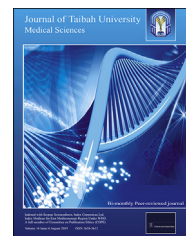




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Original Article

The effect of two therapeutic interventions on balance in children with spastic cerebral palsy: A comparative study



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المخلص

أهداف البحث: يتضمن التحكم في وضعيات الجسم، التحكم في موضع الجسم في الهواء لتحقيق الثبات والتوجه. يتم تطبيق برنامج الثبات المحوري لتحسين التوازن والسيطرة على الوضع. إحدى طرق تقوية العضلات التي تستخدم بشكل متزايد في مجموعة متنوعة من الحالات السريرية هي اهتزاز الجسم بالكامل. يهدف البحث إلى المقارنة بين تأثير اهتزاز الجسم الكامل وبرنامج الثبات المحوري على التوازن في الأطفال المصابين بالشلل الدماغي التشنجي لمدة ١٢ أسبوعاً.

طرق البحث: ٧٢ طفلاً مصابون بشلل دماغي تشنجي (فالج شقي ومزدوج) من كلا الجنسين (٥-٨ سنوات)، تم اختيارهم من العيادة الخارجية، بكلية العلاج الطبيعي، جامعة القاهرة. وتم تعيين الأطفال عشوائياً إلى مجموعتين (أ) و(ب). تلقت المجموعة (أ) برنامج الثبات المحوري لمدة ٣٠ دقيقة بينما تلقت المجموعة (ب) اهتزاز الجسم الكامل لمدة ١٠ دقائق، ثلاث مرات أسبوعياً لمدة ١٢ أسبوعاً لكلا المجموعتين. وتم تقييم التوازن بواسطة نظام بيودكس للتوازن.

النتائج: كان هناك تحسن كبير في جميع المتغيرات في كل مجموعة مع مزيد من التحسن لجميع مؤشرات الاستقرار (الأمامي الخلفي، الجانبي الجانبي والعمومي) في المجموعة (ب). كان هناك اختلاف غير مؤثر في جميع مؤشرات الاستقرار عند مقارنة الأطفال المصابين بالفالج الشقي بالأطفال المصابين بالشلل المزدوج.

الاستنتاجات: ينصح بتطبيق الاهتزاز الجسم الكامل وبرنامج الثبات المحوري في برنامج علاج الأطفال المصابين بالشلل الدماغي التشنجي. وأخيراً، كان اهتزاز الجسم الكامل أكثر تحسناً على التوازن من الثبات المحوري في الأطفال الذين يعانون من الشلل الدماغي التشنجي.

الكلمات المفتاحية: التوازن؛ الشلل الدماغي؛ الأطفال؛ الثبات المحوري؛ اهتزاز الجسم الكامل

Abstract

Objectives: Postural control involves controlling the position of the body in space to achieve stability and orientation. Core stability is needed to improve balance and postural control. Whole-body vibration is a unique strategy for muscle strengthening in various clinical situations. This study compared the effects of whole-body vibration and a core stability program on balance in children with spastic cerebral palsy, with an intervention period of 12 weeks.

Methods: A total of 72 children with spastic cerebral palsy (hemiplegic and diplegic), of both sexes (age, 5–8 years), were selected from the outpatient clinic of the Faculty of Physical Therapy, Cairo University. The children were randomly assigned to 2 groups. Group A underwent a core stability program for 30 min and group B underwent whole-body vibration training for 10 min, at 3 times a week for 12 weeks for both groups. Balance was assessed using the Biodex Balance System.

Results: A significant improvement in all variables ($p < 0.05$) was observed in each group, with greater improvement of all stability indices (anteroposterior, mediolateral, and overall) in group B. There were non-significant differences in all stability indices between hemiplegic and diplegic children ($p > 0.05$).

Conclusion: Whole-body vibration and core stability exercises are recommended for the treatment of children with spastic cerebral palsy. Whole-body vibration was more effective than the core stability program in improving balance in children with spastic cerebral palsy.

