Article

CLINICAL REHABILITATION

Clinical Rehabilitation
2017, Vol. 31(1) 23–33

DOI: 10.1177/0269215515621117
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Effects of whole body vibration on muscle spasticity for people with central nervous system disorders: a systematic review

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Abstract

Objectives: To examine the effects of whole-body vibration on spasticity among people with central nervous system disorders.

Methods: Electronic searches were conducted using CINAHL, Cochrane Library, MEDLINE, Physiotherapy Evidence Database, PubMed, PsycINFO, SPORTDiscus and Scopus to identify randomized controlled trials that investigated the effect of whole-body vibration on spasticity among people with central nervous system disorders (last search in August 2015). The methodological quality and level of evidence were rated using the PEDro scale and guidelines set by the Oxford Centre for Evidence-Based Medicine.

Results: Nine trials with totally 266 subjects (three in cerebral palsy, one in multiple sclerosis, one in spinocerebellar ataxia, and four in stroke) fulfilled all selection criteria. One study was level 1b (PEDro⩾6 and sample size>50) and eight were level 2b (PEDro<6 or sample size ⩽50). All three cerebral palsy trials (level 2b) reported some beneficial effects of whole-body vibration on reducing leg muscle spasticity. Otherwise, the results revealed no consistent benefits on spasticity in other neurological conditions studied. There is little evidence that change in spasticity was related to change in functional performance. The optimal protocol could not be identified. Many reviewed studies were limited by weak methodological and reporting quality. Adverse events were minor and rare.

Conclusion: Whole-body vibration may be useful in reducing leg muscle spasticity in cerebral palsy but this needs to be verified by future high quality trials. There is insufficient evidence to support or refute the notion that whole-body vibration can reduce spasticity in stroke, spinocerebellar ataxia or multiple sclerosis.

Keywords

Neurological disorders, spasticity, systematic review, whole body vibration

Received: 29 July 2015; accepted: 14 November 2015

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Introduction

Whole-body vibration has attracted much interest in rehabilitation in the past decade. In whole-body vibration treatment, vibration stimuli with combinations of different amplitudes and frequencies are delivered to the body from the feet which make contact with the vibration platform. Typically, static or/and dynamic exercises are performed while standing on the whole-body vibration platform.[1]

Vibratory stimulus has been shown to modulate Ia afferent–motoneuron synaptic transmission by causing presynaptic inhibition.[2] Recent studies have found that H-reflex was depressed during and after whole-body vibration in young healthy adult population.[3–6] Measured by transcranial magnetic stimulation, whole-body vibration was shown to increase the excitability of the corticomotor pathway and intracortical inhibition while decreasing intracortical facilitation.[7] In addition, there is some evidence that whole-body vibration could increase temperature and blood flow in both skin and lower limb muscles.[8–12] These changes in thermoregulation and muscle perfusion may lead to alterations in viscoelastic properties of soft tissue[12] and may partially explain the increase in flexibility of the lower extremities among athletes after whole-body vibration.[9, 13]

The effects of whole-body vibration on reflex activity and mechanical properties of muscles may thus have therapeutic implications for people with central nervous system disorders, in which muscle spasticity is a common manifestation.[14] The secondary problems stemming from muscle spasticity are diverse and may include reduced functional mobility and activity participation.[15,16] Hence, much research effort has been directed to determine effective treatment strategies to tackle the issue of spasticity in central nervous system disorders.

The past decade saw considerable increase in research studies that investigated the influence of whole-body vibration on muscle spasticity in people with central nervous system disorders. It is thus timely to conduct a systematic review to examine the overall evidence, which can be used to guide clinical decision making. The primary objective of this systematic review was to examine the effects of whole-body vibration on spasticity in people with central nervous system disorders. The secondary objective was to examine whether the whole-body vibration-induced improvement in muscle spasticity, if present, was associated with changes in functional performance.

