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CLINICAL TRIAL REPORT

The Impact of Whole Body Vibration on Muscle Tone, and Sensory Motor Function in Children with Spastic Diplegic Cerebral Palsy

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Purpose: Children with diplegic cerebral palsy (CP) have limited muscle tone, function, and sensorimotor function. Whole-body vibration (WBV) has been suggested to enhance muscle tone and function in diplegic CP. However, there were limited studies involving the effect of WBV on the tone and function of diplegic CP; we aimed to investigate the effect of WBV on muscle tone, function, and sensorimotor function in children with CP.

Patients and Methods: This is a single-blind randomized controlled clinical trial involving 54 spastic diplegic CP child recruited from local rehabilitation centers in the Ha'il region of Saudi Arabia, they were randomly divided into the WBV group (n = 28 with mean age of 9.47±1.92), which received standard physical therapy and WBV therapy, and the control group (n = 26 with mean age of 9.73±1.62) they received standard physical therapy three time per week for four weeks; Muscle tone, function, strength and Sensory motor integration were evaluated pre and post interventions.

Results: At baseline, the two groups had no significant differences. After treatment, the measured outcomes (function, muscle strength, and sensory motor integration) showed statistically significant differences ($p < 0.05$). However, muscle tone was not substantially improved ($p = 0.10$). In addition, within-group comparisons demonstrated substantial effects ($p < 0.05$) except Spasticity, Function, and trace assessment of the control group, where the p-values were(0.33, 0.06, and 0.54, respectively).

Conclusions: According to the findings in this study, both conventional physical therapy and WBV are beneficial in treating spastic diplegia.

Keywords: cerebral palsy, diplegia, whole-body vibration, spasticity, function

Introduction

Cerebral palsy (CP) describes a group of movement and posture disorders that limit activities and are caused by non-progressive disturbances in the brain during maturation. There is often a combination of sensory, perception, cognition, communication, and epilepsy associated with CP, as well as musculoskeletal disorders and neurological dysfunctions.[1]

Globally, the prevalence of CP has remained stable at around 2.1 per 1000 live births; however, it is declining in high-income countries with prevalence ranging from 1.4 to 1.7 per 1000 live births.[2–4]

In cerebral palsy, typical classifications are based on whether there is a movement disorder (spastic, athetoid, ataxic, or mixed), the body parts affected (hemiplegia, diplegia, or quadriplegia), or the function affected (mild, moderate, severe, or profound).[5,6]

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The most common form of CP is that of spastic type which affects 70–80% of children. In addition, there are other methods for classifying the functional motor impairment in CP children, such as Gross Motor Function Classification System (GMFCS), Manual Ability Classification System (MACS), and the Communication Function Classification System (CFCS).[7,8]

One of the most prevalent characteristics of cerebral palsy children (CP) is spasticity, which is present in most forms of CP, including hemiplegia, diplegia, quadriplegia, etc.[9]

In spastic diplegic CP, children have impaired trunk muscular control, which results in an anterior pelvic tilt, limiting hip and knee joint motions during gait. They sought to compensate for the lack of antigravity by lifting the upper body portion. These variables contribute to decreased daily living activities and quality of life.[10]

Interventions that enhance mobility, spasticity, and postural control are recommended to help children with CP participate in various activities and function well in their everyday activities. Rehabilitation is one of the most important interventions to improve muscle tone, posture, and mobility in children with CP.[11]

Spasticity has improved with traditional treatment, including medication and physical therapy. Alternative therapies, such as whole-body vibration (WBV), have drawn interest because of their capacity to alter muscle tone and enhance functional results.[12,13]

WBV refers to transferring mechanical vibrations to the entire body or specific body segments. These vibrations excite sensory receptors and elicit muscular responses, perhaps resulting in enhanced muscle tone regulation and reduced spasticity.[14]

Numerous research studies have examined the impact of WBV on managing spasticity; these studies have documented a range of results, offering important information about the possible advantages of WBV regarding improvement in tone, functions, and gait patterns in children with cerebral palsy.[15–17]

Additionally, it has been proposed that the mechanical vibrations induced by WBV stimulate sensory receptors, leading to increased muscle activation and modulation of spasticity. These findings were supported by Park et al, who found that activating alpha motor neurons affects the Ia afferent fibers in the muscle spindle and decreases spasticity by blocking the monosynaptic reflex.[18]

Additional studies supported the utilization of WBV and reported a reduction in lower limb spasticity measured by the Modified Ashworth Scale after WBV application on 12 children with spastic CP having Gross motor function (GMFCS) levels I–III.[19] However, it is essential to acknowledge the weaknesses of previous studies addressed in a recent systematic review.[12] Firstly, many studies' small sample sizes limit the generalizability of their findings. Variations in study designs, intervention protocols, and outcome measures make comparing results across studies and drawing definitive conclusions challenging. Some studies also lacked long-term follow-up assessments, making it difficult to determine the sustainability of the observed effects; little research has examined WBV's effect on upper limb function, hypertonicity, and strength since most studies have concentrated on lower limb measurement.[20]

The current study uses standardized assessment instruments to present additional evidence of the precise impacts of WBV on spasticity, function, and sensorimotor assessment. With these standardized evaluation instruments, the effects of WBV on managing spasticity may be thoroughly examined, taking into account both functional gains and objective measurements.