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Keywords: Balance; Cerebral palsy; Children; Core stability; Whole body vibration

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Introduction

Cerebral palsy (CP) is a motor impairment caused by maldevelopment of, or injury to, the immature brain. Children and adults with CP have different clinical manifestations, and may also have disorders of proprioception, communication, vision, hearing, cognition, behaviour, and epilepsy that may aggravate the disability due to motor impairments.¹ CP encompasses a group of long-lasting impairments of movement and posture that occur in the developing foetal or infant brain, leading to limitations in activities such as independent walking, stair climbing, running, or walking on an uneven surface.^{2,3} CP is non-progressive disease; however, the clinical manifestations change during development and cause prolonged deleterious effects on the musculoskeletal system. Children with oromotor impairment may have lower survival rates.¹ Various degrees of functional limitations may occur in children with CP owing to loss of axial control with movement imbalance.⁴

Postural mechanism defects, including righting and equilibrium reactions, antigravity mechanism, proximal stability, and postural fixation may occur in these children.⁵ A normal child begins to build core strength through continuous practice of active movements against gravity before using the functional pattern. In contrast, children with CP have limited movement patterns that lead to decreased strength and endurance of the main muscle groups later in life.⁶ Children with diplegia have greater impairment of motor control in the lower extremity than in the upper extremity. Moreover, as children with hemiplegia have motor disabilities in one-half of the body, they present with limited postural adjustment of the lower extremities in specific external disturbances.⁷

Core stabilization and strengthening programs can be modified for children with CP to facilitate fine and gross motor functional movements. In addition, such programs can improve gait, balance, postural control, stability, and reduced muscle tone.⁸ Global and local stability systems have been used in combination to achieve core stability.⁹ Global stability systems involve the superficial and longer muscles of the abdominal and lumbar areas, such as the rectus abdominis, paraspinals, and external obliques, which are the main movers of the trunk or hip.⁹ Local stability systems involve deep abdominal muscles such as the transverse abdominis and multifidus, which are responsible for lumbar spine stability during movements to gain postural adjustments.⁹ Mechanical oscillation, defined by amplitude and frequency, generates a force that acts on the whole body; thus, low-amplitude whole-body vibration (WBV) can be used for proprioceptive and balance

training.^{10,11} Previous studies have demonstrated the benefits of WBV in improving neuromuscular function after hemiplegic stroke.^{12,13}

Therefore, the purpose of this study was to compare the effects of WBV and a core stability program on balance in children with spastic CP, with an intervention period of 12 weeks.

Materials and Methods

Study design

This study was a comparative study.

Participants

The current study was conducted in 72 children with spastic CP (hemiplegic and diplegic). However, 12 children dropped out during treatment and only 60 children completed the study, as shown in the flowchart in [Figure 1](#). The ages of the children, of both sexes, ranged from 5 to 8 years. None of them had undergone a core stability program or WBV training for at least the last 6 months. The required height was >1 m. The spasticity of the children ranged from 1 to 1+ according to the Modified Ashworth Scale.¹⁴ Children with normal flexibility of the lower back muscles and normal muscle length, which are essential for proper joint function and efficient movement, were included in the study.¹⁵ In contrast, children with cardiopulmonary problems, attitude and psychiatric disorders, length discrepancy, and seizures were excluded.

Randomization

This randomized controlled trial was conducted in the outpatient clinic of the Faculty of Physical Therapy, Cairo University, in accordance with the code of ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans.

Procedures

A balance test was performed to investigate the children's ability to stabilize the angle of platform tilting. Balance assessment was performed in both groups before and after the core stability program to find any significant difference, by using the Biodex Balance System to evaluate all measurable variables of stability indices (anteroposterior stability index and mediolateral stability index). Before conducting the test, all children were given instructions on how to perform the test steps. Each child was asked to stand on the centre of a locked platform with both legs in stance phase. Hand rails were adjusted to attain optimal safety, and the child was asked to look straight at a screen for biofeedback. Then, the child was instructed to maintain the position on the centre of the platform with the body in an upright comfortable position, as reflected in the middle of the screen grid, to control the tilting platform and record the feet angles. The test begins after introducing angles into the device system. As the platform moves, the child was asked to look at the screen and keep the cursor in the middle. The test was

