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Efficacy of Induced Spherical Based Modified Balance Board on Improvement of Sitting Level Stage in Spastic Cerebral Palsy Children

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Abstract

Objectives: The aim of this work was to show Effect of induced spherical based modified balance board on improvement of sitting level stage in spastic cerebral palsy children.

Method: Thirty children were enrolled in this study and randomly assigned into two groups; group A (induced spherical based modified balance board plus traditional physiotherapy program), and group B (traditional physiotherapy program only). Level of sitting scale was used to detect and follow sitting stage of development. This measurement was taken before initial treatment and after 12 weeks of treatment. The children parents in group (A) were instructed to complete 6 hours of home routine program.

Results: Data analysis was available on the 30 spastic cerebral palsy children participated in the study. The mean value of Level of sitting scale in both groups at baseline measurement (pre-treatment) was insignificant ($p>0.05$). By comparison of both groups there was insignificant improvement in Level of sitting scale ($p>0.05$). The difference between pre and post treatment results was significant in both groups in favor of the study group ($p=0.0018$).

Conclusion: According the results of this study it can be concluded that the combined effect of physiotherapy training program in addition to induced modified balance board can be recommended in improvement sitting stage of development in spastic cerebral palsy children.

Keywords: Induced spherical based modified balance board; Sitting balance

Introduction

Cerebral Palsy (CP) is an umbrella term covering a group of non-progressive, motor impairment syndromes secondary to lesions or anomalies of the brain arising in the early stages of development. The motor disorders in children with CP are complex. The primary deficits include: muscle tone abnormalities, influenced by position, posture and movement, impairment of balance and coordination, loss of selective motor control. The secondary musculoskeletal problems are muscle contractures and bony deformities. These develop progressively in response to the primary deficits and produce further motor dysfunction [1].

Impairment of posture and balance in sitting affects the ability to perform the activities of daily living. Stability and dynamic stability are two important aspects of the sitting position. Stability is the ability to reduce the body's motion or sway. In the sitting position the body without trunk support, is unstable and its configuration has to be controlled through muscle activity: when weight is shifted in any plane, the trunk responds with a movement to counteract the change in the center of gravity [2].

The stability of the trunk on an unstable surface depends upon the ability to align the projection of the center of mass with the center of rotation of the support surface; added to this there is the need to control inertial forces generated by trunk movement Trunk stability relies on correct perception of body attitude and on the development of adequate muscular responses. Body attitude is constantly modified on the basis of information provided by the visual and vestibular systems and information deriving from somatosensory receptors, and as it is modified further muscular responses are needed different tasks, body configurations and environments require different muscular response patterns and modification of the role of each sensory cue [3].

Balance training is an important component of rehabilitation programs for patients with cerebral palsy and other neurological disorders. Balance training based on repetitive perturbation was applied in a massed practice using a moving platform improved their recovery of stability following an external perturbation 1 this type of training will enable the patients to (a) reduce body oscillations and (b) to actively explore, and hence increase, the limits of the base of support. The training would improve the ability to equally distribute body weight across the base of support [4].

Balance training with postural sway during unperturbed stance is aimed to help patients to be aware of their postural sway to improve its control. The general aims for using balance training can be summarized as follow: to keep the body closes to the vertical, to enlarge the boundaries of the area in which the body can oscillate safely, and to reduce left-right difference in weight bearing. The first two aims offer advantages for the maintenance of stance: first, small body oscillations close to the vertical reduce muscle activity, which requires less energy, and second, larger distances between the gravity line and the limits of stability are safer and make recovery from perturbations more successful [5].

Methodology

Subjects

Thirty children from both sexes with spastic diplegic cerebral palsy children were enrolled for this study, aged 1 to 3 years at time of recruitment because the children in this age are under the umbrella of neural plasticity. All children with delayed sitting either dependent or incomplete independent sitting. Children who otherwise met the inclusion criteria were excluded if they had: previous BoNT-An injections in the lower limb in the past 12 months or prior lower limb surgery (i.e. tendon transfer/tendon lengthening).

Children randomized to the experimental group (A) received induced spherical based modified balance board training plus traditional physiotherapy program. Children randomized to the control group (B) received traditional physiotherapy program only. The individual-based induced modified balance board training treatment sessions lasted approximately 120 minutes every day for 12 weeks in pediatric rehabilitation room after the physiotherapy session for group (A). In addition, children in the experimental group were exposed to home routine program 6 hours daily induced modified balance board training for the 12 week treatment period.

Group A (study group): Consists of 15 spastic diplegic cerebral palsy children (8 females and 7 males) and were treated by specialized and induced spherical based modified balance board training plus traditional physiotherapy program.