In conclusion, previous studies have provided initial evidence suggesting the potential benefits of WBV in treating spasticity. However, these studies have limitations, including small samples and inconsistent outcome measures. The current study aims to overcome these limitations by utilizing a randomized controlled trial design, a larger sample, and standardized assessments. By addressing these weaknesses, the current research contributes unique insights into the role of WBV in treating spasticity and provides more robust evidence to guide clinical practice.

Materials and Methods

Study Design

The current trial was a single-blinded randomized controlled clinical trial (RCT) between December 2023 and July 2024. Children were randomized using the permuted block method into two groups (Figure 1). A blinded assessor conducted all testing procedures, and all children and their parents or legal guardians were interviewed to familiarize themselves with the assessment and treatment procedures.

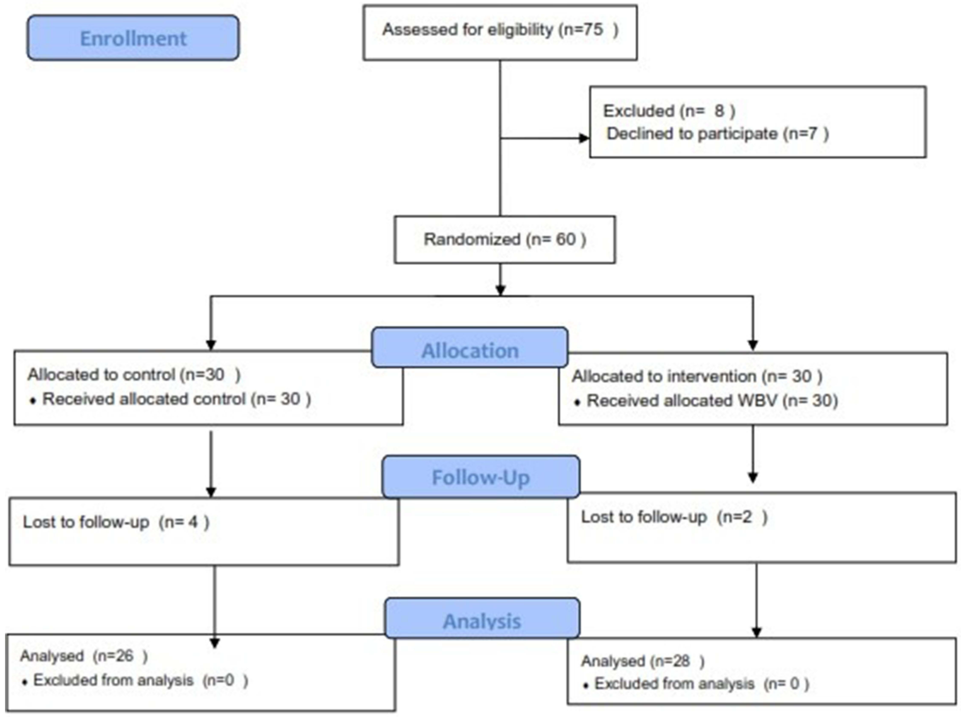

Figure 1 Flow diagram.

Ethical Issues

This study was conducted per the Declaration of Helsinki and was approved by the University of Ha'il ethical committee and the Ha'il region ethical committee on 2–10-2023, with number (H-2023-380). Informed consent was obtained from the parents or guardians of all children involved in the study. The clinical trial was registered in ClinicalTrials.gov under the number NCT06077136.

Study Setting

The current study was conducted between December 2023 and July 2024 at local rehabilitation centers in Ha'il region, Saudi Arabia. All center teams followed the same treatment protocol, and one blinded experienced pediatric physical therapist was responsible for all assessments. All outcome measures were collected pre- and 4 weeks post-study.

Randomization, Concealment and Blinding

The permuted block method was used for the allocation process. One author was responsible for the allocation process. The assessor was blind till the end of the study.

Sample Size Calculation

A priori sample size was calculated using G*Power software (3.1.9.7; Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany). The ABILHand-Kids was determined as the outcome of interest. The following parameters were used: medium effect size (0.4), alpha level = 0.05, and 80% power. The calculations revealed that 52 patients would be appropriate; sixty children with CP (30 per group) were recruited to compensate for any dropouts during the trial.

Outcome Measures

At the initial visit, a meeting with parents was undertaken to discuss the study's goal and address any questions. Further assessments were undertaken after receiving their consent to participate. An experienced paediatric physical therapist applied pre- and post-assessments.

