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[Intervention Review]

Whole-body vibration training for patients with neurodegenerative disease

Mercè Sitjà Rabert[1], David Rigau Comas[2], Azahara Fort Vanmeerhaeghe[3], Carme Santoyo Medina[4], Marta Roqué i Figuls[5], Daniel Romero-Rodríguez[6], Xavier Bonfill Cosp[7]

[1]Physiotherapy Department, Blanquerna School of Health Science, Universitat Ramon Llull, Barcelona, Spain. [2]Iberoamerican Cochrane Centre. Institute of Biomedical Research (IIB Sant Pau), CIBER Epidemiología y Salud Pública (CIBERESP), Spain, Barcelona, Spain. [3]EUSES Sports Science, Universitat de Girona, Girona, Spain. [4]Physiotherapy Department, Blanquerna School of Health Science, Universitat Ramon Llull /Barcelona Day Hospital of the MS Foundation. CEMCat, Barcelona, Spain. [5]Iberoamerican Cochrane Centre. Institute of Biomedical Research (IIB Sant Pau), Barcelona, CIBER Epidemiología y Salud Pública (CIBERESP), Spain, Barcelona, Spain. [6]EUSES Sports Science, Universitat de Girona, Girona, Spain. [7]Iberoamerican Cochrane Centre - Institute of Biomedical Research (IIB Sant Pau), CIBER Epidemiología y Salud Pública (CIBERESP), Spain - Universitat Autònoma de Barcelona, Barcelona, Spain

Contact address: Mercè Sitjà Rabert, Physiotherapy Department, Blanquerna School of Health Science, Universitat Ramon Llull, C/Padilla, 226-232, Barcelona, Barcelona, 08026, Spain. MerceSR@blanquerna.url.edu.

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ABSTRACT

Background

Whole-body vibration (WBV) may be a complementary training to standard physical rehabilitation programmes and appears to have potential benefits in the sensorimotor system performance of patients with neurodegenerative diseases.

Objectives

The aim of this review was to examine the efficacy of WBV to improve functional performance according to basic activities of daily living (ADL) in neurodegenerative diseases. Additionally, we wanted to assess the possible effect on signs and symptoms of the disease, body balance, gait, muscle performance, quality of life and adverse events.

Search methods

We searched the following electronic databases: the Cochrane Central Register of Controlled Trials (CENTRAL) (*The Cochrane Library*, 2011 Issue 4), MEDLINE (1964 to 6 May 2011; via PubMed), EMBASE (1980 to 6 May 2011; via Ovid), PeDro (1929 to May 2011; via website), CINAHL (to September 2011; via Ovid) and PsycINFO (1806 to 6 May 2011; via Ovid).

Selection criteria

We included randomised controlled trials comparing single or multiple sessions of WBV to a passive intervention, any other active physical therapy or WBV with different vibration parameters.

Data collection and analysis

Two review authors independently selected trials for inclusion, assessed trial quality and extracted data. Disagreement was resolved by discussion or, if necessary, referred to a third review author.

Main results

We included 10 trials, of which six focused on Parkinson's disease and four on multiple sclerosis. None of the studies reported data on the primary outcome (functional performance). In Parkinson's disease, after pooling two studies, a single session of WBV caused a significant improvement of gait measured using the Timed Up and Go test (TUG) in comparison to standing exercises (mean difference -3.09, 95% confidence interval -5.60 to -0.59; P = 0.02; I^2 = 0%). Nevertheless, longer duration of WBV did not show significant results in comparison with physical therapy in body balance or signs and symptoms measured with the Unified Parkinson's Disease Rating Scale (UPDRS). In multiple sclerosis there was no evidence of a short-term or long-term effect of WBV on body balance, gait, muscle performance or quality of life.

Adverse events were reported in few trials. In those trials that reported them, the intervention appeared to be safe.

Authors' conclusions

There is insufficient evidence of the effect of WBV training on functional performance of neurodegenerative disease patients. Also, there is insufficient evidence regarding its beneficial effects on signs and symptoms of the disease, body balance, gait, muscle strength and quality of life compared to other active physical therapy or passive interventions in Parkinson's disease or multiple sclerosis. More studies assessing other functional tests and accurately assessing safety are needed before a definitive recommendation is established.

