Effect of Whole Body Vibration Therapy on Spasticity, Balance, Fine and Gross Motor Functions in Patients with Spastic Cerebral Palsy: A Systematic Review of RCTs

SYED ALI HUSSAIN1, ZAINAB HASSAN2, MOHAMMAD REZA HADIAN RASANANI3, RABIA AFZAL4, NOUMAN KHAN5, HUSSEIN MOHAMAD AHMAD ZAIB6

ABSTRACT

Context: Cerebral palsy is condition that is caused by neurodevelopmental damage, which leads to problems in the somatosensory systems. It can cause spasticity in the involved muscles leading to poor function, limitations in range of motion, poor balance and coordination. Therapeutic use of whole-body vibration therapy for the management of the mentioned symptoms have been reported in the literature. This review study examines the effect of whole-body vibration on spasticity, balance and function and summarizes the effective protocols of whole-body vibration therapy for the cerebral palsy patients.

Methods: Three following databases were searched comprehensively: Pubmed, PEDro and Cochrane. The selection criteria for the research papers were based on; (1) human studies with Patient-Intervention-Comparison-Outcomes-Study design (PICOS) method, according to which, P = spastic cerebral palsy; I = Whole Body Vibration; C = comparison with conventional/traditional physiotherapy; O = dynamic balance, spasticity, functional balance, fine and gross motor hand function, hand grip strength, Balance Quantification and Range of Motion; and S = Randomized controlled trials, (2) Published in English Language (3) Full Text Available (4) The PEDro scale on which the score is greater than 4 out of 10.

Results: Nine RCTs were included based on the inclusion criteria. This systematic review showed that whole body vibration therapy can produce positive therapeutic effects on spasticity, balance, fine and gross motor function, muscle strength and range of motion. This modality can be used independently or in combination with the conventional physical therapy. No harm has been reported in the literature.

Conclusion: It can be concluded that whole body vibration therapy is safe, cost effective and fairly simple therapeutic modality that can be used at home or in clinical settings to produce a significant change in spasticity, static and dynamic balance, motor function and range of motion.

Keywords: Balance, Cerebral Palsy, Motor Function, Spasticity, Whole body vibration therapy

INTRODUCTION

Cerebral palsy (CP) is a permanent neurological condition which results in pathological tone in the muscles and altered kinesthetic sense. This abnormal tone and afferent information lead to activity limitation, postural dysfunction and movement disorders. The main cause of this condition is the damage to the child's brain in the prenatal through neonatal period (1).

Whenever there is any damage or serious pathological condition affecting the central nervous system, the patients develop abnormalities of sensorimotor system. There will be altered sensory information going to the brain. In such patients there can be growth retardation, muscle imbalances, poor postural control, poor coordination of the movements, pathological gait, which affects the quality of life and can result in even noticeable asymmetrical changes in the skeletal system as well. Children affected by such conditions like cerebral palsy, may develop serious orthopedic, neurological and behavioral problems as well (2). Cerebral palsy also affects fine and gross motor functions including speech. The muscular tone in some muscles which are most commonly the antagonistic muscles is relatively high as compared to the other muscles. This mismatch between the tone results in poor control of the voluntary movements. Even the most basic movements like head rotation, flexion and extension becomes difficult to perform (3).

Because of mismatch of muscular strength in the muscles the movements are not smooth and of poor quality. It has also been reported that there is delayed onset of muscle activation. This delay is considered to be disturbed proprioceptive feedback to the higher centers. The activities of daily living are also affected in such population (4, 5). Cerebral palsy children are not only affected physical but they are also four times more likely than the children of the same age to develop behavioral and emotional lability. It is important to consider a multidisciplinary or holistic approach while developing the treatment plan for these patients (6).

