

Effect of Vestibular Stimulation Versus Whole Body Vibration on Standing Balance in Children with Spastic Diplegic Cerebral Palsy

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Abstract

Introduction: Most cerebral palsy children have deficits in balance, co-ordination, and gait throughout childhood and adulthood. So, it is essential to seek an ideal physical therapy program to help in solving such widespread problem. The present study was conducted to compare between the effect of whole body vibration and vestibular stimulation on standing balance in children with spastic diplegic cerebral palsy.

Method: 30 children were randomly assigned to group 1 (n=15, male: 11, female: 4, mean age: 6.2, SD 2.48) and group 2 (n=15, male: 8, female: 7, mean age: 6.9, SD 2.01). Balance was measured by Pediatric balance scale and parents perception on balance. Group 1 received vestibular stimulation in addition to conventional physiotherapy while group 2 received whole body vibration addition to the same physical therapy program given to the group 1.

Statistical analysis: Data was analyzed using Mann Whitney U test by taking the change of score from pre to post. To find out the difference between the groups for changed score of Pediatric balance scale. Independent T-test was used for Parents perception on balance and within group difference analysis was done using Wilcoxon Signed Rank test for both the group separately.

Results: The Group 1 and Group 2 showed an change of 21.10 and 9.90 ranks on PBS and 3.73 & 1.60 on Parents perception on balance respectively over 4 weeks period which was significant with time. The improvement in group 1 was significantly more than the group 2.

Conclusion: Vestibular stimulation with conventional physiotherapy exercises brings about more improvement in balance than whole body vibration and conventional physiotherapy.

Keywords: Balance; Cerebral palsy; Spastic diplegia; Vestibular stimulation; Whole body vibration

Introduction

Cerebral Palsy (CP) CP is a non-progressive disorder that covers a number of neurological conditions, resulting in an abnormal development of movement and postural [1]. Spastic cerebral palsy is by far the most common type of overall cerebral palsy, occurring in 80% of all cases [2], which affects the lower extremities primarily, with relatively normal upper extremity function [3].

Balance has been defined as the elements of postural control that allow a child to safely perform everyday tasks [4]. Poor balance control is one of the most contributing factors for poor gait and reaching movement because the maintenance of stability is critical to all movements [5].

As the motor system relies heavily on deep sensory stimulation, recent studies have investigated the effect of vibration stimuli. Studies show efficacy of WBV in reducing spasticity, improving strength, balance, ankle dorsiflexion angle and gait parameters in post stroke [6,7] and spinal cord injury patients [8,9] improving posture and balance in patients with multiple sclerosis [10]. Although research suggests a positive influence of vibration on motor performance in

individuals with neurological disorders, there are very limited numbers of studies in children with cerebral palsy (CP).

A few studies of WBV have shown reduction of spasticity as measured by MAS/MMAS and Isokinetic dynamometer [11], improvement in muscle strength measured by hand held dynamometer [12], motor function measured by GMFM and GMFCS [11,13-15], Gait parameters measured by 3D gait analysis [16], Gait function measured by 1 minute walk test, 6 minute walk test and 10 meter walk test [11,17], Balance tested by timed up and go test [11,12], Posture by 2D Posturography [17], Cross sectional area of calf muscle measured by USG [16] and BMD by Dual X ray absorptiometry in children with CP [14,15].

Transmission of low amplitude low frequency vibration to the human body through a contact area i.e. feet in standing, the buttocks in sitting, the reclining body in contact with the vibrating surface is referred as Whole Body Vibration (WBV).

Tonic vibration reflex is referred as contraction of a muscle subjected to vibration. The vibrating platform stretches the muscles, which activate TVR by vibratory activation of muscle spindles which transmit the signal through the CNS to the muscles involved [18]. 30-100 Hz frequency activates receptors present in skin, tendons, muscle spindles, which transmits to the spinal cord through afferent

nerve fibers and activates monosynaptic and polysynaptic reflex arcs resulting in contraction of muscle.

Subconscious contraction of the muscles causes many more muscle fibers to contract than in a conscious, voluntary movement [19] reflected through the heightened EMG activity [20,21].

