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Whole Body Vibration versus Suspension Therapy on Balance in Children with Spastic Diplegia.

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Abstract

Background: Maintaining balance is a subordinate but necessary requirement for most human actions. Most spastic diplegic children, who constitute a large portion in our country, continue to evidence deficits in balance, co-ordination, and gait throughout childhood and adulthood. Therefore, it is essential to seek an ideal physical therapy program to help in solving such a widespread problem. **Objective:** The present study was conducted to compare between the effect of whole body vibration and suspension therapy on balance in children with spastic diplegia. **Methods**: Thirty children from both sexes who were ranging in age from eight to ten years old were assigned into two groups of equal number. Group I received whole body vibration in addition to a designed exercise therapy program and group II received suspension therapy in addition to the same exercise program given to group I. Stability indices and functional mobility were evaluated by Biodex instrument system and Timed Up and Go Test (TUG) respectively before and after three months of treatment. **Results**: The results revealed no significant difference when comparing the pre-treatment mean values of the two groups, while significant improvement was observed in all the measuring variables of the two groups when comparing their pre with that of post treatment mean values. Significant difference was also observed when comparing the post treatment results of the two groups in favor of the group II.**Conclusion:** Suspension therapy for children with spastic diplegia could be considered as a profitable additional supplement to regularly scheduled physical therapy intervention for improving the balance in children with spastic diplegia.

***Key Words**:* Whole body vibration, suspension therapy, balance, spastic diplegia.

INTRODUCTION:

Cerebral palsy (CP) is an umbrella term for a group of motor impairment syndromes secondary to brain lesions in early stages of its development (1). The most common form of CP is spastic diplegia. In this form both legs are more involved than the arms so that walking ability is affected (2). Andersson andMattsson(3) investigated walking ability in adults with CP and found that79% of those with spastic diplegia were able to walk with or without walking aids, but in 51% this ability had gradually decreased and 9% had stopped walking.

One factor that could explain the impaired walking ability characterized by flexion in the knees and hips is weakness of the quadriceps muscles. Strengthening of these muscles is therefore often a goal in the treatment of children with CP (4).Balance control is important for competence in the performance of most functional skills, helping children to recover from unexpected balance disturbances, either due to slips and trips or to self-induced instability when making a movement that brings them toward the edge of their limits of stability (5).

Difficulties in determining individual causes of balance impairment and disability are related to the diverse mechanisms involved. Decreased muscle strength, range of movement, motor coordination, sensory organization, cognition, multisensory integration and abnormal muscle tone contribute to balance disturbances at different levels(6).

A method for muscle strengthening that recently has been used on healthy persons is whole-body vibration (WBV) training. It is practiced on a vibrating platform where the person is standing in a static position or moving in dynamic movements. The vibrations stimulate the muscle spindles and the alphaMoto neurons, which initiates a muscle contraction according to the tonic vibration reflex (7). This reflex muscle contraction has been suggested to increase the synchronization of the motor units when combined with a voluntary contraction (7).

Whole Body Vibration is a cutting edge training method that through the proper utilization of technology and program customization one can rapidly achieve the following clinically proven benefits; increased muscle strength, reduced bone density loss, improved circulation, muscle flexibility, improved body awareness (otherwise referred to as proprioception) (8).

The long-term effect on muscle strength in healthy persons after WBV training with a variety of results has been investigated. More marked effect on muscle strength after WBV training was shown when the training intensity was progressive. Delecluse et al. (9) compared WBV training with resistance training in a placebo-controlled study in young healthy women and found that WBV training could increase muscle strength to the same extent as resistance training. The fact that people with CP could have benefits by muscle strengthening makes it interesting to find out if WBV training could be appropriate for this group. Suspension therapy is an innovative and effective modality for treatment.