Cerebral palsy can be categorized based on motor disturbances (spastic, dyskinetic, ataxic, hypertonic and hypotonic, among these the spastic cases are almost 80%), extensive involved (monoplegic, hemiplegic, diplegic and quadriplegic), and location of the lesion in the brain (cerebellum, pyramidal tract, extrapyramidal tract and cerebral cortex) (7). In spastic diplegic patients both lower extremities are more involved as compared to the upper extremities, so the ability to walk is affected more (8). Previous studies have indicated that spasticity, Poor balance control and poor muscle strength are known to be an important causative factor that leads to movement dysfunction in CP. There is a progressive muscular atrophy and weakness, this may result in the development of the myogenic and sometime arthrogenic cocontraction of multiple joints of the upper and lower extremity. The most important factors that contributes to pathological gait are muscle weakness and poor propioceptive feedback (8-10).

Moreover, numerous factors such as a biomechanical restraint significantly affects the patients’ capability to adjust their posture, maintain balance or able to perform different functional tasks. However a poor posture pattern in CP children is the maladaptation and inappropriate recruitments of the antagonist muscles along with the inappropriate control of postural muscles (11). Muscle strengthening training is a substantial strategy to prepare weak muscles which are responsible for debilitated walking capacity similar to quadriiceps femoris muscle in the spastic CP. Whole-body vibration (WBV) therapy was recommended as a novel therapeutic modality in rehabilitation for the management of static and dynamic balance, functional performance and gross motor function (12).

WBV is a neuromuscular training technique that was primarily used by elite players to improve their strength and speed (13). WBV therapy is a high frequency, low magnitude modality, with vibrating platform that is extensively used for the improvement of physical fitness (14). The application of this technique is usually applied in standing position on a vertical oscillating platform that changes the gravitational forces on body and displaces the individual. Whereas WBV is used to stimulate the natural stretch reflex of body and subsequently causes the muscle contractions.
Additionally, it was suggested that muscular vibration stimulates the principal endings of the muscle spindle (Ia afferent), which cause excitatory motor neuron neuromuscular contractions as a result; a tonic muscle contraction is produced (15).

The WBV therapy is performed on an oscillating platform with the subject’s body in standing position and platform vibrates horizontally between the frequency range of 10 to 25 Hz. This helps to stimulate the muscle spindles primary endings and activation of motor neurons and cause muscle contractions, as same as tonic stretch reflex. In comparison to high frequency 10-25 Hz which increases the muscle tone, low frequency therapy reduces the muscle tone. Hence, WBV therapy improves the muscle strength and muscle force that cause rapid enhancements in neuromuscular capacities and also have positive effects on the muscle performance (16). WBV therapy improves the intramuscular and intermuscular coordination by producing high-frequency muscle contractions of the both agonists and antagonists in neuro-muscular system. The stretch reflex produce by WBV therapy is effective in improving balance control and muscle endurance. This mainly enhance the power in individuals with motor impairments (10, 17).

A meta-analysis done by Saquetto M et al showed that WBV might improve physical functions and gait speed in cerebral palsy children. They also suggested that this technique could be considered for the inclusion in rehabilitation of CP. Overall focus of this study was on gait speed and standing so it failed to generate a conclusive recommendation because of heterogeneity and less sample size (12). A systematic review done by Duquette SA et al exposed that WBV has the therapeutic effects in symptomatic pain relief in CP patients. They revealed that WBV improves muscle coordination, strength and spasticity. Those studies included in this systematic review clearly focused on WBV as a primary intervention; this study did not include similar interventions in relation to frequency, interval and duration. This also failed to generate a conclusive recommendation because small sample size and heterogeneity of the population (18).

A systematic review by Alshram AR et al revealed that there was weak evidence on short term effects of WBV on spasticity, posture, balance and mobility. Beside this the long-term positive effects of WBV on mobility in neurological disorders. The optimal WBV therapy parameters in treatment of neurological disorders patients remain unclear (19). Therefore, no strong evidence exists regarding the efficacy of WBV especially on static and dynamic balance, spasticity, hand function and range of motion. This study aimed specifically to discuss the effects of WBV in spastic cerebral palsy in regard to outcome measures of static and dynamic balance, range of motion and spasticity. Thus, this systematic review will summarize the heading of an effectiveness of intervention protocol for patients with spastic CP.