PLAIN LANGUAGE SUMMARY

Whole-body vibration platform training in patients with neurodegenerative diseases

Rehabilitation is considered to be a key symptomatic and supportive treatment for neurodegenerative diseases. Exercise training using vibratory platform (whole body vibration) has been recently introduced as a complementary treatment to rehabilitation.This review identified ten trials performing whole body vibration (WBV) in neurodegenerative diseases: six in Parkinson's disease and four in multiple sclerosis. Diversity in treatments and outcomes measures makes difficult to quantitatively compare the effect of WBV intervention across studies and to assess its efficacy. There is insufficient evidence to determine the potential benefits of WBV training in functional performance according to activities of daily life, body balance, signs and symptoms of disease, muscle performance, and quality of life in patients with neurodegenerative diseases. Adverse events were poorly reported in the included studies, but this kind of training seems to be a safe intervention. These conclusions are based on a small number of studies with a limited methodological quality.

SUMMARY OF FINDINGS FOR THE MAIN COMPARISON [Explanation]

Whole-body vibration compared to an active physical therapy (short-term effects) for neurodegenerative disease

Patient or population: patients with neurodegenerative disease
Settings: hospital and community
Intervention: whole-body vibration
Comparison: an active physical therapy (short-term effects)

Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	No of participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	An active physical therapy (short-term effects)	Whole-body vibration				
Body balance Functional Reach test	The mean body balance ranged across control groups from **242 to 245 mm**	The mean body balance in the intervention groups was **19.83 higher** (20.99 lower to 60.65 higher)		45 (2 studies)	⊕⊕◯◯ **low**[1,2]	
Gait Timed Up and Go test	The mean gait in the control groups was **15 seconds**	The mean gait in the intervention groups was **3.09 lower** (5.6 to 0.59 lower)		45 (2 studies)	⊕⊕◯◯ **low**[1,2]	

*The basis for the **assumed risk** (e.g. the median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).
CI: confidence interval

GRADE Working Group grades of evidence
High quality: Further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: We are very uncertain about the estimate.

[1] One study used a quasi-random design.
[2] Wide confidence intervals.

BACKGROUND

Neurodegenerative diseases represent a challenge from both a social and health care point of view. The clinical manifestations of this group of illnesses tend to be similar; they have an insidious beginning and become progressive, chronic and debilitating. The prevalence of neurodegenerative diseases varies broadly depending on the type of disease and geographical area (Ferri 2005; WHO/WFN 2004). Alzheimer's and Parkinson's disease are the most frequent neurodegenerative diseases and are estimated to affect up to 18 million and 6 million of people worldwide respectively (Schapira 1999; WHO/WFN 2004). Alzheimer's disease is characterised by a severe cortical atrophy and the triad of senile plaques, neurofibrillary tangles and neuropil threads. The motor and cognitive impairment characteristic of Parkinson's disease is caused by the loss of melanin-containing neurons and the presence of Lewy bodies in the substantia nigra and other pigmented nuclei of the brainstem. Since their incidence is age-related a substantial increase of this disease in developing countries such as India and China is expected in the coming years (WHO/WFN 2004).

Amyotrophic lateral sclerosis (ALS) and multiple sclerosis are also considered neurodegenerative diseases. ALS is less frequent but is characterised by a selective degeneration of the upper and lower motor neurons that cause progressive weakness leading to paralysis and death within three to six years after the onset of the disease. Multiple sclerosis is an autoimmune disorder characterised by destruction of myelin in the central nervous system (CNS) and also axonal atrophy in the chronic progressive forms. It is the commonest non traumatic neurological disorder affecting young adults (Adams 1997). Although patient profile, physiopathology and some clinical features and therapeutic options differ broadly between neurodegenerative diseases, their common threats are a remarkable decline in functional capacity, the associated loss of independence and impairment of quality of life.

Physical rehabilitation is considered to be a key symptomatic and supportive treatment for neurodegenerative diseases, but the evidence to support its use is relatively poor (Khan 2008**;** Mehrholz 2010**)**. The effect of vibration stimuli on the nervous and muscular system has been studied in different fields (Goetz 2009;Cardinale 2003) and has evolved into full body training known as Whole Body Vibration (WBV). Exercise training using vibratory platforms may be a complementary training to standard physical rehabilitation programmes. WBV provides a mechanical oscillation of a specific frequency and amplitude of displacement (Jordan 2005; Luo 2005; Cardinale 2006; Rehn 2007). It generates an oscillatory vertical motion (vertical platform) or a movement around a horizontal axis (oscillating platform) (Marín 2010). The contact surface of the platform transmits a vibration (in feet or hands) throughout the body. This vibration produces rapid changes in the length of the muscle and activates the myotatic reflex. The stretching of muscles is detected by the proprioceptors (mainly the neuromuscular spindles) thus activating the called tonic vibration reflex (Eklund 1966; Cardinale 2006).