Muscle Tone

The degree of spasticity was evaluated clinically using the Modified Ashworth scale (MAS). The assessor measured the proper spasticity by applying passive ankle dorsiflexion to the affected side.[21]

The MAS grade is as follows: 0; There is no increase in tone. 1; Slight tone increases, causing limb (flexion or extension). 1+; A slight increase in tone, characterized by a catch followed by minor resistance throughout the range of motion (ROM). 2; There was a more pronounced rise in tone during the ROM, but the limb easily flexed. 3; Considerable increase in tone, passive movement difficult. 4; Limb is inflexible in flexion or extension. The minimal clinically significant difference was approved if there was at least a 1-grade change in MAS compared to baseline.[22]

Function

An assessment of manual ability in CP children is provided by the ABILHAND-Kids questionnaire, which parents complete; the scale assesses a person's ability to manage daily activities requiring the use of the upper limbs. Twenty-one items were developed and tested for construct validity and test-retest reliability.[23] The parent was requested to answer the questionnaire by estimating how much difficulty their child would have in performing each activity without assistance, regardless of which limb(s) the child used or which strategies were used. Activities are arranged in a random order to avoid a systematic effect. A total of ten different random orderings are used. For every new assessment, the evaluator chooses one of the ten orders. When the parent is evaluating their child, the 3-level response scale is presented to them, with the difficulty of the activity on the response scale as "Impossible", "Difficult", or "Easy". Activities the child does not perform because they are too difficult are scored as "Impossible"[24] The final score was obtained using software available at http://rssandbox.iescagilly.be/.

Muscle Strength

Two tests (force assessment and weight assessment) were used to assess the strength of the handgrip and the amount of weight the child can exert by the upper limbs. These two tests were performed using Tyro motion (Mayro® – Austria) device. The force assessment of the handgrip was performed using a specific accessory of the Mayro device (ball).

While the ball was connected to the Mayro device's screen, the child was instructed to grasp it as firmly as they could. The ball's sensors can measure the force the child's grip applied and display the score on the screen. This accessory can be secured to the device screen. While sitting appropriately in front of the device screen, the child was asked to hold the ball with one hand and squeeze it as much as possible. Three trials were conducted, and the highest value was recorded.

The weight assessment was assessed using the same device (Tyro motion Mayro). Using a special accessory that can also be secured to the device's screen, the child was asked to hold the accessory and try to lean on the screen using as much power as possible. Three trials were performed, and the highest value was recorded for analysis.[25–27]

Sensory Motor Integration

This outcome measure was indicated by trace assessment, and star assessment tests were applied using the Tyro motion Mayro device; the trace assessment was done by asking the child to trace the infinity figure on the device screen. The device reports the percentage of accuracy of the tracing. Three trials were performed, and the highest score was reported for further analysis.

The star assessment test asked the child to draw lines between specified circles arranged in a star fashion. This task should be performed as accurately as possible in the least time possible. The device calculates the time, in seconds, required to finish the task. Three trials were performed, and the lowest value was used for further analysis.[25–27]

Study Population

The included children were the age of 8–14 years, spastic diplegic CP, with grade 1–3 on the Ashworth Scale (MAS), and parents/guardians accepted and signed the informed consent.

The exclusion criteria were a child with upper limb deformities, who received upper limb botulinum toxin injection in the last six months, had surgery in the lower extremity during the previous year, had severely associated neurological diseases such as epilepsy, poor nutritional status, and who did not agree to participate in the study.

Interventions

Standard Intervention

Every participant in both groups (WBV and control) received the routine rehabilitation exercises tailored to their condition. It may include strengthening, stretching, splinting, developmental approaches, facilitation and inhibitory techniques, training for gait and balance, and parent guidance. For one-hour sessions every week for four weeks.

Experimental Interventions

Three weekly sessions consisted of upper limb exercises performed while the child was using the WBV machine (Galileo® MED 25 TT, Germany; 2021 model).

Each exercise has different starting postures on the WBV machine, such as weight shift and upper limb weight bearing (from prone on elbows, sitting, and standing). In addition, active upper limbs training with toys, balls, and a wand involved transferring between both hands, throwing, and catching (according to each child's ability). Then the child was asked to execute finger-to-nose (eyes open and closed), finger-to-therapist, and finger-to-index finger exercises to practice coordination.

Each exercise took about two to three minutes duration with WBV machine parameters as follows: (12 Hz, Amplitude: 2 (fixed) and session duration 10 minutes with a rest period between each exercise).

Statistical Design

SPSS version 27 (Charles R Flint, New York, USA) was used to analyze the data. The Kolmogorov–Smirnov test was used to assess the normal distribution of the data. The MANOVA test was used to analyze the within and between-group differences. The alpha level was set at 0.05, while eta squared (η^2) was used to calculate the clinical effect size. The cutoff points of the eta squared were $\eta^2 = 0.01$ for small effects, and $\eta^2 = 0.06$ indicates a medium effect. $\eta^2 = 0.14$ indicates a large effect. The intention to treat was applied to this study.

Results

After the screening, sixty spastic diplegic CP child were allocated for the study (30 child for each groups), six child were lost during the study due to social and personal reasons (two in study group and four in the control group), fifty-four children (twenty-eight in WBVG and twenty-six in CG) completed the study with 100% commitment to the treatment sessions. No intervention-related adverse effects were reported in either group (Figure 1).

The distribution of both sexes in the groups was comparable. The male/female distribution in the WBVG and CG was 19/9 and 18/8, respectively. The majority (87%) of the included children were right-handed. Additionally, the right side was affected more than the left in 39 of the 54 children (18 in the WBVG and 21 in the CG). The demographic characteristics of the participants in the two groups were not significantly different (Table 1).