METHODS

Eligibility Criteria: In present review the research study was confined to the (no of RCT should be mentioned) Randomized controlled trial from the year January 2000 till September 2022. The selection criteria for the research papers were based on: (1) human studies with Patient-Intervention-Comparison-Outcome-Study design (PICOS) method (20), according to which, P = spastic cerebral palsy; I = Whole Body Vibration; C = comparison with conventional/traditional physiotherapy; O = dynamic balance, spasticity, functional balance, fine and gross motor hand function, hand grip strength, Balance Qualification and Range of motion; and S = Randomized controlled trials; (2) Published in English Language (3) Full Text Available (4) The PEDro scale on which the score greater than or equal to 4 out of 10.

Search Strategy and Quality assessment: An extensive and thorough search was executed using the following databases PubMed, PEDro and Cochrane from the above-mentioned duration. Two reviewers independently (i.e. Dr. Rabia & Dr. Neuman) carried out selection and extraction for paper and data respectively that fit to inclusion criteria. In the case of disagreement between the reviewers, a third reviewer (Dr. Syed Ali) was involved. Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guideline were used to develop the review framework as given in the Figure 1, the searching approach was planned by linking the most suitable scientific key terms along with Boolean operators to review objectives as given in the Table 1.

Critical appraisal of the selected researches was done using the PEDro scale as shown in Table 2 that consists of 11 items encompassing external validity (item 1), internal validity (items 2 to 9), and statistical reporting (items 10 to 11) (21). The scoring was as follows; 0-3= poor, 4-5= Fair, 6-8= Good and 9-10= Excellent.

Figure 1: Showing preferred reporting items for systematic review

Table 1: Search Strategies used in the PubMed

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Search Terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Vibration</td>
</tr>
<tr>
<td>2.</td>
<td>Vibration OR Whole Body Vibration OR whole body vibration therapy OR whole body vibration training OR vibration training OR vibration therapy OR vibration training therapy OR vibration therapy OR vibration therapy OR local vibration therapy OR local vibration therapy OR local vibration therapy OR local vibration therapy OR plantar vibration OR weight bearing vibration therapy OR non weight bearing vibration therapy OR palmar vibration</td>
</tr>
<tr>
<td>3.</td>
<td>Cerebral palsy</td>
</tr>
<tr>
<td>4.</td>
<td>Cerebral palsy OR CP OR Little disease OR Little's disease OR Spastic Cerebral Palsy OR spastic hemiplegia OR spastic hemiplegic OR spastic diplegia OR spastic diplegic OR spastic paraplegia OR spastic paraplegic OR infantile palsy OR infantile cerebral palsy OR infantile cerebral palsy OR Spasticity OR Hypertonicity OR Muscle Hypertonicity</td>
</tr>
<tr>
<td>5.</td>
<td>Balance</td>
</tr>
<tr>
<td>6.</td>
<td>Balance OR dynamic balance OR Postural Equilibrium OR Postural balance OR Postural control OR postural control children OR postural balance children OR Musculoskeletal Equilibrium OR Gait OR walking OR Ambulation OR gross motor function OR motor function OR lower extremity function OR Leg function OR fine motor function OR fine motor skills OR fine motor skills OR hand function</td>
</tr>
<tr>
<td>7.</td>
<td>#4 OR #5</td>
</tr>
<tr>
<td>8.</td>
<td>#7 OR #8</td>
</tr>
<tr>
<td>9.</td>
<td>#3 AND #6 AND #9</td>
</tr>
<tr>
<td>10.</td>
<td>#10 AND [humans] AND [english] [2000-2022]</td>
</tr>
</tbody>
</table>
RESULTS
A total of 213 studies (PubMed= 45, PEDro= 96, Cochrane= 72) were identified based on the inclusion criteria mentioned above. The next step was to remove the duplicate studies which identified 118 as duplicate. The first phase of screening removed 95 studies. Only 14 studies were sought for retrieval and were subjected to detailed review in the phase 2. In the second phase of screening 5 studies were removed due to different variables (n=1), inappropriate study designs (n=2), inappropriate age (n=1) and unpublished clinical trial (n=1) Table 3. We included only 9 studies for this systematic review. Each study was analyzed on the aspects of selection, performance and other bias, the characteristics of the studies are shown in Table 4.