It could be combined with conventional physical therapy methods and could be successfully combined with most of rehabilitation and sport equipment to give postural stability while promoting independence with security, which significantly improves balance and coordination of the body and the performance of the vestibule system. It also allows more full use of the patient's strength and abilities (10).

Biodex stability system is an important balance assessment and training system. In addition, it is the unique device, which is designed to stimulate joint mechanoreceptors and assess neuromuscular control by quantifying the ability to maintain dynamic postural stability. This system also acts as a valuable training device to enhance the kinesthetic ability (11).

The aim of this study was to evaluate the effect on balance after three months of WBV training compared with suspension therapy.

PATIENTS AND METHODS

Patient

Thirty children with spastic diplegia from both sexes between the ages of 8 and 10 years (mean =9.34 ± 0.62 years) participated in the study which was held in the outpatient clinic of The Faculty of Physical Therapy, Cairo University. Their height ranged between 110 and 125 cm (mean =118 ± 0.09 cm). The inclusion criteria were: 1)sufficient cognitive ability to understand commands,2) ability to stand and walk independently with frequent falling and 3)32.1 degrees in tilt board eye open test and 25.8 in tilt board tilt eye closed test. Exclusion criteria were; 1) visual or hearing loss;2) cardiac anomalies and/or 3)muscloskeletaldisorders.Neither race nor sex precluded children from being enrolled in the study. Subjects were classified randomly into two groups of equal number group I received WBV and group II received suspension therapy. Inaddition, the two groups received a designed exercise therapy program to facilitate postural control and balance.

Instrumentation

-Whole Body Vibration device

-Spider Cage for suspension therapy.

-Biodex Stability System to assess balance and postural stability.

METHODS

All procedures were explained to the parents and participants, who signed consent form prior to participation. Participants received the treatment program in the outpatientclinic of Faculty of Physical Therapy, Cairo University, three times/week for three months successively. Test sessions lasted approximately 15 min and practice sessions lasted one hour. Each group received exercises program for balance and posture control for 30 min in addition to 30 min WBV for group I and 30 min suspension therapy for group II.Biodex stability system was used to assess balance and postural stability. Each child in the two groups was asked to stand on the center of locked platform within the device with two legs stance while grasping the handrails, the display screen was adjusted so that each participant can look straight at it. At first, certain parameters were fed to the device including ;(1) Child's weight, height and age. (2) Stability level (platform firmness).

Each participant was then asked to achieve a centered position in a slightly unstable platform by shifting his/her feet position until it was easy to keep the cursor (representing the center of the platform) 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, he/ she was asked to maintain his/her feet position until the platform was stabilized. Heels coordinates and feet angles from the platform were recorded as follows: heels coordinates were measured from the center of the back of the heel, and foot angle was determined by finding a parallel line on the platform to the centerline of the foot. The test began after introducing feet angles and heels coordinates into the Biodex system. The platform advanced to an unstable state, and 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 attempting to maintain the cursor in the middle of the bull's eye on the screen. Duration of the test was 30 s for each participant and the mean of three repetitions was calculated.

A print out was obtained at the end of each test including overall stability index, antero-posterior stability index, and medio-lateral stability index. The high values mean that the child had balance difficulty. This test procedure was carried out for each child in the two groups before and after three months of treatment programs. Balance in basic mobility maneuvers was tested with the Timed Up and Go test (TUG) (13).

The participants sat on a standard armchair and were instructed to get up and walk in a comfortable and safe pace to a line on the floor 3 meters away, turn around, return to the chair and sit down again. The time required to complete the task was recorded. One practice session was performed once before the actual test. Intra- and inter-rater reliability of TUG has been found to be good in frail elderly persons (13). The WBV group exercised 3 times weekly during 3 months. Each session consisted of 5 minutes warming up, approximately 30 minutes of WBVtraining (rest included) and finished with a short program of muscle stretching. The WBV training was performed in a static standing position with hips and knees in 508 of flexion on a device called NEMES-LSC (Nemesis BV, Hengelo, The Netherlands).