Materials and methods

Research question

This systematic review aimed to answer the following two questions. First, does whole-body vibration therapy lead to better muscle spasticity outcomes compared with no vibration under the same exercise condition, or other forms of intervention among individuals with central nervous system disorders? Second, is there a relationship between change in muscle spasticity and improvement of functional level after whole-body vibration intervention? The PICO (P=Patients, I=Intervention, C=Comparison, O=Outcomes) method was used to define the four major components of the research question:[17] P=individuals with central nervous system disorders; I=whole-body vibration; C=(1) comparison with no whole-body vibration under the same exercise condition, and (2) comparison with other forms of physical activity/intervention; O=muscle spasticity (primary outcome), and all measures of functional performance (secondary outcomes).

Study selection

The inclusion criteria for article were (1) randomized controlled trials that investigated the effects of whole-body vibration in people whose primary diagnosis was a central nervous system disorder; (2) the study had included at least one measurement related to muscle spasticity and (3) published in English. Exclusion criteria were (1) studies that used focal vibration or physioacoustic vibration as an intervention rather than whole-body vibration, or (2) animal studies, or (3) reported in books, conference proceedings, theses or dissertations.

Data sources and searches

An extensive literature search was done using the following electronic databases: MEDLINE (1950 to 21 August 2015), PubMED (until 24 August 2015), Cumulative Index to Nursing and Allied Health Literature (CINAHL)(1982 to 24 August 2015), SPORTDiscus (1830 to 24 August 2015), PsychoINFO (1806 to 24 August 2015), Cochrane Library (1898 to 24 August 2015) and Physiotherapy Evidence Database (PEDro) (until 24 August 2015). A combination of search terms pertaining to whole-body vibration therapy and central nervous system disorders (e.g., cerebrovascular disease, cerebral palsy, multiple sclerosis, spinal cord injury, etc) was generated to identify potential studies. The specific search strategy for MEDLINE database is described in the Appendix (supplementary material). A similar search strategy was used for other database, with the exception of PEDro in which the key word "vibration" was used in simple search. The search strategy and search terms used were validated by a librarian in biological sciences and confirmed with the principal investigator.

Two well-trained researchers conducted the article search and screening independently. Any disagreement was resolved by discussion with the principal investigator. Duplicate articles generated by the different databases were removed using an electronic reference management tool RefWorks (Bethesda, MD, USA). The titles and abstracts of the articles were first screened to eliminate the irrelevant studies. The full-text of the remaining articles was reviewed in detail to determine the eligible ones. The reference list of each selected article was extensively checked to identify other potential relevant studies. A forward search was conducted using Scopus on 30 August 2015 to identify all relevant articles that had referenced the selected articles.

Methodological quality assessment

The Physiotherapy Evidence Database (PEDro) scale was used to evaluate the scientific rigor of the selected clinical trials (9-10=excellent, 6-8=good, 4-5=fair, and ⩽4 =poor).[18] It was developed to assess both external validity (i.e. item 1 in PEDro scale, not considered in calculation of total score) and internal validity (i.e. item 2-11) (Table 1, supplementary material). The PEDro score of these studies could be obtained by searching PEDro database except Cheng et al.[19] Therefore, this article was rated independently by two researchers who were experienced with using the PEDro.

The Oxford Centre for Evidence-Based Medicine Levels of Evidence (2009) was used to determine the level of evidence for each reviewed articles based on the study design and methodological quality.[17] For randomized controlled trials, level 1b indicated good-quality (PEDro score ⩾6 and sample size >50), while the level 2b indicated poor quality (PEDro score <6 or sample size ⩽50).[20] The evidence level of each study was determined independently by two researchers who were familiar with the Oxford Centre for Evidence-Based Medicine Levels of Evidence (2009), and any inconsistent results were resolved after discussion with the principal investigator.

