (Leiter-R) [33], which is a standardized test of nonverbal intelligence for children and youths aged 2– 20.

They were assigned randomly, using computer generated random numbers, into two groups. The study group consisted of 15 children (11boys and 4girls) and received the conventional physical therapy program in addition to core stability exercises. Whereas, the control group consisted of 15 children (10boys and 5girls) and received the same conventional physical therapy program given to the study group.

All children and their parents were given an explanation of the purpose and procedures of the study. This work was carried out in accordance with the code of ethics of the world medical association (Declaration of Helsinki) for experiments involving humans. All parents of the children signed a consent form prior to participation. In addition, acceptance of the ethical committee of the University was taken

Instrumentation

Postural stability was assessed using Biodex balance system (Biodex, Inc., Shirley,NY). Biodex balance system (BBS)is a multiaxial device that uses a circular platform that is free to move about the AP and ML axes simultaneously and is interfaced with specialized software (Biodex, Version 3.1, Biodex Medical Systems) that enables the device to serve as an objective assessment of balance. The BBS allows up to 20° of foot platform tilt in a 360° range of motion. Biodex balance system software calculates three separate measures: overall stability index, anterior-posterior stability index and medial-lateral stability index scores. A high score in these stability indexes indicates poor balance. The stability of the platform can be varied by adjusting the level of resistance given by the springs under the platform. The platform stability ranges from 1-8, with 1 representing the greatest instability. The lower the resistance level the less stable the platform.The intratester reliability of this procedure has been previously reported as 0.43 for medial-lateral stability index, 0.80 for anterior-posterior stability index, and 0.82 for overall stability index [34].

Procedure:

Evaluation of postural stability

Evaluation of postural stability was conducted before treatment program and at eight weeks following the treatment program.

Participants were instructed to stand on both feet without footwear on the Biodex balance system locked platform. They were instructed to maintain their arms by their sides and look straight ahead to the display screen that adjusted to each child height. Child's weight, height and age were fed to the instrument. The centering process consisted of unlocking the platform to allow motion. The participants were instructed to adjust the position of the feet until they found a position where they were able to maintain platform stability.The process guided by visual feedback on the screen as the cursor moves until it was easy to keep the cursor centered on the screen grid while standing in comfortable upright position. Once the participant was centered, the cursor was in the center of the display target, participant was asked to maintain feet position till the platform was stabilized. Heels coordinates and feet angles from the platform were recorded. The platform was then locked and the subject's foot position was recorded by the software. The test began after introducing feet angles and heels coordinates into the Biodex system.Each test consisted of a 30 s evaluation, starting on level eight (most stable) and gradually decreasing to level four (less stable). The stability level automatically decreased every 3.75 s. then the child was instructed to focus on the visual feedback screen directly in front of him with both arms at the side of the body without grasping handrails and to maintain the cursor in the smallest concentric rings (balance zones) of the Biodex balance system.The measure of postural stability, both before and after stability training, included overall stability index, anterior-posterior stability index and medial-lateral stability index.

All participants were trained 1 min for adaptation to the machine, following which three practice trials, to reduce any learning effects, and three test evaluations were performed. A mean score was calculated from the three test evaluations.

Treatment program

- Core stability exercises for study group:

Experimental group subjects performed Jeffrey's core stability exercises three times per week for an 8-weeks period and each session lasted 45-60 minutes.

The core stability exercises program included exercises of progressively increasing difficulty, focusing on strengthening the abdominal, low-back, and pelvic muscles.

Jeffreys[35] proposed exercise protocol included 3 levels starting with level 1 and gradually progressed to level 3. Level 1 consisted of static contraction training which was done in a stable condition. Level 2 consisted of dynamic training which was done in a stable condition and level 3 consisted of dynamic and resistance training which was done in an unstable condition. Swiss balls were used to create an unstable condition [36].