Between-Group Comparisons

The outcome measures in both groups were comparable at baseline, where no statistically significant differences were evident ($p > 0.05$); their mean age was 9.47±1.92 for the WBV group and 9.73±1.62 for the control group (P value 0.65). Body mass index (BMI) 27.51±3.72 for the WBV group and 26.34±3.54 for the control group (P value 0.32) (Table 1).

Table 1 Basic Characteristics of the Participants

Dependent Variables	WBVG	CG	F	P value
Age (years)	9.47±1.92	9.73±1.62	0.207	0.65
Weight (Kg)	30.42±4.04	29.00±3.38	1.38	0.24
Height (m)	1.09±.04	1.10±.06	0.262	0.61
BMI	27.51±3.72	26.34±3.54	0.994	0.32

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Regarding the measured outcome, there was a statistically significant effect in the estimated parameters of (Function, Star, Weight, and Trace assessment) in both groups when the pre- and post-treatment mean values were compared ($P < 0.05$); these significant differences were high in the study group (WBVG).

Both groups showed no statistically significant difference in spasticity when comparing their pre- and post-treatment values ($p = 0.10$). Moreover, most outcome measures demonstrated high effect sizes except for spasticity, where a medium effect size (η^2 ranged between 0.11 and 0.53) was evident (Table 2).

Within-Group Analysis

As shown in Table 3, there were statistically significant differences in all outcome measures in WBVG with p value <0.05; in the control group, there were significant difference in all measured outcomes except for Spasticity, Function, and trace assessment on the left side, where the p-values were 0.33, 0.06, and 0.54, respectively. All within-group analyses demonstrated higher effect sizes in the WBVG than control group, in the control group the effect size was little high in all measured outcomes except for function and trace assessment of the right side in the CG ($\eta^2 = 0.09$) and the spasticity and trace assessment of the left side ($\eta^2 = 0.02$ and 0.01, respectively).

Table 2 The One-Way ANOVA Results for Between-Group Comparisons

Dependent Variables	Timing	WBVG M±SD	CG M±SD	MD	η^2 Effect Size	95% CI of Effect Size		F	P value
						Low	High		
Spasticity (MAS)	Baseline	1.73±.45	1.68±.47	0.05	0.003	0.00	0.11	0.122	0.72
	Post-treatment	1.26±.45	1.52±.51	0.26	0.07	0.00	0.26	2.81	0.10
Function (ABILHand-Kids)	Baseline	27.10±3.72	27.05±3.55	0.05	0.001	0.00	0.01	0.002	0.96
	Post-treatment	35.10±2.42	29.15±3.27	5.95	0.53	0.28	0.67	40.55	<0.001
Star assessment LT	Baseline	1.26±.28	1.11±.24	0.15	0.07	0.00	0.26	3.01	0.09
	Post-treatment	0.66±.13	0.82±.30	0.16	0.11	0.00	0.31	4.77	0.03
Star assessment RT	Baseline	1.32±.16	1.31±.17	0.01	0.01	0.00	0.04	0.006	0.94
	Post-treatment	0.84±.15	1.07±.27	0.23	0.22	0.03	0.43	10.72	0.002
Force assessment LT	Baseline	1.45±.34	1.46±.35	0.01	0.02	0.00	0.02	0.002	0.96
	Post-treatment	2.08±.47	1.97±.46	0.11	0.01	0.00	0.15	0.44	0.50
Force assessment RT	Baseline	2.12±.42	2.18±.46	0.06	0.04	0.00	0.12	0.16	0.69
	Post-treatment	2.60±.30	2.93±.60	0.33	0.11	0.00	0.31	4.53	0.04
Weight assessment LT	Baseline	3.39±.83	3.05±.52	0.34	0.06	0.00	0.24	2.28	0.13
	Post-treatment	4.85±.82	4.39±.80	0.46	0.28	0.06	0.47	14.32	<0.001
Weight assessment RT	Baseline	3.63±.44	3.29±.56	0.34	0.10	0.00	0.30	4.18	0.061
	Post-treatment	5.30±.78	4.33±.67	0.97	0.31	0.08	0.50	16.70	<0.001
Trace assessment LT	Baseline	78.21±8.22	77.81±.9.05	0.40	0.02	0.00	0.10	0.079	0.78
	Post-treatment	90.05±8.80	79.21±9.02	10.84	0.28	0.06	0.47	14.04	<0.001
Trace assessment RT	Baseline	88.89±6.23	89.94±6.24	1.05	0.07	0.00	0.13	0.27	0.60
	Post-treatment	99.05±7.98	93.68±5.47	5.37	0.14	0.01	0.34	5.84	0.02

Abbreviations: MAS, Modified Ashworth scale; WBVG, whole body vibration group; CG, control group; LT, lift side; RT, right side; M, mean; SD, standard deviation; F, ANOVA value; MD, mean difference; CI, confidence interval control group.