Quality of whole-body vibration reporting

It is important to clearly report the whole-body vibration protocol in order to facilitate clinical application of scientific findings. Thus, the quality of whole-body vibration reporting was assessed using the checklist adapted from the one endorsed by the International Society of Musculoskeletal and Neuronal Interactions.[21] There are 13 items in the original checklist related to various aspects of the whole-body vibration protocols. In addition, we also added an item related to the supervision received during the whole-body vibration exercise training, which may have important impact on treatment outcomes.[22] A score was given if the criterion described in a particular item was fulfilled. The maximum possible score was 14 (Table 2, supplementary material).

Data synthesis and analysis

Information about the key demographic characteristics of the participants, whole-body vibration

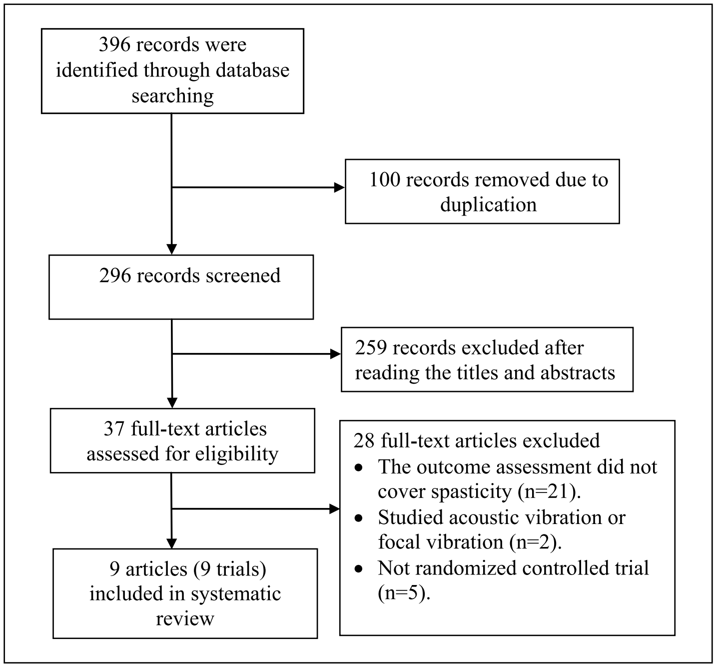

Figure 1. Study flowchart.
A total of 9 articles were included in this systematic review.

intervention protocols, and outcomes of each study was extracted. After reviewing the results of the selected studies, it was decided that meta-analysis was not appropriate because only few studies (<5) used the same outcome measures, and the treatment protocols also varied substantially among the different studies. To estimate the size of the treatment effect for those outcomes that yielded significant results, the standardized effect size (SES) with Hedges' correction was computed (small SES= 0.2, medium= 0.5, large=0.8) based on the data provided in the selected articles.[23, 24] Kappa statistic was used to assess the degree of agreement between the two researchers in selection and rating of the articles, using IBM SPSS software (version 20.0, IBM, Armonk, NY, USA).

Results

A total of 296 records were identified after duplicates were removed. Of these, nine articles met our selection criteria (Figure 1). Excellent inter-rater agreement for article selection was found at the stage of title and abstract screening (kappa=0.830, $P<0.001$), as well as full text screening (kappa=0.856, $P<0.001$).

Study population

Three trials studied the effects of whole-body vibration on muscle tone in cerebral palsy,[19,25,26] one in multiple sclerosis,[27] one in spinocerebellar ataxia,[28] and four in stroke.[29–32] A total of 266 subjects with central nervous system disorders were involved, with the mean age ranging from 9.8 to 69.7 years. The key characteristics of participants in each study are summarized in Table 1.