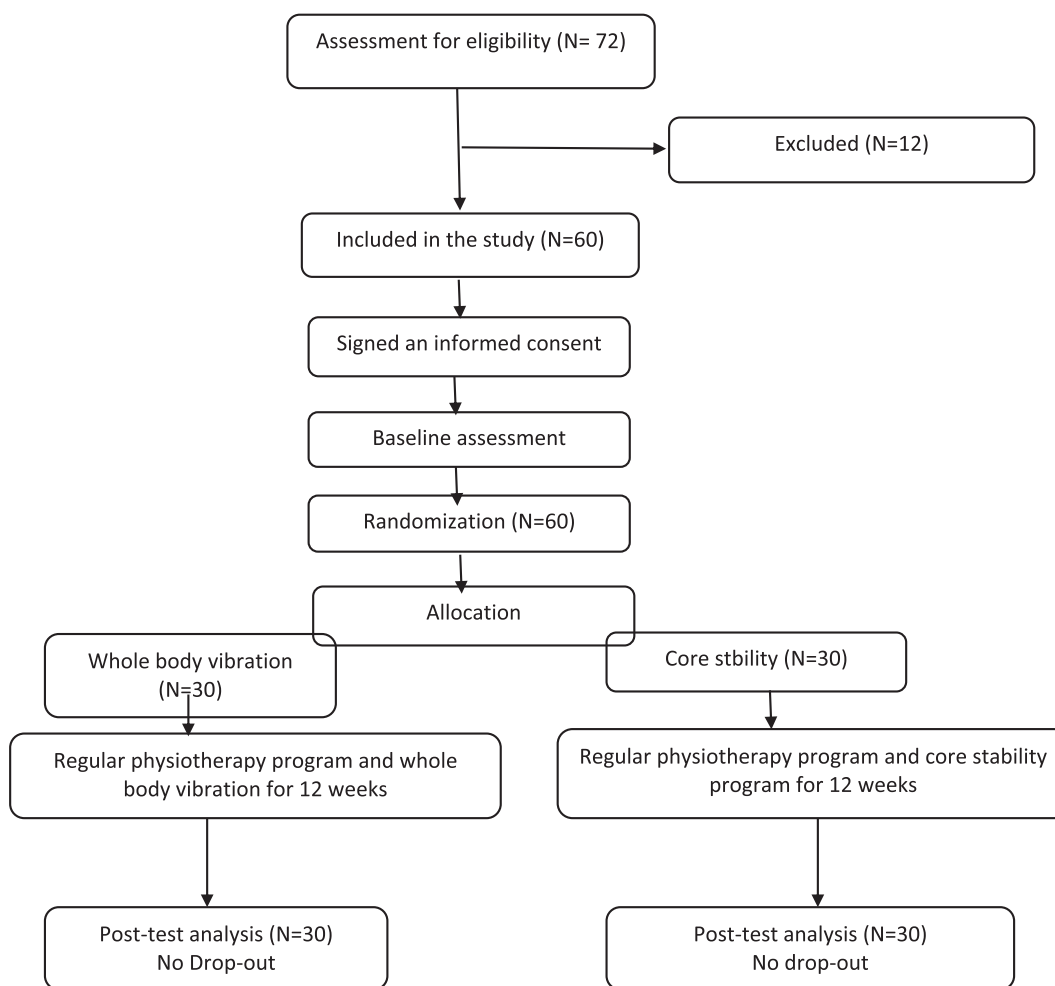


Figure 1: Flow chart demonstrates the experimental design of the study.

performed 3 times. At the end of each test trial, a printed report that includes the measurable variables of stability indices was obtained.

Interventions

Group A (regular physiotherapy program + core stability program)

Thirty children underwent a regular therapeutic exercise program (neurodevelopmental techniques, balance exercises, facilitation of milestones, and facilitation of postural reaction) for 1 h daily, 3 days per week for a total of 12 weeks, in addition to a core stability program for 12 weeks, 3 times per week, at 30 min per session. The core stability program included 3 levels. Each exercise lasted 5 min, and the children shifted from one exercise to the next after the complete performance of the preceding exercise. The first (simple) level included supine abdominal draw-in (20 repetitions), abdominal draw-in with both knees to the chest (10–20 repetitions), and supine twist (10–20 repetitions).

The second (medium) level included pelvic bridging (3–5 repetitions) and twist with a medicine ball (10–20 repetitions).

Finally, the third (difficult) level included bridging with the head on a physioball (the position was held for 3–5 s, followed by a slow relaxation phase, with 10–20 repetitions)

and prone bridging (the entire sequence was repeated 3–5 times). These exercises have been used in previous studies to determine the effects of core stability exercises.¹⁶

Group B (regular physiotherapy program + WBV)

Thirty children underwent the same regular therapeutic exercise program (neurodevelopmental techniques, balance exercises, facilitation of milestones, and facilitation of postural reaction) for 1 h daily, 3 days per week for a total of 12 weeks, in addition to 10 min of WBV training.

Technique of WBV application

The children assumed a full squat position on a vibration platform. The apparatus was set at a frequency of 30 Hz, amplitude of 2 mm, and duration of 5 min. The children were instructed to remain in the squatting position after turning on the vibration and to report any discomfort that might arise. At the end of 5 min, the vibration turned off automatically. Thereafter, the children took a 1-min rest. They were then asked to stand on the vibration platform while supported by the therapist for 5 min, with the same parameters as those used in the squatting position. Thus, the total time for the application of WBV in each session was 10 min.