Group B (control group): Consisted of 15 spastic diplegic cerebral palsy children (5 females and 10 males) and were treated with traditional physiotherapy program only.

Outcome measurements

All children were assessed for sitting level using sitting level scale. All measurements were taken at baseline (pre) and after 12-week of intervention (post).

Assessment of sitting level

Level of Sitting Scale (LSS): The eight levels of the LSS are based on the amount of support required to maintain the sitting position and, to assess the level of sitting, the child is first asked or assisted to assume the sitting position. If the sitting position is independently maintained for 30 seconds, the child is then requested to shift his trunk and re-erect or is further encouraged to do so by being offered a toy to reach.

Maintenance of sitting for 30 seconds is required to pass Levels 2 to 4. If the child has passed Level 5, it is not necessary to again maintain the position to pass Levels 6 to 8.The training seemed to improve the time they could sit independently without aid [6,7].

Grades of sitting levels scale

Level 1 Unplaceable: Child cannot be placed or held by one person in sitting position.

Level 2 Supported from Head Downward: Child requires support of head, trunk and pelvis to maintain the sitting position.

Level 3 Supported from Shoulders or Trunk Downwards: Child requires support of trunk and pelvis to maintain sitting

Level 4 Supported at Pelvis: Child requires support only at the pelvis to maintain sitting

Level 5 Maintains Position, Does Not Move: Child maintains the sitting position independently if he/she does not move limbs or trunk

Level 6 Shifts Trunk Forward Re-erects: Child, without using hands for support, can incline the trunk at least 20 anterior to the vertical pane and return to the neutral (vertical) position

Level 7 Shifts Trunk Laterally Re-erects: Child, without using hands for support, can incline the trunk at least 20 to one or both sides of midline and return to the neutral position

Static sitting balance test

In this test, the children is seated on a firm surface chair and asked to maintain sitting position feet flat on the floor and Hand supported on resting hand chair Stand beside the subject to give support if necessary Use the stop-watch to detect time in seconds. Count the number of times the subject can maintain sitting position.

Children with sitting ability from level 1 to 4 have poor postural ability. Without seating support they remain physically dependent and often are unable to observe what is happening around them. Seating systems incorporating the biomechanical principles described above to achieve the independent sitting are essential. Full postural stabilization and an improved functional ability can be achieved leading to improvement in postural ability. In addition, it is particularly important to adjust the environment around the child whilst he is in the seating system. Level 5 is the separation between dependent sitting and independent sitting. Children with greater postural ability, that is, level 6 and above, require postural stability to encourage independence. Seating systems which incorporate the biomechanical principles described above but with reduced trunk support will allow both and rest positions for the child. The dimensions of the seat cushion and sacral pad are crucial as incorrect sizes [8].

Intervention

For all children, the programs were conducted every day, for 12 weeks. Each session lasted for 45 to 60 minutes in a pediatric rehabilitation room for both groups in addition to 120 minutes induced modified balance training for experimental group plus 6 hours of induced modified balance training as a home program, 7 days a week during the treatment period.

The aims of these interventions are: (a) to minimize the development of secondary problems (contractures and deformities) by reducing or nearly normalizing the tone, facilitating adequate stretch to muscles, and increasing the active range of motion; (b) to facilitate motor control (c) to improve mobility and acquire functional motor skills; (d) to promote functional independence in the house and in the community.

The Experimental Group (group A) Received Specialized and Induced Modified Spherical Based Balance Board Training Program as Following

The main physical problem with cerebral palsy children is (how can pass the primitive stage to maturated stage?) the solution is gaining rolling as a first step of righting reaction development together with righting reaction training. Once righting reaction start to appear the child transform from primitive stage to maturated well developed stage. Leaning forward, backward, on the left and right side, oblique and all directions. These balance training occurred by using induced spherical based modified balance board which has sitting support from posterior edge, lateral edges ,anterior edge performing anterior – posterior telting and lateral telting, oblique telting and telting in all directions for two hours then ask parents for repeation of balance sitting training for addition 6 hours as a home routine program. Use of an induced spherical based modified board can help to develop balance, core strength and flexibility in the trunk and pelvis. These skills are important for general body awareness and upright posture in sitting. It consists of large wooden rectangular shape; the bottom is smooth plastic spherical based board so it can move in all directions.

Both groups (A and B) received a traditional physiotherapy program, as the following

1. Facilitation of anti-spastic muscles: tapping followed by movement, quick stretch, triggering mass flexion, biofeedback, weight bearing, clenching to toes, compression on bony prominence, rapping the muscle, approximation for shoulder girdle and sacroiliac joint , vibration, irradiation to weak muscles by strong muscles, and ice application for brief time.