Whole-body vibration training protocol

The summary of whole-body vibration training protocols adopted in various studies is provided in table 3 (supplementary data online). Six studies used synchronous (vertical) vibrations,[19,27,29–32] one used side-alternating vibrations,[26] and one utilized stochastic vibrations.[28] One study did not

Table 1. Subject Characteristics in the reviewed studies.[a,b]

Study	PEDro Score / WBV reporting quality[c]	Disease	Sample size	Subject characteristics			Impairment level at baseline	
				Age (years)	Disease duration	Relevant medications	Measure	Value
Studies that the assessed acute effects of WBV on spasticity								
Chan et al., 2012[30] (comparision 1)	RCT-level 2b PEDro=8 Report Quality=9	Stroke	*n*=30 WBV, *n*=15 CON, *n*=15	55.5 (9.4)	34.7(32.6) mo	Antispastic drug WBV, *n*=7; CON, n= 6	MAS (0-5) VAS (0-10) Achilles tendon reflex (0-4)	2.4(0.5) 5.8 (1.8) 2.7(0.5)
Studies that assessed the effects of multiple sessions of WBV on spasticity								
Brogårdh et al., 2012[29] (comparision 1)	RCT-level 2b PEDro=9 Report Quality=11	Stroke	*n*=31 WBV, *n*=16 CON, *n*=15	62.6 (7.3)	35.3(30.6) mo	NR	FIM(18-126) MAS(sum, 0-35)	83.3(3.2) WBV1.5(0–7)[d] CON 1.0(0–9)[d]
Kaut et al., 2014[28] (comparision 1)	RCT-level 2b PEDro=6 Report Quality=8	SCA	*n*=32 WBV, *n*=17 CON, *n*=15	59.4 (12.5)	10.85(5.43)	NR	SARA sum(0-40)	12.89(6.03)
Pang et al., 2013[31] (comparision 1)	RCT-level 1b PEDro=8 Report Quality=11	Stroke	*n*=82, WBV, *n*=41 CON, *n*=41	57.4 (11.2)	5.0(3.9) y	NR	MAS(0-5)	Knee 0(0–1) [d] Ankle2(1–3) [d]
Schyns et al., 2009[29] (comparision 1)	RCT-level 2b PEDro=4 Report Quality=6	MS	*n*=16	47.7 (7.4)	WBV: 6.7y (range:10 mo - 23y) CON: 11.8y (range: 3.5 –18 y)	"Subjects were asked to stabilize their medications, especially antispasmodic drugs"	NR	NR
Cheng et al., 2015[27] (comparison 1)	RCT-level 2b PEDro=4 Report Quality=8	CP	*n*=16	9.2 (2.1)	NR	NR	MAS	4.61 (0.95)
Ahlborg et al., 2006[25] (comparision 2)	RCT-level 2b PEDro=4 Report Quality=7	CP	*n*=14 WBV, *n*=7 CON, *n*=7	31 (6.5)	NR	None	MAS(0-5)	3(2–3)[d]
Ibrahim et al., 2014[26] (comparision 2)	RCT-level 2b PEDro=4 Report Quality= 12	CP	*n*=30 WBV, *n*=15 CON, *n*=15	9.6 (1.4)	NR	None	MAS(0-4)	"range 1-2"
Tankisheva et al., 2014[32] (comparision 2)	RCT-level 2b PEDro=7 Report Quality= 10	Stroke	N=15 WBV, *n*=7 CON, *n*=8	61.6 (9.2)	6.4(6.4) y	NR	AS(sum score 0-24)[f] Fugl-Meyer test(0-44)	WBV: 4 (0–9)[d] CON: 5 (0–14)[d] 22.92(5.3)

[a]Comparison 1: compared with no WBV under the same exercise condition; Comparison 2: compared with other forms of physical activity/intervention.
[b]AS: Ashworth Scale; CON: Control group; CP: Cerebral palsy; F: Female; FIM: Functional Independent Measure; FSE: First swing ex; GMFM: Gross Motor Function Measurement; M: male; MAS: Modified Ashworth Scale; mo: month; MS: Multiple Sclerosis; NR: Not report; PROM: Passive Range of Motion; RCT: Randomized Control Trial; SARA: Scale for the Assessment and Rating of Ataxia; SCA: Spinocerebellar Ataxia; SCI: Spinal Cord Injury; UPDRS: Unified Parkinson Disease Rating Scale; VAS: Visual Analog Scale; WBV: Whole-body Vibration group; y: Year.
[c]PEDro score ranges from 0 to 10. Reporting quality score ranges from 0 to 14.
[d]Mean(SD) presented unless otherwise.
[e]Median (IQR).
[f]Sum score of gastrocnemius, soleus, quadriceps, hamstrings, adductors, and psoas muscles.