The effects of sustained vibratory stimulation on muscle contraction, posture and kinesthetic perceptions are much more complex than merely contraction of the muscle being vibrated.

Vestibular system is one of the main structures to maintain balance, as it serves as an absolute reference in relation to the others, such as visual and somatosensorial systems. Adequately administered vestibular stimulation has been reported to improve balance; the vestibular-spinal reflex generates body motion compensation, to maintain head and postural stability, and thus preventing falls [22].

Vestibular system when stimulated elicits responses that facilitate, muscles, to evoke movements of head, trunk and limbs to compensate for postural sway. The cerebellum with input from the vestibular system provides balance, orientation & coordination [23].

Vestibular stimulation over a period of time would improve sensory integration and balance in individual with cerebral palsy [24]. Vestibular stimulation could enhance arousal level, visual exploratory behavior, motor development and balance and reflex integration in infants who are at risk and in development delay disorders [25].

Research has concluded the effect of SI therapy & particularly vestibular stimulation for balance was effective in children with CP [26].

A comparative study between Suspension therapy and whole body vibration was done for improving standing balance in children with cerebral palsy. Significant difference was observed in favor of suspension therapy which was attributed to the effect of spider cage on improving function of vestibular system through development of equilibrium reactions to maintain & regain balance during standing.

Application of vestibular stimulation for CP children led to significant improvement in standing balance. Also, the children showed a new strategy which would lead to an increase in exploratory behavior which would help them to maintain balance.

Aim of study: The aim of the study was to compare the effects of vestibular stimulation with whole body vibration on balance in children with spastic diplegic cerebral palsy.

Methodology

Study design

A pre-test post-test experimental study design

Sample size: 30 children randomly allocated to 2 Groups by chit picking.

Group 1: Conventional therapy and vestibular stimulation (n=15, male: 11, female: 4, mean age: 6.2, SD 2.48)

Group 2: Conventional therapy and Whole body vibration (n=15, male: 8, female: 7, mean age: 6.9, SD 2.01)

Study duration: 4 weeks

Inclusion criteria

Children diagnosed as spastic diplegic cerebral palsy, of either sex in the age group ranging from 3 to 12 years, could understand and follow commands given by the therapist and could stand independently or with one hand support for at least 10 seconds.

Exclusion criteria

Children with types of cerebral palsy other than spastic diplegia, History of convulsions/epilepsy, impaired cognitive function, negative tilt board tip test, any recent surgical procedure for correction of deformity, soft tissue release etc.,

Procedure

Informed consent was obtained from parents of children who fulfilled inclusion and exclusion criteria and randomly assigned to Group 1 and Group 2 Pre-test measurements of the dependent variables pediatric balance scale (PBS) and parents perception on balance (PPB) were measured on recruitment for the study by one investigator, who was blind to the type of treatment given.

Paediatric Balance Scale (PBS) is a reliable measure of functional balance for school age children with mild to moderate motor impairments. Test retest reliability=0.87 to 1.0; interrater reliability=0.997; correlation=0.89 to 1.0 [55].

Parent's perception on balance (PPB) is an observational measure of functional balance of child by parents using Visual Analogue Scale. Parents were asked to grade child's standing balance on 0-10 scale.

Group 1 treated by conventional physiotherapy + Vestibular stimulation

Technique of application of Vestibular stimulation: Procedure was explained to the parents. SPINNING- Child was asked to sit on hammock and spun 10 times to the right and 10 times to the left, SLIDING- Child was asked to lie in supine position on a large physio roll, then the child was accelerated forward and backward direction 10 times by holding both the legs, BOUNCING UP AND DOWN- Child was made to sit on a large physio roll, holding the child from pelvis by therapist then bounced the child vertically up and down for 5 minutes. Total treatment duration was 10 minutes.

Group 2 treated by conventional physiotherapy + whole body vibration

Technique of application of WBV: Procedure was explained to the parents, child was seated on vibration platform in full squat position with feet flat on whole body vibration platform. The mains of the machine were switched on. The timer was set on 5 minutes. The vibration switch was turned on (At frequency 30 Hz and amplitude 2 mm). Child was instructed to sit still and report immediately if any discomfort. Therapist sat in front of the child to spot for fall. After 5 minutes, vibration turned off automatically. After 1 minute rest, child was made to stand on the vibration platform with hands held in front by the therapist. Again, the timer was set on 5 minutes and the vibration switch was turned on. Child was instructed to stand still and report immediately if any discomfort. After 5 minutes, vibration turned off automatically. Thus, WBV was applied for total 10 minutes in each session.