DISCUSSION
The current review gives a viewpoint of the effectiveness of Whole body vibration therapy on spastic cerebral palsy. Overall, all of the selected researches concluded that WBV was a new, safe and effective therapeutic modality. WBV was recently introduced as a novel way to improve static and dynamic balance, spasticity, muscle strength, motor skills, proprioception, gross motor skills, posture and gait among participants with cerebral palsy. Included studies conclude that WBV was a practical and novel method of improving overall performance of cerebral palsy children (9). In WBV therapy the individual has a full body exposure to mechanical stimulus of low frequency and low amplitude through a vibrating platform. These oscillatory movements stimulate the muscle spindles and also generate nerve impulses which initiate the contraction of muscle same like tonic vibration reflex. WBV is a useful tool in the rehabilitation of the elderly also (12). Its effects on improvement of balance, posture, gait and muscular strength have been studied; however, little work has done on WBV in children with spastic CP. Therefore, the current review is important because it investigates the WBV as a valuable modality in the rehabilitation of spastic CP children. The findings from different studies incorporated in this review also emphasizes that WBV advances the understanding of vibration training as a therapeutic tool in CP children and also explain the ideal parameters of the intervention in term of duration and frequency for the improvement of outcomes (22).
This novel therapy in rehabilitation provides a paradigm shift in rehabilitation. It is of absolute significance that each of the patient’s experiences as in different health care services need to be considered while applying health care related services. Findings of included studies in systematic review addressed the safety, efficacy and feasibility of WBV in CP children. A study showed significant improvement in gait, gross motor function, balance, spasticity in both limbs, related to children’s who only received traditional physical therapy treatment. So it was evident that combining WBV with conventional physiotherapy treatment shows relatively more improvement (23). Previous studies have also discussed potential effects of WBV in combination therapy. WBV can improve walking speed, muscle strength, spasticity and gross motor functions related to walking and standing without any negative effects (8, 24).

Previous related studies have reported the favorable effects for the first time addressed the safety, feasibility and efficacy of home based WBV therapy in CP. Studies showed that combination of WBV and passive muscle stretching could increase the muscle strength and balance control and decrease the spasticity in adolescents and children with CP. WBV could be an alternate additional treatment to the muscle stretching for the both home therapy and clinical therapy programs for adolescents and children with CP (25). The current study review exposed that in the included studies, heterogeneity exists in terms of mode of delivery and outcome measures etc., but there is persistent pattern of encouraging the use of WBV therapy and supporting its effectiveness in rehabilitation. The main point of this systematic review is that (the) evidence has summarized in regards to the utilization of WBV for improvement of spasticity, balance, gross motor function, gait and promoting long term goal of muscle strength in CP children. This review will provide a clear picture for the physiotherapists treating or managing cerebral palsy children to utilize WBV as an alternative or adjunct therapeutic modality. Limitations of the current review are that only studies with English language were included and unpublished or studies with different designs were excluded. Future research is needed to evaluate the utilization of WBV for specific types of CP and using high-quality research methodologies.

CONCLUSION
Whole body vibration alone or in combination with conventional physical therapy can reduce spasticity, improve static and dynamic balance, fine and gross motor function in the spastic cerebral palsy children. Hence it can be considered as a valuable, low cost and low risk treatment intervention that can be done at home or in the clinical settings. To this point of time, the whole-body vibration therapy has been applied to the lower extremity of the patients.

Disclaimer: None
Conflict of Interest: None
Funding Disclosure: This project was funded by Shifa Tameer e Miliat University Islamabad Pakistan, through Faculty Development Program.

REFERENCES