Table 3 The One-Way ANOVA Results for the Within-Group Comparisons

Dependent Variables	Groups	Baseline M±SD	Post-Treatment M±SD	MD	η^2 Effect Size	95% CI of Effect Size		F	P value
						Low	High		
Spasticity (MAS)	WBVG	1.73±.45	1.26±.45	0.47	0.22	0.03	0.42	10.41	0.003
	CG	1.68±.47	1.52±.51	0.16	0.02	0.00	0.18	0.964	0.333
Function (ABILHand-Kids)	WBVG	27.10±3.72	35.10±2.42	8	0.63	0.41	0.74	61.55	<0.001
	CG	27.05±3.55	29.15±3.27	2.1	0.09	0.00	0.28	3.61	0.06
Star assessment LT	WBVG	1.26±.28	0.66±.13	0.6	0.66	0.45	0.76	70.86	<0.001
	CG	1.11±.24	0.82±.30	0.29	0.22	0.03	0.42	10.21	0.003
Star assessment RT	WBVG	1.32±.16	0.84±.15	0.48	0.69	0.50	0.78	82.20	<0.001
	CG	1.31±.17	1.07±.27	0.24	0.22	0.03	0.42	10.36	0.003
Force assessment LT	WBVG	1.45±.34	2.08±.47	0.63	0.37	0.12	0.55	21.24	<0.001
	CG	1.46±.35	1.97±.46	0.51	0.28	0.10	0.52	14.63	<0.001
Force assessment RT	WBVG	2.12±.42	2.60±.30	0.48	0.30	0.06	0.48	15.61	<0.001
	CG	2.18±.46	2.93±.60	0.75	0.33	0.10	0.52	18.23	<0.001
Weight assessment LT	WBVG	3.39±.83	4.85±.82	1.46	0.28	0.06	0.47	14.32	<0.001
	CG	3.05±.52	4.39±.80	1.34	0.50	0.26	0.65	37.14	<0.001
Weight assessment RT	WBVG	3.63±.44	5.30±.78	1.67	0.64	0.42	0.75	64.90	<0.001
	CG	3.29±.56	4.33±.67	1.04	0.42	0.17	0.59	26.59	<0.001
Trace assessment LT	WBVG	78.21±8.22	90.05±8.80	11.84	0.33	0.10	0.52	18.34	<0.001
	CG	77.42±9.05	79.21±9.02	1.79	0.01	0.00	0.14	0.37	0.54
Trace assessment RT	WBVG	88.89±6.23	99.05±7.98	10.16	0.34	0.10	0.53	19.10	<0.001
	CG	89.94±5.47	91.81±6.09	1.87	0.09	0.00	0.29	3.84	0.058

Abbreviations: MAS, Modified Ashworth scale; WBVG, whole body vibration group; CG, control group; LT, lift side; RT, right side; M, mean; SD, standard deviation; F, ANOVA value; MD, mean difference; CI, confidence interval control group.

Discussion

In the current study, we evaluated whether adding WBV to standard regular rehabilitation procedures affected spastic cerebral palsy children's muscle tone, function, and sensory-motor function.

When comparing the mean values pre- and post-treatment, there was a statistically significant improvement in function, star, weight, and trace assessment in both groups ($P < 0.05$); these significant differences were higher in the WBVG. Regarding spasticity, no significant difference was detected in both groups ($P = 0.10$). Moreover, the within-group analyses showed that all outcome measures were statistically significant in WBVG; but for the control group, there was a considerable difference in the measured outcomes except for Spasticity, Function, and trace assessment on the left side, where p-values were 0.33, 0.06, and 0.54, respectively.

Using WBV has recently been widely popularised and has achieved positive therapeutic effects, its looks to be a promising addition to the traditional CP treatment;[28] it may help to improve walking, mobility, and muscle power and reduce muscle tone; furthermore, it was recommend that CP children benefit from WBV training because it improves physical performance without provoking negative effects.[12,29]

According to Huang (2017), WBV can have clinical implications on upper limb muscles' mechanical properties and reflex activity, potentially impacting individuals with spasticity caused by central nervous system disorders; WBV was associated with a decreased H-reflex, WBV has also been linked to increased corticomotor pathway excitability and intracortical inhibition; additionally, it may cause changes in muscle perfusion and thermoregulation, which could modify the viscoelastic characteristics of soft tissues.[30]

A recent study investigated the impact of WBV when combined with physiotherapy on the upper limb. The measured outcomes were ROM and muscle strength in CP children. They included only children with a spasticity level of 1 and 1+; results revealed higher improvements in the upper limb ROM and shoulder and elbow joint strength, indicating a significant WBV effect in CP child.[31]

Regarding muscle tone measurement, Cheng et al's trial to assess the impact of WBV on Spasticity using (MAS) and Function with TUG and 6 MWT in CP children demonstrated that WBV controls spasticity and improves ambulation, with the following p values for the study group; AROM ($p = 0.000$), MAS ($p = 0.001$), TUG ($p = 0.001$) and 6MWT ($p = 0.000$), which supported our finding. Still, they only measure WBV effects after 20 minutes on day.[32]

In terms of function, earlier observations by Hussain et al corroborated the current findings to evaluate the effect of WBV in improving upper and lower extremity function and performance; results indicate that WBV leads to substantial improvements in ROM, strength, mobility, balance, and Function; Several mechanisms may account for the effectiveness of WBV, including cross-training effects, neural coupling, and inter-limb coordination. These mechanisms appear responsible for the intricate connections between the upper and lower limbs' muscles, emphasizing the possibility of implementing targeted interventions to achieve comprehensive improvements across the entire limb.[33]