The wWhole body vibration training haves been studied in others populations. Current evidence suggests that exercise programmes (involving static or dynamic exercises, or both) on vibratory platforms have beneficial effects in older populations (Merriman 2009; Mikhael 2010; Totosy de Zepetnek 2009). It has been shown that vibration interventions with a low amplitude (ranging from 0.7 to 14 mm), a moderate frequency (ranging from 10 to 50 Hz) and short periods of exposure are safe and have beneficial effects on muscular strength (Bosco 1998; Cardinale 2006; Jordan 2005; Luo 2005), bone mineral density (Mikhael 2010; Totosy de Zepetnek 2009) and body balance in both young healthy and elderly populations (Merriman 2009). In addition WBV may have short-term effects, obtained immediately after a single session of vibration stimuli and long-term effects, obtained after regular vibration stimuli (multiple sessions) (Rehn 2007).

In recent years, some rehabilitation programmes have introduced vibratory platform training in neurodegenerative diseases such as Parkinson's disease or multiple sclerosis (Schuhfried 2005; Turbanski 2005). The aim of this review is to clarify the potential benefits of whole-body vibration training in the treatment of neurodegenerative diseases

OBJECTIVES

To examine the efficacy of WBV training for improving functionality and balance, decreasing symptoms and improving quality of life in neurodegenerative diseases.

METHODS

Criteria for considering studies for this review

Types of studies

We included randomised clinical trials (RCT) or quasi-randomised clinical trials.

Types of participants

We considered studies that included participants with any type of neurodegenerative diseases, such as Parkinson's disease, multiple sclerosis, amyotrophic lateral sclerosis (ALS), Alzheimer's disease, Huntington's chorea, etc. We grouped the effects of the interventions separately by illness.

Types of interventions

This review focused on any intervention with WBV which evaluated both short-term (single session) and long-term effects (multiple sessions). We included trials where WBV was compared to:

- a passive intervention (waiting list, non-treatment, usual lifestyle);
- any other active physical therapy intervention (balance programme, walking, resistance training etc.);
- another WBV intervention under different vibration parameters.

Types of outcome measures

Primary outcomes

- Functional performance according to basic activities of daily living(ADL)

Secondary outcomes

- Signs and symptoms of the disease
- Body balance: includes all the assessments (test, scale etc.) that analyse equilibrium, postural control or proprioception in a standing position
- Gait: includes all the measurements (test, scale etc.) that analyse the action of walking
- Muscle performance
- Quality of life
- Adverse events

Search methods for identification of studies

Electronic searches

We searched the following electronic databases: the Cochrane Central Register of Controlled Trials (CENTRAL) (*The Cochrane Library*, 2011 Issue 4), MEDLINE (1964 to 6 May 2011; via PubMed), EMBASE (1980 to 6 May 2011; via Ovid), PeDro (1929 to May 2011; via website), CINAHL (to September 2010; via Ovid) and PsycINFO (1806 to 6 May 2011; via Ovid). We applied no language restrictions.

We designed the following search strategy for MEDLINE (PubMed) and we modified this strategy to search the other databases (Appendix 1):

1 whole body vibration[tw] OR vibration exercise[tw] OR wbv[tw]

2 randomized controlled trial[pt] OR controlled clinical trial[pt] OR randomized[tiab] OR placebo[tiab] OR drug therapy[sh] OR randomly[tiab] OR trial[tiab] OR groups[tiab]

3 1 AND 2

Searching other resources

We handsearched conference proceedings from the World Physical Therapy Congress (World Confederation for Physical Therapy; http://www.wcpt.org/), *Congreso Nacional de Neurología (Sociedad Española de Neurología;* http://www.sen.es/*)*, International Conference of the European Committee for Treatment and Research in Multiple Sclerosis (ECTRIMS; http://www.ectrims.eu/), World Parkinson Congress (http://www.worldpdcongress.org/) and International Conference on Alzheimer's and Parkinson's diseases (http://www2.kenes.com/adpd/Pages/Home.aspx). We reviewed conference proceedings from January 2002 to March 2011.

Additionally, we checked the reference lists from relevant studies to identify further eligible studies. We also identified ongoing and unpublished trials by contacting researchers in the field.

Data collection and analysis

Selection of studies

Two review authors independently screened the title, abstract and descriptors of references identified by the searches for possible inclusion and they obtained the full text of studies if required. We agreed the list of studies eligible for inclusion and in case of disagreements we called in a third review author to reach consensus.

Data extraction and management

We independently extracted data using a data extraction form which was designed and tested prior to use. Disagreement was resolved by discussion or, if necessary, referred to a third review author.