Both the groups received conventional physiotherapy which includes bridging, quadruped, kneeling, sit to stand, reaching. Treatment was given for 5 days a week for 4 weeks.

Data Analysis

Data was analysed using Mann Whitney U test by taking the change of score from pre to post. To find out the difference between the groups for changed score of Paediatric balance scale. Independent T-test was used for Parents perception on balance and within group difference analysis was done using Wilcoxon Signed Rank test for both the group separately (Figure 1).

An alpha level of 0.05 of significance was set for both the tests.

Analysis was performed using SPSS package 23 version.

Results

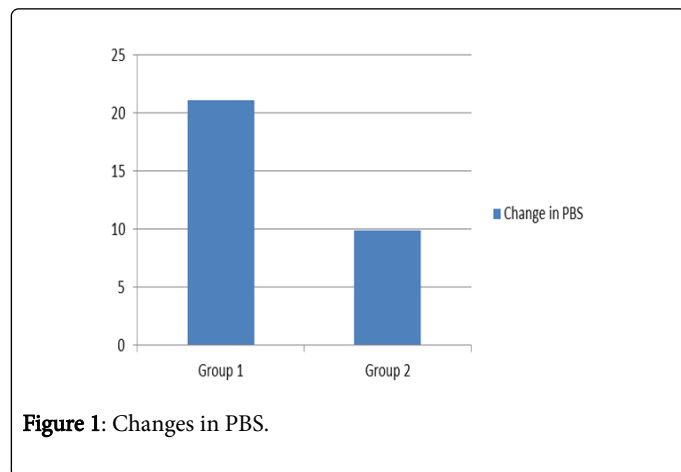


Figure 1: Changes in PBS.

Wilcoxon Signed rank test showed that the value of Z is -3.429 with p (2-tailed)=0.001 for group 1 and the value of Z is -3.424 with p (2-tailed)=0.001 for the group 2, indicating a significant change within groups.

Mann Whitney U test showed that Z score is -3.508; value of test is 28.5 with p<0.000, indicating a significant difference in changed score pre to post between both groups (Figure 2).

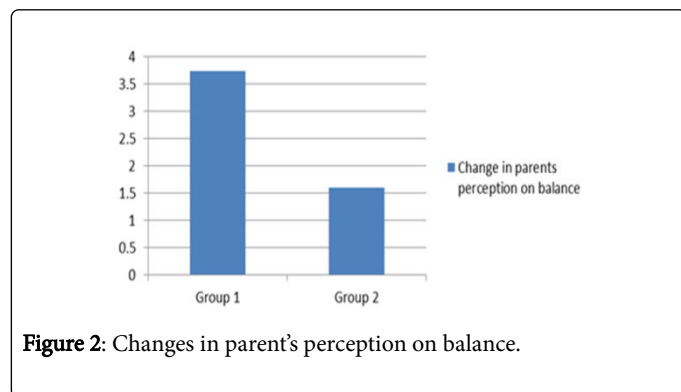


Figure 2: Changes in parent's perception on balance.

The t-test showed a significant change in parents perception on Balance (t=-4.980 & p=0.00).

Discussion

The conventional exercise protocol which was common to both groups consisted of: Bridging, quadruped, kneeling, sit to stand, reaching.

The prime factor for improvement of balance in both the groups could be an improved trunk stability and postural control as a result of increased trunk muscle strength by conventional exercises [27-30]. Balance is correlated to trunk muscle strength [31].

The improvement in trunk stabilization by performing trunk exercises lead to (a) improved length tension relationship of the upper and lower limb muscles which originate from the girdles which in turn are linked to spine, (b) improved phasic contraction of spinal muscles, (c) decreased freezing and improved degree of freedom leading to smoother and more appropriate and purposeful movements [32].