In recent years, simpler devices with sensors for measuring patients' movement and interaction have been developed. They provide training feedback, motivation, and measurement by using visual, auditory, and sensory stimuli to induce skills learning in real or virtual environments. Additionally, subjects can learn how to control movements and get feedback on the required and actual performance.[34,35]

Different tools for CP children measured muscle power; for example, a handheld dynamometer,[36] functional muscle testing,[37] and manual muscle testing.[38] In the current study, we used MYRO sensor-based surface to measure upper extremity power (force assessment and weight assessment); results revealed a significant positive effect of WBV on force and weight assessment in both between and within groups analysis, Myro® was very motivated and used to facilitate, enhance and better therapy in an inspired method. With the Myro®, you can train and measure motor skills through video gaming without needing any physical support. Both motion and pressure can trigger it, it can be adjusted to fit the child's needs by changing height, and work surface.[25,39]

Sensory motor integration refers to the ability of the child to recognize and respond to different sensory inputs, including auditory, visual, touch, proprioception, and vestibular system, which provides information about movement, changing head position and gravity. This method uses play-based sensory and motor exercises and focuses on therapist-child contact to encourage sensation processing and integration.[40]

Different tools were used to measure sensory motor integration, such as the Sensory Integration and Praxis Test to detect sensory discrimination and sensorimotor disorders,[41] the Child Sensory Profile to examine child Sensory modulation.[42]

In the current study, sensory-motor integration was measured using Trace and Star assessment tests using the Tyro motion Mayro device. Results showed improvement in these measurements in the WBV group when compared with the control group.

In children with cerebral palsy, WBV has emerged as a viable therapy that boosts coordination, decreases spasticity, and improves neuromuscular function. WBV enhances muscle tone and limb function by stimulating neuromuscular adaptations similar to strength training using mechanical oscillations. Athletes frequently use WBV to build muscle and can also treat neurological illnesses that cause stiffness and functional deficits.[43]

Despite its widespread use, the precise mechanism of vibration treatment is still uncertain. It was previously thought that vibrations cause muscles to contract by stimulating alpha motor neurons and muscle spindles. Furthermore, vibration therapy had several short-term effects, such as elevated blood flow, muscle power, temperature, oxygen consumption, and blood insulin levels.

Vibration therapy also appears promising to improve gross motor function in children with cerebral palsy by activating the musculoskeletal system. CP children who receive local vibration treatment report less spasticity.[44]

In recent years, whole-body vibration (WBV) has emerged as a potential adjunct therapy for CP. A mechanism for WBV's activation of muscle spindles and modulation of the neuromuscular system is believed to reduce exaggerated stretch reflexes and promote motor unit recruitment by generating mechanical oscillations at the spinal level. As a result, spasticity may be reduced, and sensorimotor integration may be enhanced. WBV may improve coordination, strengthen muscles, and increase joint range of motion.[45]

The study's key limitation was the lack of a follow-up period, and the lack of blinding participants might raise the possibility of bias. Future research should include longer treatment durations and follow-up analyses with children with different types of cerebral palsy.

Conclusion

According to our findings, WBV significantly improved spasticity, function, muscle strength, and sensorimotor assessment in spastic diplegic CP children. WBV combined with standard physical therapy seems to be a promising and advisable option for children with CP.

Data Sharing Statement

Data for the current study will be available upon reasonable request from the principal investigator or corresponding author.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors report no conflicts of interest in this work.

References

1. Wimalasundera N, Stevenson VL. Cerebral palsy. *Pract Neurol*. 2016;16(3):184–194. doi:10.1136/practneurol-2015-001184
2. Sellier E, Platt MJ, Andersen GL, et al. Decreasing prevalence in cerebral palsy: a multi-site European population-based study, 1980 to 2003. *Dev Med Child Neurol*. 2016;58(1):85–92. doi:10.1111/dmcn.12865
3. Oskoui M, Coutinho F, Dykeman J, Jetté N, Pringsheim T. An update on the prevalence of cerebral palsy: a systematic review and meta-analysis. *Dev Med Child Neurol*. 2013;55(6):509–519. doi:10.1111/dmcn.12080
4. Badawi N, Mcintyre S, Hunt RW. Perinatal care with a view to preventing cerebral palsy. *Dev Med Child Neurol*. 2021;63(2):156–161. doi:10.1111/dmcn.14754
5. Rosenbaum P. The definition and classification of cerebral palsy: are we any further ahead in 2006? *Neoreviews*. 2006;7(11):e569–e574. doi:10.1542/neo.7-11-e569
6. Bax M, Goldstein M, Rosenbaum P, et al. Proposed definition and classification of cerebral palsy, April 2005. *Dev Med Child Neurol*. 2005;47(8):571–576. doi:10.1017/s001216220500112x
7. Paulson A, Vargus-Adams J. Overview of four functional classification systems commonly used in cerebral palsy. *Children*. 2017;4(4):30. doi:10.3390/children4040030
8. Hidecker MJC, Paneth N, Rosenbaum PL, et al. Developing and validating the communication function classification system for individuals with cerebral palsy. *Dev Med Child Neurol*. 2011;53(8):704–710. doi:10.1111/j.1469-8749.2011.03996.x
9. Patel DR, Neelakantan M, Pandher K, Merrick J. Cerebral palsy in children: a clinical overview. *Transl Pediatr*. 2020;9(S1):S125–S135. doi:10.21037/tp.2020.01.01