report the type of vibration used.[25] The frequency and amplitude of vibrations varied from 6–50Hz and 0.44mm-6mm, respectively. The theoretical peak acceleration of the signals, calculated by [Amplitude × (2×π×frequency)^2], ranged from 0.4g to 20.1*g*, where g denotes the unit of Earth's gravity (9.81m/s^2). One trials investigated the acute effect of whole-body vibration,[30] while eight trials examined the effects of long-term whole-body vibration training. [19,25–29,31,32]

Methodological quality

The PEDro score of selected studies could be obtained by searching PEDro database, which ranged from 4 to 9. Overall, only one trial in stroke was considered to have excellent methodological quality (PEDro score=9),[31] and four studies (one in spinocerebellar ataxia,[28] and three in stroke[29,30,32]) were regarded as having good methodological quality (PEDro score= 6–8), and four studies (three in cerebral palsy,[19,25,26] one in multiple sclerosis)[28] were fair quality trials (PEDro score=4).

The level of evidence of each study was rated by two researchers and the agreement was excellent with kappa=0.886 (P<0.001).One stroke trial were level 1b (PEDro⩾6 and sample size>50),[31] eight were level 2b (PEDro< 6 or sample size⩽50).[19,25–30,32]

Quality of whole-body vibration reporting

All the selected studies explicitly reported the specific vibration device and vibration frequency used. Vibration amplitude and vibration type (i.e. synchronous, side-alternating, stochastic) was unknown in one study.[25] Six studies clearly reported whether the patients were supervised during whole-body vibration invention.[19,26,29–32] However, only one study calibrated the whole-body vibration device and reported the validated peak acceleration.[31]

Muscle spasticity measurement tools

Various measurement tools were used to assess muscle spasticity in different studies. The clinical measurement tools included Modified Ashworth Scale, [19,25–27,29–32] Multiple Sclerosis Spasticity Scale-88,[27] Inventory of Non-Ataxia Symptoms,[28] and Visual Analogue Scale for measuring self-perceived level of spasticity.[30] Other assessment tools included H-reflex,[30] tendon reflex testing[30] and Pendulum test.[19] Five of the studies used only one measurement tool to examine muscle spasticity,[25,26,29,31,32] while four studies involved two or more measurement tools.[19,27,28,30]

Comparison group

Six studies involved a comparison group that performed the same exercises as the whole-body vibration group but without the vibration stimuli[19, 27, 30, 31] or with sham vibrations [28,29](i.e., comparison 1 as defined in the Methods section) so that the effects of the whole-body vibration alone could be delineated. Three studies incorporated a control group that was involved in other activities (e.g. routine treatment, strength training) (i.e., comparison 2).[25,26,32] This comparison would determine whether the whole-body vibration training overall (whole-body vibration and exercise components) was better than other interventions.

Acute effect of whole-body vibration on muscle spasticity

The results of each study are presented in Table 4 (supplementary material).

Comparison 1. Only one trial studied the acute effect of whole-body vibration on spasticity when compared with the same exercise training but without whole-body vibration.[30] Chan et al.[30] employed four measurement tools (i.e. Modified Acworth Scale, Visual Analogue Scale, H-reflex, Achilles tendon jerk) to measure the change of ankle spasticity in patients with chronic stroke after a single session and the results were inconsistent. The Modified Ashworth Scale and Visual Analogue Scale score were significantly more reduced in the whole-body vibration group compared to the control group after whole-body vibration, but not the H-reflex response (H-reflex, H_{max}/M_{max}) and Achilles tendon reflex on the affected side.[30] Postural control and functional mobility were also improved significantly more in the whole-body vibration group.[30]