The participants were instructed to avoid holding on to the handles if possible and to focus on standing with equal weight on both legs. The WBV training program was progressive and consisted of 11 different levels of intensity with a frequency of 25 _40 Hz. The choice of level was depending on the participant's rating of perceived exertion on the Borg CR-10 scale (14). The level of intensity when the rating of perceived exertion was ‘‘7/very strong’’ was considered being appropriate for the training session.For group II: The children received a designed physical therapy program inside the ‘‘spider cage’’.

Each childwas placed in standing position in the center of the cage. He/ she hooked up in the spider cage by a means of belt around his/her waist that attached to the cage using elastic cords. The belt was fixed around his trunk by Velcro straps. The elastic cords were applied in a spider shape. This suspension system ‘‘spider cage’’ provides horizontal and vertical dynamic features of functional suspension as a support, assistance, or even resistance during training. The suspension system also provides just the right amount of support needed for securing and balancing patient while practicing or performing needed movements (15). Different types of exercises were applied according to the level of the cords.

(1) Cords beside: In which the level of the cords connected to the cage is at the same level of the cords connected to the belt so that the whole weight of the body falls on the lower limbs to give a chance for full weight bearing. At first, tension of cords was equal to each other. This enables the child to assume mid or upright position. Then the tension of cords was decreased gradually. The cords were checked to be elastic enough to allow the child to re-adjust himself and to develop his own control. The tension of the front and back cords were interchangeably decreased while repeating the same exercises.Different exercises were applied to improve balance from different positions including; high kneeling, half kneeling, kneel-walking, stoops and recover, standing weight shift, squatting from standing position (squat balance), kicking ball, throwing ball, stepping, jumping in place, jumping abroad, standing on one foot and standing on balance board.

(2) Full suspension: In this type the level of the cords connected to the cage was above the level of the cords connected to the belt in which the child was fully suspended (the child's feet were off the ground). This type of suspension was used as vestibular stimulation, to provide body awareness and to promote or develop posturalreflexes (protective extension reactions, righting or equilibrium reactions).The therapist pulled the child backward, allowing him to swing forward and backward through space until he stops, also up and down, and side to side movements were allowed. Each child was asked to keep his balance, while he was moved through space.Duration of each exercise was 1–2 min with a time of rest (1–2 min) in between exercises (16).The two groups in addition, received a designed exercises program for balance and posture control including the following items with clear instructions to the child to perform it:

1) Standing with feet together while the therapist sitting behind and manually locking the child knees, and thenslowly tilt him to each side, forward and backward.

(2) Step standing with therapist behind the child guiding him to shift his weight forward then backwardalternately.

(3) High step standing and try to keep balanced.

(4) Standing with manual locking of the knees followed by active stoop and recover.

(5) Equilibrium, righting and protective reactions training.

Since gait is an important dynamic balance component, so gait training was important for balance training. The following exercises were performed:

_ forward, backward, and sideways walking between theparallel bars (closed environment gait training).

_ Obstacles including rolls and wedges with different diameters and heights, were put inside parallel bars.

_ Open environment gait training was conducted with the previous obstacles but without parallel bars.

Statistical Analysis:

The collected data from this study represent the statistical analysis of the stability indices including overall stability index, antero-posterior (A/P) stability index and medio-lateral (M/L) stability index ofthe dynamic balance test atlevel 8 stability (more stable platform), and Time Up and Go Test were measured before and after three months of treatment for the two groups. Non-parametric tests (Wilcoxon signed-ranks) was used to compare between the stability indices before and after treatment within the same group. Mann-Whitney test was used to compare the results from each group to see the significance between the two groups. Parametric test was used to compare mean and standard deviation for time up and go test in the same group and between both groups.