10. Kim Y, Lee B-H. Clinical usefulness of child-centered task-oriented training on balance ability in cerebral palsy. *J Phys Ther Sci*. 2013;25(8):947–951. doi:10.1589/jpts.25.947
11. Mutlu A, Büğüsan S, Ök K. Impairments, activity limitations, and participation restrictions of the international classification of functioning, disability, and health model in children with ambulatory cerebral palsy. *Saudi Med J*. 2017;38(2):176. doi:10.15537/smj.2017.2.16079
12. Cai X, Qian G, Cai S, Wang F, Da Y, Ossowski Z. The effect of whole-body vibration on lower extremity function in children with cerebral palsy: a meta-analysis. *PLoS One*. 2023;18(3):e0282604. doi:10.1371/journal.pone.0282604
13. Shaw L, O'Leary K, Stewart S, Poratt D. Whole-body vibration training protocols for people with cerebral palsy: a systematic review of randomised controlled trials. *Adv Neurodev Disord*. 2023;(0123456789). doi:10.1007/s41252-023-00331-8
14. Peungsuwan P, Chatchawan U, Donpunha W, Malila P, Sriboonreung T. Different protocols for low whole-body vibration frequency for spasticity and physical performance in children with spastic cerebral palsy. *Children*. 2023;10(3):458. doi:10.3390/children10030458
15. Elshafey MA, Mostafa MS, mohamed Tharwat M, et al. Effect of whole-body vibration on Spastic Diplegic children. *Eur J Mol Clin Med*. 2021;8:1025–1033.
16. Ibrahim MM, Eid MA, Moawd SA. Effect of whole-body vibration on muscle strength, spasticity, and motor performance in spastic diplegic cerebral palsy children. *Egypt J Med Hum Genet*. 2014;15(2):173–179. doi:10.1016/j.ejmhg.2014.02.007
17. Yurttutmuş ZR, Zincirci DE, Bardak AN, Karacan İ, Türker KS. The effect of whole-body vibration on spasticity in post-stroke hemiplegia: a prospective, randomized-controlled study. *Turkish J Phys Med Rehabil*. 2022;68(4):484–492. doi:10.5606/tftrd.2022.10391
18. Park C, Park ES, Choi JY, Cho Y, Rha D. Immediate effect of a single session of whole body vibration on spasticity in children with cerebral palsy. *Ann Rehabil Med*. 2017;41(2):273. doi:10.5535/arm.2017.41.2.273
19. Tupimai T, Peungsuwan P, Prasertnoo J, Yamauchi J. Effect of combining passive muscle stretching and whole body vibration on spasticity and physical performance of children and adolescents with cerebral palsy. *J Phys Ther Sci*. 2016;28(1):7–13. doi:10.1589/jpts.28.7
20. Pulay MÁ, Nagy R, Kói T, et al. The effect of additional whole-body vibration on musculoskeletal system in children with cerebral palsy: a systematic review and meta-analysis of randomized clinical trials. *J Clin Med*. 2023;12(21):6759. doi:10.3390/jcm12216759
21. Emara HA, Al-Johani AH, Khaled OA, Ragab WM, Al-Shenqiti AM. Effect of extracorporeal shock wave therapy on spastic equinus foot in children with unilateral cerebral palsy. *J Taibah Univ Med Sci*. 2022;17(5):794–804. doi:10.1016/j.jtumed.2021.12.010
22. Wang T, Du L, Shan L, et al. A prospective case-control study of radial extracorporeal shock wave therapy for spastic plantar flexor muscles in very young children with cerebral palsy. *Medicine*. 2016;95(19):1–13. doi:10.1097/MD.0000000000003649
23. Arnould C, Penta M, Renders A, Thonnard JL. ABILHAND-Kids: a measure of manual ability in children with cerebral palsy. *Neurology*. 2004;63(6):1045–1052. doi:10.1212/01.WNL.0000138423.77640.37
24. Bleyenheuft Y, Gordon AM, Rameckers E, Thonnard J-L, Arnould C. Measuring changes of manual ability with ABILHAND-Kids following intensive training for children with unilateral cerebral palsy. *Dev Med Child Neurol*. 2017;59(5):505–511. doi:10.1111/dmcn.13338
25. Hussain A, Balasubramanian S, Roach N, et al. SITAR: a system for independent task-oriented assessment and rehabilitation. *J Rehabil Assist Technol Eng*. 2017;4:205566831772963. doi:10.1177/2055668317729637
26. Pinter D, Pegritz S, Pargfrieder C, et al. Exploratory study on the effects of a robotic hand rehabilitation device on changes in grip strength and brain activity after stroke. *Top Stroke Rehabil*. 2013;20(4):308–316. doi:10.1310/tsr2004-308
27. Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. *Cochrane Database Syst Rev*. 2018;9(9):CD006876. doi:10.1002/14651858.CD006876.pub5