2. Prolonged stretch to spastic muscles to gain relaxation via prolonged stretch (positioning, night splint, reflex inhibiting pattern, Bobath technique) for 20 minutes.

3. Passive stretching to tight muscles (tendoachillis muscles, hamstring, hipadductor, hip flexors) to destruct adhesions in muscles and sheath. It must be decent gentle gradual stretch not over stretch at all, lasting 20 second then relaxation 20 second 3-5 times per session.

4. Graduated active exercise for trunk muscles.

5. Weight bearing exercise using aids as standing frame for 30 minutes

6. Postural reaction training concentrates mainly on righting reaction training on ball, lab, roll and facilitation of rolling on mat, ball, and wedge

7. Inhibition of released abnormal pattern and primitive reflexes

8. Night splinting (static ankle foot orthoses, knee immobilizer, wrist splint)

9. Sitting disturbance from shoulder girdle, from trunk, pelvis girdle, sudden raising of one limb the release and then raising of both upper limbs the release, rocking both shoulder and pelvis with each other.

Results

Patient's characteristics

Table 1 shows the demographic and clinical characteristics of all patients. There were 17 boys (56.66%) and 13 girls (43.33%). There was no significant difference between the two groups in terms of age (p=0.4529), in term of sex (p=0.3582) and in term of degree of spasticity ratio (0.8974).

Changes in sitting level

Mean test scores and standard deviations for both groups are shown in the Table 2. The mean value of sitting level score in both groups at baseline measurement (pre-treatment) was insignificant (p>0.05). Also By comparison of both groups there were insignificant difference in sitting level score post-treatment (p>0.05). The statistical difference between pre and post treatment results was significant in both groups in favor of the study group (p=0.0018). The average improvement of sitting level score tended to being highly significant in the study group (2.33 ± 1.40 versus 4.29 ± 1.44, p=0.0018) than in the control group (3.00 ± 1.56 versus 3.50 ± 1.99 p=0.0130). The percentage of improvement of sitting level score was statistical significant difference with p=0.0295 with ratio of improvements (84.12%) in the study group compared to the (16.66%) in control group.

variables	Control group n=15	Study group n=15	p-value
age	2.036 ± 0.664	2.233 ± 0.729	0.4529
Sex N(%) Boys girls	10(66.66%) 5(33.33%)	7(46.66%) 8(53.33%)	0.3582
Degree of spasticity% Grade 1 Grade 1+	3(20%) 12(80%)	4(26.66%) 11(73.33%)	0.8974

Table 1: Patients characteristics

Sitting level	Study group Mean ± SD	Control group Mean ± SD	p-values (Between group)
Pre-treatment	2.33 ± 1.40	3.00 ± 1.56	0.2443
Post-treatment	4.29 ± 1.44	3.50 ± 1.99	0.3568
% improvement	84.12%	16.66%	0.0295
p-values (Within group)	0.0018	0.0130	

Table 2: Changes in sitting level

Discussion

The results of the present study suggest that balance training with induced spherical based modified balance board might be useful to decrease the amplitude of postural sway during sitting and increase the amplitude of the voluntary weight shifts during sitting in addition to increase of core stability. Both groups showed increases of the voluntary weight shifts in the forward, lateral and backward directions in favor training group. In the training group, postural sway during sitting appears to be more stable after the training of induced modified balance board. The parallel increase of time on the target confirms that the children became better in quiets sitting with balance training. In other words, after the training the children improved the performances on the tasks that were trained by reducing the amplitude of postural sway and enlarging the area of possible weight-shift without making a fall [9].

The trunk being the central key point of the body, also been identified as an important early predictor of functional outcome. Proximal trunk control is a prerequisite for distal limb movement control, balance and functional activities. Trunk control is the ability of the trunk muscles to allow the body to remain upright, adjust weight shift, and per-forms selective movements of the trunk so as to maintain the center of mass within the base of support during static and dynamic postural adjustments [2].

The benefits of balance training are to continually increase the patient awareness of balance threshold or limits of stability by creating controlled instability. The somato-sensory, visual, and vestibular systems interact and contribute to the maintenance of sitting balance. They are considered the key of postural control, as each system must be integrated to determine the body's center of gravity (COG). It receives this information from peripheral sources such as muscles, joint capsules and soft tissue receptors (called muscle spindles, ruffini endings and paciniform corpuscles). This system plays an important role in regulating sitting balance. The information must be detected peripherally and transmitted centrally for processing. These impulses stimulate the child postural reflex mechanisms. It affects multiple systems such as the sensory, musculoskeletal, limbic, vestibular, and ocular systems simultaneously, leads to different therapeutic benefits that will be evidenced in behavioral patterns used in sitting balance [10].