RESULTS

[I]Stability Indices:

The obtained results in this study revealed no significant differences when comparing the pre-treatment mean values of the two groups. Significant improvement was observed in all the measuring variables of the two groups when comparing their pre and post-treatment mean values. After treatment, significant difference was observed when comparing the post-treatment results of the two groups in favor of group II.

As revealed from table (1) and (2) significant reduction was observed in the mean rank values of stability indices for the group I and group II at the end of treatment as compared with the corresponding mean rank values before treatment.Significant improvement was also observed when comparing the post-treatment mean rank values of the stability indices of the two groups in favor of the group II ($P < 0.05$) as shown in table (3).

Table (1): *Pre and post-treatment mean values of the stability indices for Group I (n=15).*

	Antero-posterior stability index	Medio-lateral stability index	Overall stability index
	Pre Post	Pre Post	Pre Post
Mean rank	0.22	0.12	0.37
Z-value	-3.40	-3.40	-3.40
P-value	0.0006	0.0006	0.0006

Table (2): *Pre and post-treatment mean values of the stability indices for Group II (n=15).*

	Antero-posterior stability index	Medio-lateral stability index	Overall stability index
	Pre Post	Pre Post	Pre Post
Mean rank	0.35	0.14	0.38
Z-value	-3.40	-3.40	-3.40
P-value	0.0006	0.0006	0.0006

Table (3): *Post-treatment mean values of the stability indices for Group I and II.*

	Anteroposterior stability index		Medio-lateral stability index		Overall stability index	
	Gp I	Gp II	Gp I	Gp II	Gp I	Gp II
Mean rank	0.22	0.35	0.12	0.14	0.37	0.38
Z-value	2.32		3.89		2.11	
P-value	0.02		0.0001		0.03	

[II] Time up and go test (TUG): There were no significant differences when comparing the pre-treatment mean values for up and go test variables of the two groups before treatment. Significant improvement was observed in the time up and go test for the two groups when comparing their pre and post-treatment mean values as shown in table (3). Significant improvement was also observed when comparing the post-treatment mean values of the time up and go test for the two groups in favor of group II (P < 0.05) as shown in figure (1).

Table (4): *Pre and post-treatment mean values of the time up and go test (seconds) for both groups.*

	Group I (n=15)		Group II (n=15)	
	Pre	Post	Pre	Post
X'	22.20	19.27	21.67	18.00
SD	2.14	1.70	2.16	1.41
t-value	7.19		10.16	
P-value	0.001		0.001	

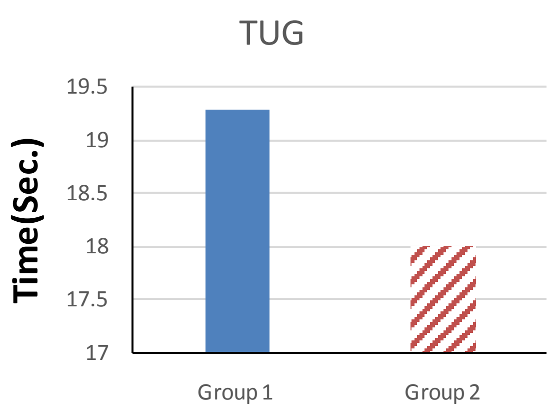

Fig.1 Post means comparisons of Timed up & Go test (seconds) in both groups

DISCUSSION

Impaired balance, gait disturbances and frequent falls are common problems in diplegic children. Spastic diplegic were found to demonstrate deficits in postural control that provides a partial explanation for balance problems that are common in these subjects which was explained by Bax and Brown(17) who reported that diplegic children have been known to have difficulty with the timing of motor responses to support surface perturbations as the muscle activation onset is frequently delayed. The purpose of this study was to compare between the effect of WBV and suspension therapy on balance in children with diplegia.