28. Hussein HM, Aldhahi MI, Alshammari HZM, et al. Effect of whole-body vibration on muscle tone, function, and quality of life in children with spastic cerebral palsy: a systematic review with meta-analysis. *J Disabil Res*. 2024;3(1):1–9. doi:10.57197/jdr-2023-0056
29. Song S, Lee K, Jung S, Park S, Cho H, Lee G. Effect of horizontal whole-body vibration training on trunk and lower-extremity muscle tone and activation, balance, and gait in a child with cerebral palsy. *Am J Case Rep*. 2018;19:1292–1300. doi:10.12659/AJCR.910468
30. Huang M, Liao LR, Pang MYC. Effects of whole body vibration on muscle spasticity for people with central nervous system disorders: a systematic review. *Clin Rehabil*. 2017;31(1):23–33. doi:10.1177/0269215515621117
31. Heneidy WE, Farouk MA, Olama KA, Ibrahim AF. Effect of vibration therapy on upper limb range of motion and muscle strength in children with hemiplegia: a randomized controlled trial. *Bull Fac Phys Ther*. 2025. doi:10.1186/s43161-025-00274-2
32. Cheng HYK, Ju YY, Chen CL, Chuang LL, Cheng CH. Effects of whole body vibration on spasticity and lower extremity function in children with cerebral palsy. *Hum Mov Sci*. 2015;39:65–72. doi:10.1016/j.humov.2014.11.003
33. Hussain SA, Hadian DM-R, Hassan Z, et al. The effects of whole-body vibration therapy in weight-bearing and non-weight-bearing positions for upper and lower extremities on balance and function in cerebral palsy children: a randomized controlled trial. *Cureus*. 2024;16(5). doi:10.7759/cureus.61404
34. Timmermans AAA, Seelen HAM, Geers RPJ, et al. Sensor-based arm skill training in chronic stroke patients: results on treatment outcome, patient motivation, and system usability. *IEEE Trans neural Syst Rehabil Eng a Publ IEEE Eng Med Biol Soc*. 2010;18(3):284–292. doi:10.1109/TNSRE.2010.2047608
35. Klein J, Chen A, Burdet E. Instrumented sorting block box for children, a preliminary experiment. *IEEE Int Conf Rehabil Robot*. 2011:0–5. doi:10.1109/ICORR.2011.5975458.
36. Eek MN, Lidman G. Arm muscle strength in children with bilateral spastic CP. *Phys Occup Ther Pediatr*. 2021;41(5):529–539. doi:10.1080/01942638.2021.1872757
37. Aertssen W, Smulders E, Smits-Engelsman B, Rameckers E. Functional strength measurement in cerebral palsy: feasibility, test–retest reliability, and construct validity. *Dev Neurorehabil*. 2019;22(7):453–461. doi:10.1080/17518423.2018.1518963
38. Klingels K, De Cock P, Molenaers G, et al. Upper limb motor and sensory impairments in children with hemiplegic cerebral palsy. Can they be measured reliably? *Disabil Rehabil*. 2010;32(5):409–416. doi:10.3109/09638280903171469
39. Goikoetxea-Sotelo G, van Hedel HJA. Responses of several measures to different intensity levels of upper limb exergames in children with neurological diagnoses: a pilot study. *Front Rehabil Sci*. 2024;5(October):1–13. doi:10.3389/fresc.2024.1405304
40. Warutkar VB, Kovela RK, Samal S. Effectiveness of sensory integration therapy on functional mobility in children with spastic diplegic cerebral palsy. *Cureus*. 2023;15(9). doi:10.7759/cureus.45683
41. Jorquera-Cabrera S, Romero-Ayuso D, Rodriguez-Gil G, Triviño-Juárez J-M. Assessment of sensory processing characteristics in children between 3 and 11 years old: a systematic review. *Front Pediatr*. 2017;5:57. doi:10.3389/fped.2017.00057

42. Barakat MKA, Elmeniawy GH, Abdelazeim FH. Sensory systems processing in children with spastic cerebral palsy: a pilot study. *Bull Fac Phys Ther*. 2021;26(1). doi:10.1186/s43161-021-00044-w
43. Kelaiditi M, Lepoura A, Christakou A, Chrysagis N, Sakellari V. The effect of whole-body vibration on upper extremity function in children with cerebral palsy: a pilot study. *Appl Sci*. 2025;15(2):1–12. doi:10.3390/app15020552
44. Duquette SA, Guiliano AM, Starmer DJ. Whole body vibration and cerebral palsy: a systematic review. *J Can Chiropr Assoc*. 2015;59(3):245–252.
45. Monzón-Tobalina I, Ortiz-Gutiérrez RM, Álvarez-Melcón ÁC, Pérez-Somarriba Á, Martín-Casas P, Díaz-Arribas MJ. Effectiveness of combined whole-body vibration and intensive therapeutic exercise on functional capacity in children with cerebral palsy: a randomized controlled trial. *Med*. 2025;61(5):1–12. doi:10.3390/medicina61050873