First and second week:
- Contracting abdominal muscles while lying in a supine position (3 sets and 20 reps in each set).
- Contracting abdominal muscles while lying in a prone position (3 sets and 20 reps in each set).
- Contracting abdominal muscles while in a squat position (3 sets and 20 reps in each set).

Third week
- Contracting abdominal muscles while lying in a supine position with one leg stretched and the other bent at knee and pressed against the abdomen (3 sets and 20 reps in each set).
- Contracting abdominal muscles while lying in a prone position with one leg stretched and the body weight on the other leg which is bent at knee (3 sets and 20 reps in each set).
- side lying bridge for each side of the body (6 reps, 10 seconds pause).

Fourth week
- Contracting abdominal muscles while lying in a supine position and pulling the limbs upward with arms and legs kept close together (3 sets and 20 reps in each set).
- In squat position, one leg is raised and pulled outward and backward (3 sets for each leg and 20 reps in each set).
- Trunk rotation while holding weights in each hand (3 sets each part of the body and 20 reps in each set).

Fifth week
- Sitting on a Swiss ball and holding the abdomen in (3 sets ,10 seconds).
- Squatting while the Swiss ball is on the shoulder (3 sets and 15 reps for each set).
- Bringing up the arms and legs simultaneously in the prone position (3 sets and 10 reps for each set).

Sixth week
- Bending 45 degrees to the left or right.
- Bridging while shoulders and hands are on the floor and one leg is raised (3 sets and15 second pause for each set).
- Contracting abdominal muscles while lying in a supine position on the Swiss ball (3 sets and 20 reps for each set).

Seventh week
- Lying supine on the Swiss ball and rotating the trunk to the sides(3 sets and 15 reps for each set).
- Doing the above exercise with holding weights in the hands (3 sets and 15 reps for each set).
- Side lying bridge with bringing up the leg (6 repetitions for each side of the body and 10-second pause).

Eighth week
- Lying supine on the Swiss ball and holding the abdomen in and bringing one leg up (3 sets and 20 reps for each set).
- Raising the opposite arm and leg while squatting (3 sets and 20 reps for each set)
- Bridge so that the feet are placed on the Swiss ball and raise one leg (3 sets and 15 second pause for each set).

Conventional physical therapy program for both groups

A designed exercises program for strength, balance and posture control including the following items
- Static muscle contraction for the hip extensors, the quadriceps, the hamstrings, the anterior tibial group, and the calf muscles for 15 mins. It was performed five times initially, building up to ten repetitions as tolerated, two to three times per day. Each contraction was maintained for five counts, then relaxation for another five counts.
- Standing with feet together while the therapist sitting behind and manually locking the child knees, and then slowly tilt him to each side, forward and backward.
- Step standing with therapist behind the child guiding him to shift his weight forward then backward alternately.
- High step standing and try to keep balanced.
- Standing with manual locking of the knees then triesactively to stoop and recover.
- Equilibrium, righting and protective reactions training.
- Open environment gait training was conducted with the different obstacles.

DATA ANALYSIS

Descriptive statistics and t-test were conducted for comparison of subject's **c**haracteristics between both groups. T test was conducted to compare mean values of stability indices between both groups. Paired t test was conducted to compare between pre and post treatment mean values of stability indices in each group. The level of significance for all statistical tests was set at $p < 0.05$. All statistical tests were performed through the statistical package for social studies (SPSS) version 19 for windows (IBM SPSS, Chicago, IL, USA).

RESULTS

- Subject characteristics:

Table (1) showed the mean ± SD age, weight, height, and IQ of study and control groups. There was no significant difference between both groups in the mean age, weight, height, and IQ (p > 0.05).