Assessment of risk of bias in included studies

Two review authors independently evaluated each study's risk of bias according to the criteria outlined in the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2008). We evaluated the following domains: random sequence generation (selection bias); allocation concealment (selection bias); blinding (performance bias and detection bias); selective reporting (reporting bias); the description of the number and the causes of follow-up loss and other bias. We evaluated each criterion and assigned a judgement of low, unclear or high risk of bias, based on the information reported in each study. Review authors were not blinded to author and source institution of included studies. Disagreements were resolved by involving a third author. If necessary, we contacted study authors to obtain additional data for enhanced 'Risk of bias' assessment.

Measures of treatment effect

We measured treatment effect with mean differences for continuous outcomes when assessed with the same scale. We computed standardised mean differences when outcomes were measured with different scales (i.e. body balance measured with the Tinetti test and Berg Balance Scale).

Although we had planned to present absolute measures in relation to baseline risks observed in the included studies, this was ultimately not done due to poor reporting of data in studies.

Unit of analysis issues

For all included cross-over trials, we assessed the appropriateness of their analysis methods from their publications. Since all of them were adequately analysed using design-adjusted tests, we reported their statistical results, P values and conclusions in the results section with no modifications. Cross-over trials could not be pooled due to clinical heterogeneity in comparisons and outcomes.

Dealing with missing data

The studies included had low numbers of patients lost to follow-up. We analysed data as presented in the original trials, without assumptions regarding missing data.

Assessment of heterogeneity

We assessed clinical heterogeneity based on comparability of interventions and outcome measures. We only attempted pooling of data for clinically homogeneous trials. When appropriate, we assessed statistical heterogeneity using the I^2 statistic to determine heterogeneity observed across studies. I^2 values superior to 50% indicated the existence of substantial heterogeneity.

We organised the analyses and presentation of results according to the two subgroup analyses that had been planned in the protocol:

1. Type of neurodegenerative disease (Alzheimer's disease, Parkinson's disease, multiple sclerosis, ALS, others).
2. WBV training duration. We assessed the short-term effects of WBV training, defined as the effects immediately observed after application of a single WBV session and the long-term effects of WBV training, defined as a performance after regular WBV sessions (Rehn 2007).

Data synthesis

Whenever pooling of data was possible (i.e. the included trials assessing a common comparison provided adequate data for a specific outcome), we carried out a meta-analysis using the generic inverse variance method by means of a fixed-effect model. When pooling was not possible, we carried out a qualitative description and assessment of the results and conclusions of the included studies. We performed all statistical analyses with the Cochrane Review Manager (RevMan 5) statistical package (RevMan 2008), following the recommendations of the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2008).

RESULTS

Description of studies

See: Characteristics of included studies; Characteristics of excluded studies.

Results of the search

We retrieved he following results from the searches:

Source	Hits retrieved
MEDLINE	305
EMBASE	264
PeDro	27
CENTRAL (the Cochrane Central Register of Controlled Trials)	176
CINAHL	64
PsycINFO	52

(*Continued*)

World Physical Therapy Congress (World Confederation for Physical Therapy)	13
Congreso Nacional de Neurología (Sociedad Española de Neurología)	0
International Conference of the European Committee for Treatment and Research in Multiple Sclerosis (ECTRIMS) http://www.ectrims.eu/	0
World Parkinson Congress	1
International Conference on Alzheimer's and Parkinson's disease	1

The search strategies identified a total of 903 references. Removal of duplicates resulted in 573 references. We obtained 49 full-text studies for consideration and eventually excluded 39 of them.

Included studies

We included 10 studies with 264 participants. The effects of WBV were assessed in two different neurodegenerative diseases: Parkinson's disease (six trials) and multiple sclerosis (four trials). Seven trials used a parallel design (Arias 2009; Broekmans 2010; Chouza 2011; Ebersbach 2008; Haas 2006 (a); Schuhfried 2005; Turbanski 2005) and three used a cross-over design (Haas 2006 (b); Jackson 2008; Schyns 2009). Six trials studied the short-term effects of WBV in a single session (Chouza 2011; Haas 2006 (a); Haas 2006 (b); Jackson 2008; Schuhfried 2005; Turbanski 2005) and three trials studied the long-term effects of WBV (up to 20 weeks training programme) (Broekmans 2010; Ebersbach 2008; Schyns 2009). One trial presented short-term and long-term results for WBV, after a single session and after a five-week training programme (Arias 2009).