Effects of multiple sessions of whole-body vibration on spasticity

Comparison 1. Five studies (one multiple sclerosis trial,[27] one cerebral palsy trial,[19] two stroke trials,[29,31] one spinocerebellar ataxia trial)[28] involved a control group in which the participants underwent the same exercise as whole-body vibration group but without vibration stimulus or sham vibration (Table 4, supplementary material). The results were mixed. In between-group analysis, Schyns et al.[27] (multiple sclerosis trial) reported significantly more reduction of muscle spasm (muscle spasm item of Multiple Sclerosis Spasticity Scale-88) after 4 weeks of treatment, but no significant results on Modified Ashworth Scale score were found. In patients with cerebral palsy, Cheng et al.[19] found significantly more reduction of quadriceps spasticity in the whole-body vibration group than the control group (medium to large effect sizes) as measured by the Modified Ashworth Scale and Pendulum test after a 4-week intervention period, and the effects lasted up to 3 days after the termination of the intervention. In the two stroke trials, only Pang et al.[31] reported some favorable effects on spasticity. The knee Modified Ashworth Scale score in the affected leg was significantly reduced in whole-body vibration group but not in the control group.[31] However, no between-group analysis was done.[31] Another stroke trial by Brogardh et al.[29] reported no treatment effect of whole-body vibration on spasticity. Finally, no significant effect on spasticity was detected after whole-body vibration in patients with spinocerebellar ataxia.[28]

Among those studies that reported favorable effects of whole-body vibration on reducing spasticity, [19,27,31] only Cheng et al. found the changes in six-minute-walk distance and timed up-and-go performance were significantly correlated with the improvement of the relax index derived from the Pendulum test.[19] Otherwise, no other study showed significant between-group differences in mobility functions after the treatment period.[27,31] In contrast, Kaut et al., which produced negative results on muscle tone, reported significantly more improvement in postural and gait stability in the whole-body vibration group than controls.[28]

Comparison 2. Three studies (two cerebral palsy trials,[25,26] one stroke trial)[32] compared the effect of multiple sessions of whole-body vibration treatment with other treatment modalities. Ahlborg et al.[25] found significant reduction in Modified Ashworth Scale score of knee extensors on the stronger side after whole-body vibration treatment among children with cerebral palsy, but comparison with the resistance training group was not performed. In another cerebral palsy trial, Ibrahim et al.[26] found a significant reduction of Modified Ashworth Scale score on the weaker side after whole-body vibration. However, as revealed by between-group analysis, whole-body vibration did not lead to better outcomes in lower limb Modified Ashworth Scale scores than conventional physical therapy.[26] Improvement of Gross Motor Function Measurement in domain D (standing) and E (walking, running, and jumping) was found in the whole-body vibration group but not the control group.[25,26] However, no between-group analysis of these outcomes was presented. Finally, Tankisheva et al.[32] did not find any improvement of Ashworth Scale score in both the whole-body vibration group and control group (habitual activity) after 6 weeks of whole-body vibration among people with stroke.

Side effects

A total of 150 people with central nervous system disorders were exposed to whole-body vibration in the nine selected studies. Eight studies actually reported whether there were any adverse events or not.[19,25–29,31,32] Among these, three studies explicitly stated that no adverse events occurred.[26–28] Brogardh et al.[29] reported that 15 out of 31 participants had transient mild muscle soreness or muscle fatigue, but did not specify the number of these cases in each of the whole-body vibration and sham treatment groups. Tankisheva et al.[32] reported that "some of the participants described some itching in the legs after the first vibration sessions but this phenomenon resolved spontaneously". Isolated cases of dizziness (n=3),[31] muscle stiffness (n=2),[19,25] back muscle soreness (n=1)[19] and lower limb soreness (n=2)[31] were also reported in other studies. It is not clear whether any adverse effect occurred in Chan et al.[30]

Discussion

This is the first systematic review to examine the effects of whole-body vibration on spasticity among people with central nervous system disorders. The results showed that whole-body vibration may be useful in reducing leg muscle spasticity in cerebral palsy, but the effect is uncertain in multiple sclerosis, stroke and spinocerebellar ataxia. No clear association was found between the reduction in muscle spasticity and changes in functional measures.