Table (1): Comparison of mean age weight, height and IQ between study and control groups

	Group A	Group B		
	$\bar{X}$ ±SD	$\bar{X}$ ±SD	t- value	p- value
Age (years)	8.11 ± 1.26	8.34 ± 1.07	-0.52	0.6*
Weight (kg)	21.46 ± 2.44	22.06 ± 2.4	-0.67	0.5*
Height (cm)	120.46 ± 5.46	119.26 ± 4.35	0.66	0.51*
IQ	48.33 ± 6.38	50.33 ± 4.70	-0.97	0.34*

*$\bar{x}$, Mean; SD, Standard deviation;t value, unpaired t value;p value, Probability value; *Non significant.*

- Comparison within group:

Results of study group:

There was a significant decrease in antero-posterior, medio-lateral, and overall stability indices post treatment in study group compared with pre treatment

(p <0. 001). The percent of decrease in antero-posterior, medio-lateral, and overall stability indices were 46.37, 46.92, and 40.61% respectively. (Table 2, figure 1).

Results of control group:

There was a significant decrease in antero-posterior, medio-lateral, and overall stability indices post treatment in control group compared with pre treatment (p <0. 01). The percent of decrease in antero-posterior, medio-lateral, and overall stability indices were 28, 29.25, and 18.24% respectively. (Table 3, figure 1).

Table (3): Comparison of serotonin level between pre and post treatment in group I and II

Stability indices		Pre treatment	Post treatment				
		$\bar{x}$±SD	$\bar{x}$±SD	MD	% of change	t-value	p-value
Study	**Antero-posterior**	2.48 ± 0.27	1.33 ± 0.27	1.15	46.37	9.79	0.0001**
	Medio-lateral	2.28 ± 0.43	1.21 ± 0.25	1.07	46.92	8.99	0.0001**
	Overall	2.93 ± 0.18	1.74 ± 0.37	1.19	40.61	13.15	0.0001**
Control	**Antero-posterior**	2.5 ± 0.24	1.8 ± 0.3	0.7	28	8.69	0.0001**
	Medio-lateral	2.29 ± 0.34	1.62 ± 0.4	0.67	29.25	5.34	0.0001**
	Overall	2.96 ± 0.27	2.42 ± 0.49	0.54	18.24	3.05	0.009**

*$\bar{x}$, Mean; SD, Standard deviation; p value, Probability value; ** significant*

- Comparison between groups:

There was no significant difference between study and control groups in mean values of antero-posterior, medio-lateral, and overall stability indices pre-treatment (p>0.05). Comparison between study and control groups post treatment revealed a significant decrease in anteroposterior, mediolateral, and overall stability indices of the study group compared with control group (p < 0.001).Table 4, figure 1).

Table (4): Comparison of stability indices between study and control groups

	Stability indices	Study group	Control group		
		$\bar{X}$ ±SD	$\bar{X}$ ±SD	t- value	p- value
Pre	**Antero-posterior**	2.48± 0.27	2.5± 0.24	-0.27	0.78*
	Medio-lateral	2.28± 0.43	2.29± 0.34	-0.09	0.92*
	Overall	2.93 ± 0.18	2.96 ± 0.27	-0.31	0.75*
Post	**Antero-posterior**		1.8± 0.3	-4.44	0.0001**
	Medio-lateral	1.21± 0.25	1.62± 0.4	-3.37	0.002**
	Overall	1.74± 0.37	2.42± 0.49	-4.26	0.0001**

*$\bar{x}$, Mean; SD, Standard deviation; p value, Probability value; * Non significant; ** significant*