Conducting the study on children aged from 8 to 10years may be attributed to the fact that this age group show defect in agility and balance. This comes in agreement with Woollacott and Shumway-Cook (5)who confirmed that infant and young children (aged 4 months to 2years) are dependent on the visual system to maintain balance, while at 3 to 6 years of age, children begin to use somatosensory information appropriately. Finally, at 7 to 10 years of age, children are able to resolve a sensory conflict and utilize the vestibular system as a reference and that postural control is essentially adult like around 7 to 10 years of age.

TheBiodex stability system was used for evaluation using dynamic balance test which was performed on stability level 8. This agrees with Revel et al. (18) who reported that, balance assessment should attempt to stimulate dynamic condition in order to stress the postural control system fully and reveal the presence of balance disorder.

The pre-treatment mean values of overall stability index, (A/P) and (M/L) stability indices of the dynamic balance test showed a significant increase in their values which indicated that those children had significant balance problems.Theincreased value of stability indices reported before treatment in both groups were consistent withTesterman and Griend (19) who emphasized that the larger the numerical value of the stability index (represents the variance of platform displacement in degrees from level), the greater the degree of difficulty or instability in balancing the platform. This comes in agreement with Rozzi et al. (11)who concluded that, compared to low stabilityindices, high stability indices indicate greater platform motion during stance and therefore denoting less stability.

The post-treatment results of the group I reinforced the effectiveness of WBV on improving balance. Improvements in this group come in agreement with the study of Cormie et al.(20) who reported that WBV can improve the strength of back and abdominal muscles improving coordination between them.Thedorsiflexors, quadriceps and hip extensors are also strengthened increasing the efficacy of the vertical jump and lower limb extension. These results are supported by MeCollum andLeen(21) who highlighted that postural control is achieved and maintained when balance exists between flexor and extensor muscles of the trunk.Significant improvement gained in this study might be attributed to the effect of WBV on improvement of hip strategy through the rapid perturbation of the platform. This is supported byGeuze(22)who stated that hip strategy controls stability when the centre of mass is moved at the level of the hip joint by producing large and rapid motion at hip joints.Hip strategy is used to restore equilibrium in response to largeand faster perturbations.The improvements in this group could be attributed to an increased enhancement of neuromuscular excitability.Blottner et al.(7) also reported that in comparison to single muscle stimulation the use of WBV involves larger portions of the body. In standing, vibration would have an effect not only on the many muscles and tendons but on the joint structured too. This would mean additional potent sensory motor effects through the proprioceptive joint mechanoreceptors. A relationship was also found between activation of joint mechanoreceptors and stimulation of gamma efferent(to sensitize the spindles) which results in muscle and joint stability. In respect to the group II who received suspension therapy via using spider cage, there was significant improvement in the mean values of stability indices. This improvement in the group II may be attributedto the use of spider cage. It provided more stabilization to the child which minimized the displacement of center of pressure (COP) under each foot, so keeping the COP near the middle.

In addition to that, it helped the child to keep small amplitude of COP motion and decreased postural sway which reflected a good balance control and tended to achieve quiet stance (21).

Improvement of balance reported in group II may be attributed to the effect of spider cage on improving the agonist/ antagonist relationship of the lower limb muscles through loading and unloading (joints distraction and/or approximation) resulting in improvement of weight bearing activities through alteration of the proprioceptive sense. The results of this study come in agreement with Stillman (23) who reportedthat proprioceptive awareness of postures and movements is required during the learning of new skills. He added that, with slower movements the proprioceptive system can monitor and adjust the movements as they occur. This is able to trigger immediate, rapid and precisely-tailored compensatory muscular contractions reflexively in response to unexpected changes in external or internal forces; for example as requiredduring standing balance.

This confirms the findings of Keen (24) who reported that training with the use of spider cage helped the patient firstly to overcome the gravitational effect on their static and dynamicpatterns and secondarily to modulate the muscle tone, which helped in keeping the body from collapsing.Improvement observed in group II may be also due to the effect of suspension therapy which helped in the development of equilibrium reaction to maintain and regain balance during standing pattern. This can be achieved primarily from vestibular input and secondarily from proprioception and vision. If the speed or magnitude of displacement of the child's center of gravity is too great, vestibular, proprioception and vision(equilibrium reaction) will help to regain balance in such cases. This treatment gives postural stability while promoting independence with security, which significantly improves balance,coordination of the body and the performance of the vestibule system (25).