Effect of whole-body vibration on muscle spasticity

The evidence related to the acute effect on spasticity of people with chronic stroke was provided by one level 2b study only.[30] Although favorable results were shown with Modified Ashworth Scale and Visual Analogue Scale, they were not accompanied by any significant between-group differences in results generated from neurological assessment (H-reflex and tendon reflex testing).[30] It should be noted that Visual Analogue Scale is a subjective measure of perceived level of spasticity. The change in Visual Analogue Scale may be explained by placebo effect of the whole-body vibration, as sham vibrations were not used.[23] The Modified Ashworth Scale, on the other hand, is a single-item assessment tool that is ordinal in nature. However, parametric rather than non-parametric statistics were used by the authors to analyze the data, which leads to questions about the validity of the results.[30] Therefore, no solid conclusion can be made on the acute effect of whole-body vibration alone on spasticity in people with stroke. It was suggested in quasi-experimental studies that whole-body vibration would significantly inhibit H-reflex in healthy populations[3–6] and people with spinal cord injury.[33] The vibration intensity used in the these studies was higher (frequency in 20~40 Hz and peak-to-peak amplitude 1~4mm) than that adopted in Chan et al.[30] Therefore, apart from difference in subject characteristics, the difference in whole-body vibration intensity may also explain the discordance of the results related to the acute effect on H-reflex.

Is there any evidence that whole-body vibration can effectively reduce spasticity after training of longer durations (e.g., in the order of weeks)? All three cerebral palsy trials[19,25,26] reported results in favor of whole-body vibration training but they provided level 2b evidence only. Cheng et al.[19] demonstrated that adding whole-body vibration to exercise induced a significant treatment effect on reducing quadriceps spasticity than exercise alone without whole-body vibration. The other two cerebral palsy trials also found significant reduction in quadriceps spasticity within the whole-body vibration group, but the comparison with the control group (resistance training, conventional physical therapy) was either not done or not statistically significant.[25,26] Given the study design, it was impossible to delineate the effects of the vibratory stimuli alone in these two studies. [25,26] In addition, even if the imposed vibrations, rather than the exercises done while receiving vibrations, are the main cause of the observed reduction in spasticity, the findings of these two studies provided no evidence that whole-body vibration training is better than other treatments in reducing spasticity in individuals with cerebral palsy. Taken together, while all three cerebral palsy trials reported some positive effects on whole-body vibration training on reducing spasticity with medium to large effect sizes,[19,25,26] the overall evidence is not strong, considering the limitations of the study design of the latter two studies.[25, 26]

The evidence found in the stroke population is inconsistent. Of the three stroke trials, only Pang et al.[31](level 1b) found significant reduction in spasticity within the whole-body vibration group. Upon examining the difference in subject characteristics and treatment protocols among these studies, no specific trends were identified that may explain the difference in results, except that the intervention period was longer in Pang et al.[31] (8 weeks) than the other two studies (6 weeks).[29,32] Overall, there is no strong evidence that the added whole-body vibration can confer additional effects on reducing spasticity post-stroke.

Similar to stroke, there is not sufficient evidence to support or refute the use of whole-body vibration in reducing spasticity in individuals with multiple sclerosis (one level 2b study)[27] and spinocerebellar ataxia (one level 2b study),[28] due to the limited number of studies.

When considering the overall evidence related to the effects of whole-body vibration on muscle spasticity, only one cerebral palsy trial,[19] one stroke trial[30] and one multiple sclerosis trial[27] reported some results that clearly point to beneficial effects of the imposed vibratory stimulation alone. The protocols used in these three studies were very different.[19,27,30] In the cerebral palsy[19] and multiple sclerosis trials,[28] the vibration intensities used were greater (2.3g–20.1g Vs 1.6–2.3g), but the duration of the vibration exposure per session (3–10 minutes Vs 15 minutes) was shorter when compared with the stroke trial.[30] Due to the small number of studies that reported significant results, and the vast differences in the intervention protocols, we could not determine the specific parameters that may account for the positive treatment outcomes.