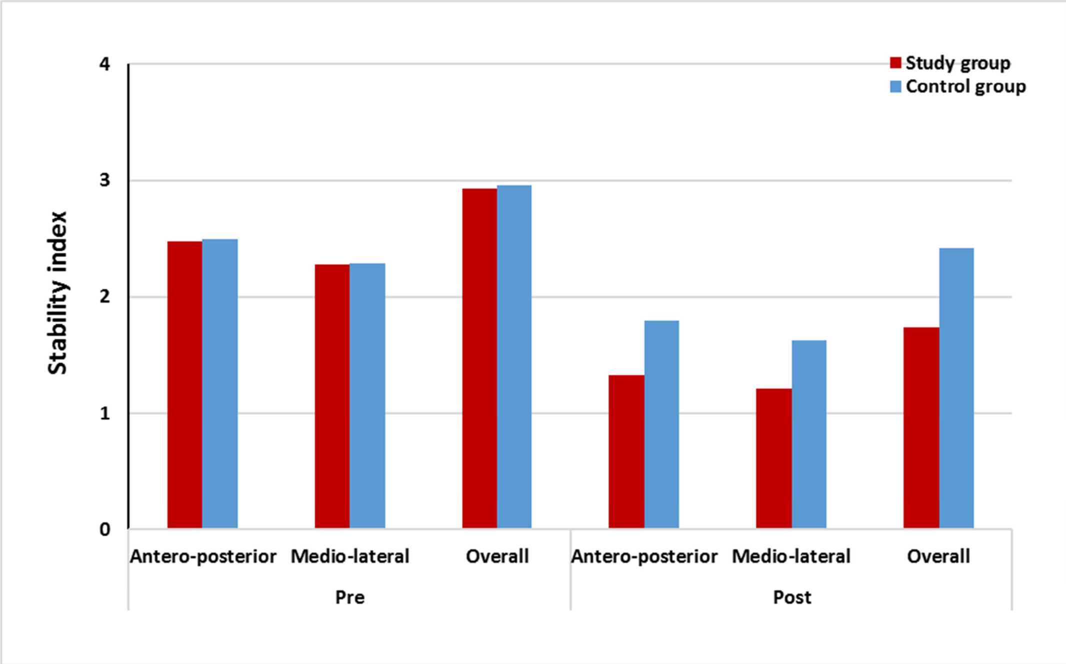

Figure (1): mean antero-posterior, medio-lateral, and overall stability indices of study and control group at pre and post treatment

DISCUSSION

Down syndrome is one of the commonest causes of developmental delay in children, with balance problems being an integral part of the syndrome [37].

The pre-treatment values of the Biodex balance system obtained from the two groups regarding the measured variables (anteroposterior, mediolateral, and overall stability indices) revealed abnormal values of these variables. This may be attributed to Motor dysfunction in children with Down syndrome limits successful completion of many activities of daily living, and produced low physical work capacity. This results in increased dependence on others and assisted living [38].in addition to Muscle hypotonia and weakness is one of the major clinical features of down syndrome that contributes to postural instability. Postural instability tends to progressively worsen asthe clinical picture advances, severely limiting the patients' quality of life [14].

The purpose of this study was to investigate the effect of core stability training on postural stability in children with Down syndrome.The core is important because it is the anatomical location in the body where the center of gravity is located and movements stem from, therefore it seems strengthening of muscles of core causes to improvement of neuromuscular system and decrease of center of gravity displacement and sway [39].

Results of this study showed improvement in postural stability in both groups when comparing pre to post treatment measurements. This improvement might be attributed to the effect of exercises therapy program for balance, postural control, and strength exercises. This agrees with the findings of Gupta et al. [40] who studied the effects of resistance and balance exercises on strength and balance in children with Down syndrome. They reported improvement in strength and balance after the exercise program.

Improvement in balance indices in both groups that treated with Swiss ball training that created unstable environment comes in agreement with Jankowicz-Szymanska et al. [41] who studied the effect of physical training on static balance in young people with intellectual disability. Their results lead to a conclusion that exercises with the use of unstable surfaces improve deep sensibility in people with mild mental retardation. Keeping one's balance in changeable conditions of external environment is possible thanks to coordinated cooperation of the organ of sight, the inner ear, deep sensibility and the central nervous system. This is a dynamic process steered subconsciously [41].

Exercise tools such as Swiss balls and balance boards have been shown to activate muscular contraction strategies differently than on flat earth surfaces. Appropriate use of these devices during exercise increases the contraction speed and intensity of muscles connected to motor control strategies, involved in a specific movement acts. The demand on the motor control system is also increased [42,43].