Improvement fulfilled in the study groups I and II might be attributed to the effect of exercises therapy program for balance and postural control. This agrees with the findings of Carvalho and Almeida (26) who suggested that proprioceptive information is essential for the motor control system to selectthe appropriate motor strategy of reciprocal activation among the agonist and antagonist to efficiently maintain balance. Significant difference was observed when comparing the post treatment results of the two groups in the favor of the study group II who received suspension therapy via using spider cage.

These results might be attributed to the effect of spider cage on improving function of the vestibular system. Stimulation of vestibular response provided by spider cage stimulates otolith organs through linear displacement. These findings come in agreement with Rine (27) who reported that stimulation of otolithic organs by transient linear acceleration and/or by changes in head position with respect to gravity evokes phasic and tonic vestibule–ocular and vestibule–spinal reflexes, which act on the head and limbs to maintain posture. He added that orientation in space depends to a high extent on input from vestibular receptors, visual cues, impulses from `proprioceptors in joint capsules and from cutaneous extra receptors especially those of touch and pressure. These four inputs are integrated at various levels of the nervous system to maintain posture.

Conclusion: Both WBV and suspension therapy via using spider cage are effective in treatment of spastic diplegic children with high recommendation for using suspension therapy in addition to the physical therapy program.

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الملخص العربي

الاهتزاز الكلي للجسم مقابل العلاج بالتعليق على الاتزان عند اطفال الشلل المزدوج التشنجي

خلفية البحث والهدف: يعتبر الحفاظ على الاتزان من اهم متطلبات الحركة البشرية. تمثل حالات الشلل المزدوج التشنجي الغالبية في بلدنا وهم يعانون من صعوبة في الاتزان،تنسيق الحركة والمشي اثناء مرحلة الطفولة والشباب. ولذا كان من الضروري ايجاد برنامج علاج طبيعي يساعد في حل هذه المشكلة المنتشرة. اجريت هذه الدراسة للمقارنة بين تأثير الاهتزاز الكلي للجسم والعلاج بالتعليقعلى الاتزان عند اطفال الشلل المزدوج التشنجي. **عينة البحث والطريقة**: شارك ثلاثون طفلا من الجنسين في هذه الدراسة تراوحت اعمارهم بين الثامنة والعاشرة قسموا الي مجموعتين متساويتين. مجموعة الدراسة الاولي تلقت علاج بالاهتزاز الكلي للجسم بالإضافة الي برنامج علاج طبيعي مصمم لمثل هذه الحالات ومجموعة الدراسة الثانية التي تلقت العلاج بالتعليق بالإضافة الي نفس البرنامج للمجموعة الاولي. تم تقييم قياسات الاتزان باستخدام جهاز بيو دكسواختبار الجلوسوالمشي الزمني قبل وبعد ثلاث شهور من العلاج.**النتائج:**أظهرت نتائجالبحث عدموجودفروقذاتدلالهإحصائية بين جميع المتغيرات عند مقارنتها قبل العلاج في المجموعتين وبعد العلاج لصالح مجموعة الدراسة الثانية التي تلقت العلاج بالتعليق. **الاستنتاج:** العلاج بالتعليق لأطفال الشلل المزدوج التشنجي يعد اضافة ايجابية لبرنامج العلاج الطبيعي المتبع لمثل هذه الحالات هادفا الي تحسين درجة الاتزان عند هؤلاء الاطفال

الكلمات الدالة: الاهتزاز الكلي للجسم-العلاج بالتعليق-الاتزان-اطفال المزدوج التشنجي