Sitting balance is considered the bottleneck stage of development because it is the separation between primitive a pedal stage and postural reaction stage which its developed lead functionally to sitting, standing, walking, prevent fallen. Postural control of the head, neck, and trunk is essential for normal functions of the sitting level. The spastic diplegic patient must have control of the head and trunk to manage shifting and bearing weight in sitting to free an extremity for function. The establishment of head, neck, and trunk control allows for dissociation of the shoulder and pelvic girdles from the trunk and dissociation of the extremities from the girdles [7].

Balance training is brain training

Essentially, when using balance or postural stabilizing exercises, an individual perform actually brain training, as it stimulates various centers in the brain. When incorporating balance exercises in a patient's program, musculoskeletal reaction is not only improved, but also brain to joint connections, therefore improving reactivity. Reactivity is key to preventing falls in sitting stage. Balance leads to proper recruitment of joint stabilizing muscles, and maintains proper axis of rotation of the joint. This leads to accurate proprioceptive information from the somato -sensory system as the joint capsule, muscle, and ligament structures. With proper somatosensory input, balance will be improved. Additionally, poor posture, such as thoracic kyphosis, and forward head posture also reduces spinal rotation. Spinal rotation and three-dimensional freedom of movement is needed to correct an individual when balance reaction is called upon. Overall, to train balance, strive for proper alignment so the body learns how to move to good posture for its position of strength and reactivity, and not to one of compensation [11] (Table 3).

Brain Structure	Function of Brain Structure
Spinal Cord	Conveys proprioceptive information to higher levels of the CNS and back to the muscles via motor fibers. Necessary for muscle tone and joint stabilization as well as antagonistic and synergistic patterns of muscle contraction (coordination).
Lower Brain Brain Stem	Coordination and control of movement and balance (equilibrium) Posture stabilization.
Lower Brain Cerebellum	Vestibulocerebellum - balance regulation and eye-head movement and head position changes. Cerebrocerebellum - decision to move (initiation of movement). Spinocerebellum - regulation of movement execution and muscle force to overcome load variations.
Lower Brain Basal Ganglia	Initiation and control (sustaining) of repetitive voluntary movement as walking and running Postural maintenance and muscle tone. Scaling of movement parameters such as velocity, direction, and amplitude.

Table 3: Brain structures stimulated by balance training

Righting reactions can be trained in antero-posterior and lateral direction, oblique and other directions. Righting reaction training started by facilitation of rolling in different position. Sitting on an unstable surface moving arms or legs to shift center of gravity - Sitting on unstable surface in combination with traditional lifting exercises .When your vestibular system senses that your body is not erect, it triggers the righting reflex by stimulating the vestibular system which stimulate vestibule-spinal tract which modulate the gamma fibers lead to modulate stretch reflex lead to modulate abnormal co-contraction and posture sway in sitting leading to improvement of core stability and sitting balance [12].

The vestibular organs provide sensory information about motion, and spatial orientation. The organs in each ear include the utricle, saccule, and three semicircular canals. The utricle and saccule detect gravity (vertical orientation) and linear movement. The semicircular canals detect rotational head movements and are located at right angles to each other. When these organs on both sides of the head are functioning properly, they send symmetrical signals to the brain that are integrated with other sensory and motors systems. If vestibular dysfunction occurs early in development, it slows the development of righting, equilibrium and protective reactions and motor-control tasks such as sitting unsupported, standing, and walking. Stable vision is important for learning to read and write and for developing fine and gross motor control. If left untreated, a vestibular disorder can have adverse consequences for a range of functions as the child grows to adulthood. concentration on vestibular system training occurred by make the child blindfolded within the modified balance board which lead to isolate of proprioceptors and vision so pure vestibular stimulation occurred which lead to stimulation of vestibule-spinal tract which modulate the exitability of alpha-motor neuron of stretch reflex lead to modulation of muscle tone allowing the functional sitting to occur after repletion and massed practice [13].

Conclusion

The combined physiotherapy program which include (traditional physiotherapy program + induced spherical based modified balance board) is recommended in sitting balance delay, to improve the ability to upright posture in sitting, normal distribution of weight bearing during sitting, provide sensory feedback via gaining of righting reaction so this combined program may be used as a therapeutic intervention for improving sitting balance in children with spastic diplegia.

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