Data analysis

The results are expressed as mean \pm standard deviation. A test of normality (Kolmogorov–Smirnov test) was used to determine the distribution of data measured before treatment. As the results showed that the data were normally distributed, the comparison of variables between the 2 groups was performed using the analysis of covariance (ANCOVA) test. Bonferroni correction was used to compare within-group differences. The Statistical Package for Social Sciences computer program (version 19 for Windows) was used for data analysis. A p-value of ≤ 0.05 was considered significant.

Results

At post-treatment, the ANCOVA test revealed that there was a statistically significant decrease in all stability indices in the WBV group when compared with the corresponding values in the core stability program group (overall stability index: $F = 28.046$, $p = 0.001$; anteroposterior: $F = 333.877$, $p = 0.001$; and mediolateral: $F = 46.340$, $p = 0.001$). Further, all stability indices in each group showed a significant decrease at post-treatment ($p = 0.001$) when compared with their corresponding values at pre-treatment (Table 1).

At post-treatment, the ANCOVA test revealed that there was no statistically significant difference in all stability indices in both groups when compared between hemiplegic and diplegic children. Moreover, all stability indices in each group showed a significant decrease post-treatment ($p = 0.001$) when compared with their corresponding values at pre-treatment (Table 2).

Discussion

The objective of the current study was to compare the effects of WBV and a core stability program on balance in children with CP. All children had the spastic type of CP, which represents the main type of CP. This is consistent with the report of Berker et al., who revealed that the spastic type is the most common type accounting for approximately 70%–80% of all children with CP and that 50% of children with spastic CP have diplegia or hemiplegia.¹⁷

The main reason for the improvement of balance in both groups might be the increased trunk muscle strength resulting from the regular physiotherapy program.^{18,19} The strength of trunk muscles is directly linked to balance.²⁰ The stabilization of the trunk, which is improved by trunk exercises, leads to improved spinal muscle contraction

Table 1: Comparison of mean values of stability indices measured pre- and post-treatment in the 2 studied groups.

		Core stability program (n = 30)	Whole-body vibration (n = 30)	F-value ^a	p-Value
Overall SI	Pre	3.48 \pm 0.32	3.43 \pm 0.65	28.046	0.001
	Post	2.35 \pm 0.56	1.69 \pm 0.54		
p-Value ^b		0.001	0.001		
Anteroposterior	Pre	2.60 \pm 0.27	2.92 \pm 0.56	33.877	0.001
	Post	1.67 \pm 0.34	1.41 \pm 0.46		
p-Value ^b		0.001	0.001		
Mediolateral	Pre	2.60 \pm 0.51	2.77 \pm 0.58	46.340	0.001
	Post	1.64 \pm 0.48	1.12 \pm 0.25		
p-Value ^b		0.001	0.001		

Data are expressed as mean \pm standard deviation. SI, stability index.

p < 0.05, significant.

^a F-value = between-group comparison (overall effect).

^b Within-group comparison.

Table 2: Intra- and inter-group comparison between median values of stability indices measured pre- and post-treatment in the 2 studied groups.

		Core stability program		F-value ^a	p-Value	Whole-body vibration		F-value	p-Value
		Hemiplegia	Diplegia			Hemiplegia	Diplegia		
Overall SI	Pre	3.40 \pm 0.34	3.56 \pm 0.03	2.119	0.157	3.35 \pm 0.69	3.51 \pm 0.62	0.080	0.780
	Post	2.15 \pm 0.56	2.55 \pm 0.49			1.67 \pm 0.47	1.70 \pm 0.62		
p-Value ^b		0.001	0.001			0.001	0.001		
Anteroposterior	Pre	2.63 \pm 0.30	2.57 \pm 0.24	0.890	0.354	2.97 \pm 0.54	2.88 \pm 0.60	0.163	0.690
	Post	1.73 \pm 0.31	1.60 \pm 0.36			1.46 \pm 0.46	1.36 \pm 0.47		
p-Value ^b		0.001	0.001			0.001	0.001		
Mediolateral	Pre	2.66 \pm 0.49	2.55 \pm 0.54	1.048	0.315	2.67 \pm 0.64	2.87 \pm 0.52	2.933	0.098
	Post	1.61 \pm 0.43	1.67 \pm 0.54			1.17 \pm 0.29	1.07 \pm 0.20		
p-Value ^b		0.001	0.001			0.001	0.001		

Data are expressed as mean \pm standard deviation. SI, stability index.

p > 0.05, not significant.

p < 0.05, significant.

^a F-value = between-group comparison (overall effect).