Another factor contributing to improve balance in both the groups would have been protraction and retraction of shoulder girdle as well as rotation movement of trunk while reaching obliquely for objects. In a study conducted, the weighted differential center of pressure signals showed that the estimated body transverse rotation contribution is critical for postural stability in children with cerebral palsy. They found that limb protraction/retraction control was found to be dominant during medial-lateral sway, whereas the estimated body transverse rotation contribution was significant for anterior-posterior balance. Their study identified the significance of body transverse rotation control contribution in upright posture. These findings were consistent during both eyes open and eyes closed trials [33]. In the present study this could be a factor contributing in improvement of PBS score which has items with both eyes open and eyes closed.

Practice of functional activities like reaching in various directions while sitting upright have the potential to train aspects of muscle performance such as coordination, strength, endurance, physical conditioning [22]. As well as motor learning as reaching tasks resembled items of PBS. Since the exercises simulated the goal movement and context of movement, neuromuscular organization to movement occurs [34]. Thus, this can be transformed as an improved performance on Pediatric balance score.

Cerebral palsy children lack the ability to distribute the load i.e. body weight appropriately during static balance and transfer the body weight adequately from one supporting limb to another during dynamic balance tasks [35]. An improvement in postural control parameters with core stabilization training in low back pain subjects probably due to the efficient changes related to load transfer and weight distribution patterns of core instability patients. Similar effects of core stabilization exercises could have brought about improvement in balance in our CP subjects [36].

Exercise of bridging cause all back muscles to contribute in a similar way to control spine positions and movements in a healthy population [37]. Veerle K Stevens [27] has supported the above mentioned view by studying the relative muscle activity and the ratios of the back muscles in 3 bridging exercises (single bridging, Ball Bridge and unilateral bridging), demonstrating similar activity levels for all back muscles, resulting in ratios about 1.

Kneeling position is important as it integrates contraction of hip muscles especially gluteus Maximus along with trunk in an antigravity and more functional and developmental position [38].

Quadruped position is used as a progression of core stabilization [37]. It increases the activity of oblique's to maintain a neutral pelvic and spinal posture, in effect balancing the internal moments and lateral shear forces; but it occurs in association with ipsilateral internal oblique activity so as to make trunk a stable unit [29].

Sit to stand exercises were done to stimulate the motor control tasks as ideal neuromuscular organization to movement occurs when the movement is in similar pattern to the goal movement and practiced in context of the particular movement [34]. Thus, the core muscles which were trained during the previous positions get an opportunity to activate a functional task. The performance of core stabilization exercises to improve trunk control could be responsible for an improvement in Pediatric balance score.

Group 1 has shown a significantly better improvement in balance than Group 2, possibly due to addition of vestibular stimulation along with these conventional exercises.

Individuals with CP have dysfunctional vestibular sensory information within the brain. Vestibular stimulation over a period of time would improve sensory integration and balance [24].

The connectivity of vestibular system with cerebellum provides powerful influence on motor development, then the other sensory inputs. Abnormal motor behaviors are produced due to imbalance in sensory systems [32].

The vestibular system integrates all other functional systems, which stimulate the postnatal development of the CNS. The CNS determines the normalization of motor development, speech and cognitive development. With repeated vestibular stimulation neuroplasticity and activation of dormant synapses occurs [33].

Vestibular system is important in the achievement of normal motor development and treatment approach to CP should consist of vestibular stimulation for development of postural reactions, and normalization of tone [34].

A number of researchers attribute improved motor development following VS to an enhanced interaction between the vestibulo-ocular and vestibulospinal systems [38].

A systematic review in which 17 out of 19 studies in which vestibular stimulation was used reported positive effects in development and strongly suggested that vestibular stimulation could enhance arousal level, visual exploratory behaviour, motor development and balance and reflex integration in infants who are at risk & in development delay disorders [39].

The effect of Vestibular stimulation on CP's. In the study, 20 CP children with mild spasticity, age ranging from 3-6 years, were sub-classified in to two groups of equal number. First group received Vestibular stimulation in addition to traditional therapy, while second group received only traditional treatment. Program was performed for 8 weeks, 6 days/week. Gross motor skills were measured using GMFM. Results showed a significant improvement in the VS group [40].