Relationship to functional level

There is no consistent evidence to show that improvement in spasticity is correlated with improvement in functional ability of the study participants. In Chan et al.[30] (stroke trial), although the improvement in spasticity was accompanied by improvement in balance and mobility function, it is difficult to determine whether it was related to modification of post-stroke spasticity after whole-body vibration, as correlation analysis was not performed. Only Cheng et al.[19] specifically reported that the change in timed up-and-go score was significantly associated with the change in the relax index (Pendulum test) in children with cerebral palsy. Overall, the evidence pertaining to the relationship between changes in muscle tone and those in functional ability after whole-body vibration treatment is weak.

Quality of reviewed articles

Only one of the nine reviewed studies provided level 1b evidence.[31] Four of nine studies had very small sample size (<20),[19,25,27,32] which lowered the statistical power and limited the generalizability of the results to the wider patient populations.

With few exceptions, the protocols of whole-body vibration were not described in adequate details, particularly the use of footwear and supportive device. Only one trial has calibrated and validated the whole-body vibration dosage delivered to the patients (i.e. amplitude and frequency).[31] However, a recent study has shown that for most whole-body vibration platforms, the actual frequency and amplitude of vibrations delivered are different from the intended values.[34] The body weight of subjects would often influence the vibration intensity generation.[34] Future studies should thoroughly describe the protocols in detail in accordance with the guidelines set by the International Society of Musculoskeletal and Neuronal Interactions[21] and validate the vibration signals of platform before conducting the study.

Finally, the Modified Ashworth Scale was extensively used in the reviewed studies, despite its low reliability, validity, and responsiveness.[35,36] Future research should use measurement tools with good psychometric properties to examine the effects of whole-body vibration on muscle spasticity.

Limitations at the review level

Some potentially relevant studies may have been missed because reports not written in English were excluded. Those articles that did not use appropriate words in the titles or abstracts may also have been missed.

We used spasticity only as the outcome of interest. Other outcome measures were considered only if spasticity was measured in the same studies, so as to examine whether changes in spasticity were related to changes in functional performance. This review, therefore, was not designed to assess whether whole-body vibration has therapeutic value on improving outcomes other than spasticity (e.g., gait, balance, quality of life, etc.).

As the intervention protocols used differed on more than one whole-body vibration parameter (whole-body vibration type, frequency, amplitude, treatment duration and frequency), it is difficult to make meaningful comparisons across studies and delineate the independent effects of different whole-body vibration parameters. Meta-analysis was not possible due to the heterogeneity of the studies.

In conclusion, based on extensive review of the literature, there is some evidence that whole-body vibration may be useful in reducing leg muscle spasticity in patients with cerebral palsy but the evidence is of level 2b only. More high quality trials should be conducted to verify the results. There is insufficient evidence to support or refute the notion that whole-body vibration alone confers any significant effects on spasticity in stroke, multiple sclerosis and spinocerebellar ataxia or that whole-body vibration is better than other alternative physical therapy or exercise training in modifying spasticity in these patient populations. There is little evidence that whole-body vibration induced change in spasticity is related to change in functional performance among people with central nervous system disorders.

Clinical messages

- Whole-body vibration may be useful in reducing leg muscle spasticity in cerebral palsy.
- The use of whole-body vibration on reducing muscle spasticity in multiple sclerosis was supported by one level 2b study only.
- There is insufficient evidence to support or refute the use of whole-body vibration on reducing muscle spasticity in stroke or spinocerebellar ataxia.

Conflict of interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: Meizhen Huang was supported by Hong Kong Polytechnic University Full-time PhD studentship (Grant no: RTSA). All other authors received no financial support for the research, authorship, and/or publication of this article.

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