The results of the present study revealed that there was a significant decrease in anteroposterior, mediolateral, and overall stability indices of the study group compared with control group post treatment as there was significant effect of core stability exercises on postural stability. This results comes in agreement with Ghaeeni et al. [44] who investigated the effect of core stability on static balance in children with Down syndrome. They reported that core stability exercises increase static balance of children with Down syndrome, evaluated by modified stork stand test,through developing strength and endurance of superficial and deep muscles of core stabilization area.

Also results of this study come in agreement with Golsefidi et al. [36] they found a significant effects of 8-week corestability training on students' balance with high functioning autism. In the same context Sayadinezhad et al. [45] concluded that progressive resistance training increases balance capacity in children with Down syndrome. The results of this study come in line with Ahmadi and Daneshmandi [46] who studied the effects of six weeks of core stability exercises program on physical fitness of children with mental retardation. Static balance test results showed that children with mental retardation in training group improved significantly in the static balance test after intervention.

The significant effect of core stability training may be attributed to that core stability training improves neuromuscular system performance that causes the optimal lumbar-pelvic -hip chain mobility and good acceleration and deceleration, appropriate muscular balance, proximal stability and good function [47]. These will result in strengthening the lower extremity muscles which can control the movement[48].

Kibleret al[49] stated that strengthening deep muscles of trunk will stabilize the trunkand prepare the lower extremity to move. Transverse abdominal muscle, external and internal and rectus abdominus stabilize the spine and support the movement of lower extremity. Also multifidus and transverse abdominal muscles support the spine and maintain the dynamic balance of lower extremity. When the transverse abdominal muscles contract, internal abdominal pressure and thoraco-lumbar fascia tension will increase that will stabilize the region [49,50]. Core stability exercises improved the pattern of trunk muscle activity and strength [49]. Also Hodges and Richardson [51] identified trunk muscle activity before activity of the lower extremity, which helps the spine to stiffen leading to a foundation for functional movements. They also found that the transverse abdominus is the first muscle to become active prior to actual limb movement and this pre-programed activation of the transverse abdominus was a component of the strategy used by the central nervous system to control spinal stability.

Infant motor milestones provide a progressive training pathway to prepare the child to exhibit mature and sophisticated movements including multi-segmental stability strategies that can be easily adapted to a wide variety of tasks [52,53]. Examples of these progressions are seen in the infant postures from rolling, supine creeping and crawling, sitting up, sit to stand, squat, lunge, standing and balancing, walking then walking and carrying and running. The core stability training, i.e. supine bridge, side bridge, quadruped cross crawl, lunge and squat mimic the movement pattern progressions seen in the developing infant aimed to establish the ability to control dynamic body orientation [54].

Numerous studies confirmed the significant effect of core stability in adult populations with different pathological conditions. Ko et al. [55] concluded that core stability exercises have a positive effect on the improvement of physical and psychological performances of older women who are vulnerable to falls. Ozmen et al. [24] concluded that core stability exercises resulted in significant gains in balance and core endurances in adolescent badminton players. Sandrey and Mitzel [56] found that a 6-week core stabilization training resulted in significant improvement in balance test score in high school track and field athletes. YU and Park [57] concluded that the core stability-enhancing exercise is effective in improving muscle activity of the lower trunk in stroke patients.

Core stability training can be used for children with down syndrome suffering from balance disorders, so as to improve balance and reduce risk of fall and injuries, thus leading to a better quality of life. Core stability training can be incorporated to improve performance and minimize injuries.

CONCLUSION

Eight weeks of core stability exercises is effective in improving postural stability and balance of children with Down syndrome. Core stability exercises should be considered as important part of the rehabilitation program for children with Down syndrome.

Competing interest
All authors have no conflicts of interest or any financial interest.

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