Another study in support evaluated the effect of vestibular stimulation program on motor function in children with spastic cerebral palsy. Thirty spastic cerebral palsied children, age ranging from 1-5 years, were involved in the study, Children were randomly distributed into two groups; vestibular stimulation group and traditional physical therapy group. Both basic gross motor abilities and motor abilities in daily situations of all children were assessed before and after application of the intervention by using gross motor function

(GMFM) and Pediatric Evaluation of Disability Inventory (PEDI). Intervention was applied daily for six weeks. The result of this study supported the hypothesis that using vestibular stimulation program in addition to traditional physical therapy for the treatment of spastic CP children is more effective than using traditional physical therapy alone [41].

In a study on vestibular stimulation in 20 CP children to improve the standing balance by using force plate twice weekly, for 12 sessions in 20 CP children. Application of vestibular stimulation for CP children led to significant improvement in standing balance [35].

Group 2 has shown improvement in balance, possibly due to addition of whole body vibration along with conventional exercises. This can be attributed to the strengthening effects of WBV on the postural muscles of trunk and lower limb. Strength is closely related to function in spastic cerebral palsy [36,37].

Increases in Maximal Voluntary Contraction for Vastus Lateralis, Vastus Medialis, Rectus Femoris and Gastrocnemius after WBV training (vertical type, 35 Hz, 2.5 mm amplitude) in EMG studies [38].

Following WBV training, significant improvement in knee extensors and/or plantar flexors strength as measured by peak torque using isokinetic or motor driven dynamometer has been demonstrated by many authors [39-47].

Vibration causes an increase in the g-forces acting on the muscles, increasing the loading parameters of any exercise. Increased loading may enhance neuromuscular potentiation [48].

Vibration training has beneficial effects in muscle strength and power enhancement. This would have led to improvement in balance [49].

The results of the present study are consistent with those of previous studies. Study on the effects of WBV (once a week during 3 months with a stimuli of 40 Hz for duration of 20 minutes) in children with cerebral injury and showed that there was a significant improvement in motor performance, as was seen in the facilitation of rotations, better postural trunk stability and in greater selectivity of movements in children who were developing the classification of spastic cerebral palsy [13].

Patients with chronic stroke, a single session of whole body vibration could significantly improve balance as measured by the timed up and go test [7].

Improvement on the Berg Balance Scale was larger in vibration training than in control group after 3 weeks in patients with Multiple Sclerosis [10].

Equilibrium and gait improved in patients with Parkinson's disease receiving WBV. Quantitative dynamic post urography only improved in patients with WBV whereas there was no significant change in controls [50].

There was significantly better improvement in body balance in elderly in the WBV group who received exercise intervention concurrently than in the control group who received exercise intervention only [51].

Researcher found WBV (vertical type, 3 × weekly session, maximum of 40 minutes/session, variable 30-40 Hz) may contribute to improvement in some aspects of postural control in adults over 60 years of age [52].

Study demonstrated effect of 6 weeks of WBV (vertical type, 3 × per week, 30-50 Hz, 2-5 mm amplitude) in elderly subjects as compared with sham treatment. Body balance scores, total Tinetti test scores and timed up-and-go scores were significantly better in the WBV group [53].

Study found that the whole-body vibration training may be a useful tool for improving muscle strength and balance in children with diplegic cerebral palsy [54-56]. Experimental group (n=15) received WBV training (9 mins per day, 5 days per week). Control group (n=15) participated in a traditional physical therapy exercise program for 3 successive months [57-61]. A significant improvement when compared with those in the control group in the knee extensors peak torque at 60 degrees per second and 90 degrees per second using the Biodex isokinetic dynamometer and also in overall stability index using the Biodex balance system after treatment was found. In the present study, improvement in balance may be attributed to improvement in muscle strength as is likely due to similar treatment parameters (10 mins per day, 5 days per week for 6 weeks) [12, 62-65].

Conclusion

Vestibular stimulation with conventional physiotherapy exercises brings about more improvement in balance than whole body vibration and conventional physiotherapy.

Limitations

Study sample was small; Carry over effect of the study has not been studied.

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