^b Within-group comparison.

enabling smooth decided movements and to improved upper- and lower-limb muscle strength, which affects the spine through the length–tension relationship.²¹

The core stability program stimulates the feed-forward system to achieve postural activity of the extremities, and the coordination between the trunk and the upper extremities allows the body to move without regard to the starting position within the available range of motion.²² The core stability program improves the feedback mechanism as a component of stability control, as the stability of the spine relies on muscle strength in addition to accurate sensory signals from environment–body interactions that are delivered to the central nervous system to form continuous feedback and refinement of movement. Therefore, the core stability program is a sensory and motor training for spinal stabilization adjustment.²³

The balance improvement that occurred in group A was supported by the findings of Sterba et al., who reported that postural and equilibrium reactions in children with CP could be improved by strengthening the core muscles in addition to achievement of joint stability, co-contraction, and improved ability to shift weight.²⁴ In this study, group A children underwent a specially designed program for core stability, as the core muscles are important for moving in and out standing position in children with CP. Similarly, Dodd et al. reported that the core muscles stabilize the central part of the body to allow controlled movements of the upper and lower limbs. Thus, the core stability program may be modified to enhance postural control and balance in children with CP.⁸

The results of the current study were reinforced by those of Gillen, who concluded that children with spastic CP have defects in the timing of motor responses to support surface perturbations, such as delayed muscle activation onset, which moves the centre of mass towards the limit of stability and leads to more proximal muscle activation before distal muscle activation when responding to support surface perturbations in the standing position, which is the opposite to that observed in children with normal control.

Finally, children with spasticity have postural adjustment deficits associated with voluntary control in static and dynamic activities.²⁵ There was a significant improvement in balance in the post-treatment results of group A after 3 months of the core stability program, as compared with the pre-treatment values. This was consistent with the findings of Hessari et al., who reported that core stabilization training improved the dynamic balance in students with mental retardation.²⁶ Moreover, this improvement might be explained by the results of Sterba et al., who reported that trunk and pelvic strengthening exercises improved the postural and equilibrium reactions in children with CP.²⁴

Children with CP cannot allocate their body weight during static balance and shift the body weight from one limb to another during dynamic balance.²⁷ In patients with low back pain with an unstable core, a core stability program improved balance as a result of better modification of load transfer and efficient patterns of weight distribution²⁸; thus, core exercises could improve balance in our children with CP.

The current study showed that WBV training has benefits on balance adjustment in children with spastic CP. This result was positively correlated with the reduction in spasticity induced by tonic vibration reflex stimulation, which

activates muscle receptors responsible for detecting the change in the length of a muscle. As another mechanism, vibration training has a potential to induce proprioceptive reflex and counteract the sensation of pain.²⁹ Vibration training elicits a warm-up effect that improves muscle power and balance in subpopulations prone to falls.³⁰

The improvement of balance in group B may be due to the WBV training and the regular physiotherapy program. It may be attributed to the strengthening of the trunk and lower-limb muscles caused by WBV, achieving functional improvement in children with spastic CP.^{28,31} The g-forces acting on the muscles were increased by vibration, which improved the exercise load and enhanced neuromuscular activation.³² Vibration training affects muscle strength and increases the power to improve balance.³³

The results of previous studies that applied WBV at a frequency of 40 Hz for 20 min once a week for 3 months in children with CP agree with our results, as there was greater improvement of motor performance including postural stability and trunk rotation, which improved the selectivity of movement in children with CP.^{34–36} The more significant balance improvement in group B than in group A might be due to the application of WBV in addition to regular physiotherapy exercises.

Previous studies concluded that a WBV program can be a valuable method to improve strength and balance in children with the spastic type of CP; however, the difference between the hemiplegic and diplegic types was not significant.^{35,36} Group B (n = 30) underwent WBV training and group A (n = 30) underwent a core stability program for 3 successive months. More improvement occurred in group B than in group A in all stability indices, and this improvement may be due to the progress of muscle strength with similar treatment parameters.^{37–39}

Study limitations

This study was limited by the small sample size.

Conclusions

WBV training together with a regular physiotherapy program yielded a significantly better improvement of balance than the core stability program with the same regular physiotherapy program, without a significant difference in balance improvement between the hemiplegic and diplegic types of CP.

Source of funding

This study received no financial support.

Conflict of interest

The author have no conflict of interest to declare.

Ethical approval

Ethical committee approval from the Faculty of Physical Therapy, Cairo University, Egypt (no. P.T.REC/012/

002184) and a signed written consent form with parent acceptance for participation in the study and publication of the results were obtained before starting the procedures

Authors' contributions

The authors testify that all persons designated as authors qualify for authorship. MS was involved in the study concept and design, interpretation of data, and writing of the initial and final drafts of the article. AS and MI were involved in data acquisition and analysis. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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