Participants

Six studies were conducted in patients with Parkinson's disease (Arias 2009; Chouza 2011; Ebersbach 2008; Haas 2006 (a); Haas 2006 (b); Turbanski 2005). The mean age of participants in these trials was 67.9 years and 31.5% of them were female. Four studies were conducted in patients with multiple sclerosis (Broekmans 2010; Jackson 2008; Schuhfried 2005; Schyns 2009). The mean age of participants in these trials was 48.9 years and 73.3% of them were female. No studies were conducted in others neurodegenerative diseases.

Interventions

Different vibration platform types were used in the included trials. Four studies used a rotational platform (oscillating platform) that rotates in a sinusoidal manner around an anteroposterior axis that thrusts the right and left legs upward alternately (Arias 2009; Chouza 2011; Ebersbach 2008; Jackson 2008). Two studies used a platform that generates vertical sinusoidal displacements (Broekmans 2010; Schyns 2009). Finally, four studies used a platform that performs a non harmonious generation of oscillating movements (random) in vertical and horizontal planes (transversal axis) (Haas 2006 (a); Haas 2006 (b); Schuhfried 2005; Turbanski 2005).

Vibration parameters in the rotational platform were diverse: vibratory frequency ranged from 2 to 26 Hz; amplitude ranged from 6 to 14 mm and vibration time per session ranged from 30 seconds to 5 minutes. The platform that generated vertical displacements used higher vibratory frequencies (ranging from 20 to 50 Hz) with an amplitude of 2.5 mm and a vibration time per session that ranged from 2.5 to 16.5 minutes. The platforms that generated a random vertical and horizontal movement used more homogeneous vibration parameters: vibratory frequency up to 6 Hz; amplitude of 3 mm and vibration time per session of 5 minutes.

Comparison

There were four trials that compared the effects of WBV to a passive intervention, mostly a resting period (Broekmans 2010; Haas 2006 (a); Haas 2006 (b); Schuhfried 2005). In four trials WBV was compared to active physical therapy interventions that included standard balance training, moderate walking, conventional resistance training or standing exercises (Arias 2009; Ebersbach 2008; Schyns 2009; Turbanski 2005). One trial compared two modali-

ties of WBV with different frequencies of vibration (Jackson 2008) and finally one trial compared different frequencies of vibration and standing exercises (Chouza 2011).

Excluded studies

We excluded 39 trials after reading their full text. Reasons for exclusion are detailed in the Characteristics of excluded studies. The most frequent reason of exclusion was that the participants included were not patients with a neurodegenerative disease. All identified studies that included older persons were obtained in full text to ascertain if they provided data on any subgroup with a neurodegenerative disease.

Risk of bias in included studies

The assessments of methodological quality for the individual studies are detailed in the 'Risk of bias' tables included in the Characteristics of included studies and summarised in Figure 1 and Figure 2.

Figure 1.

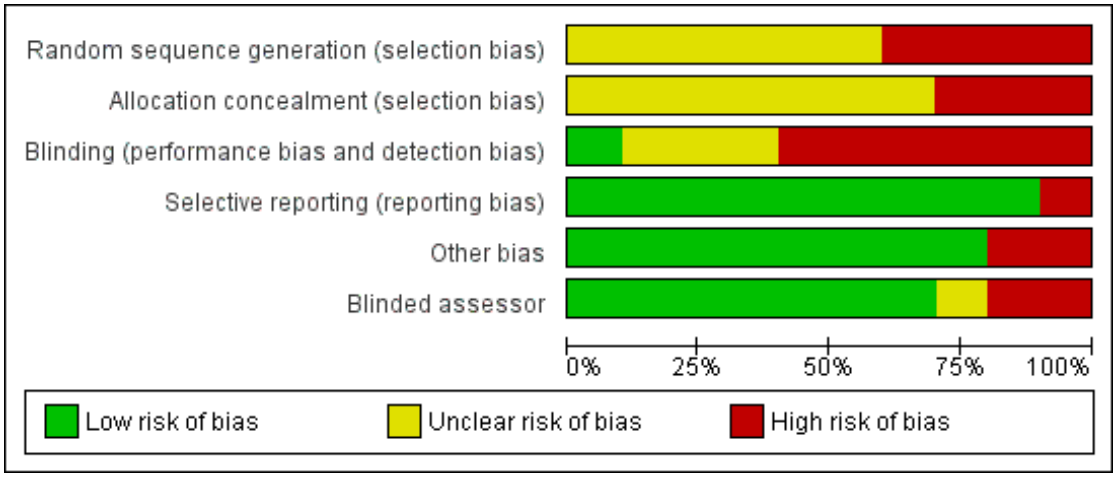
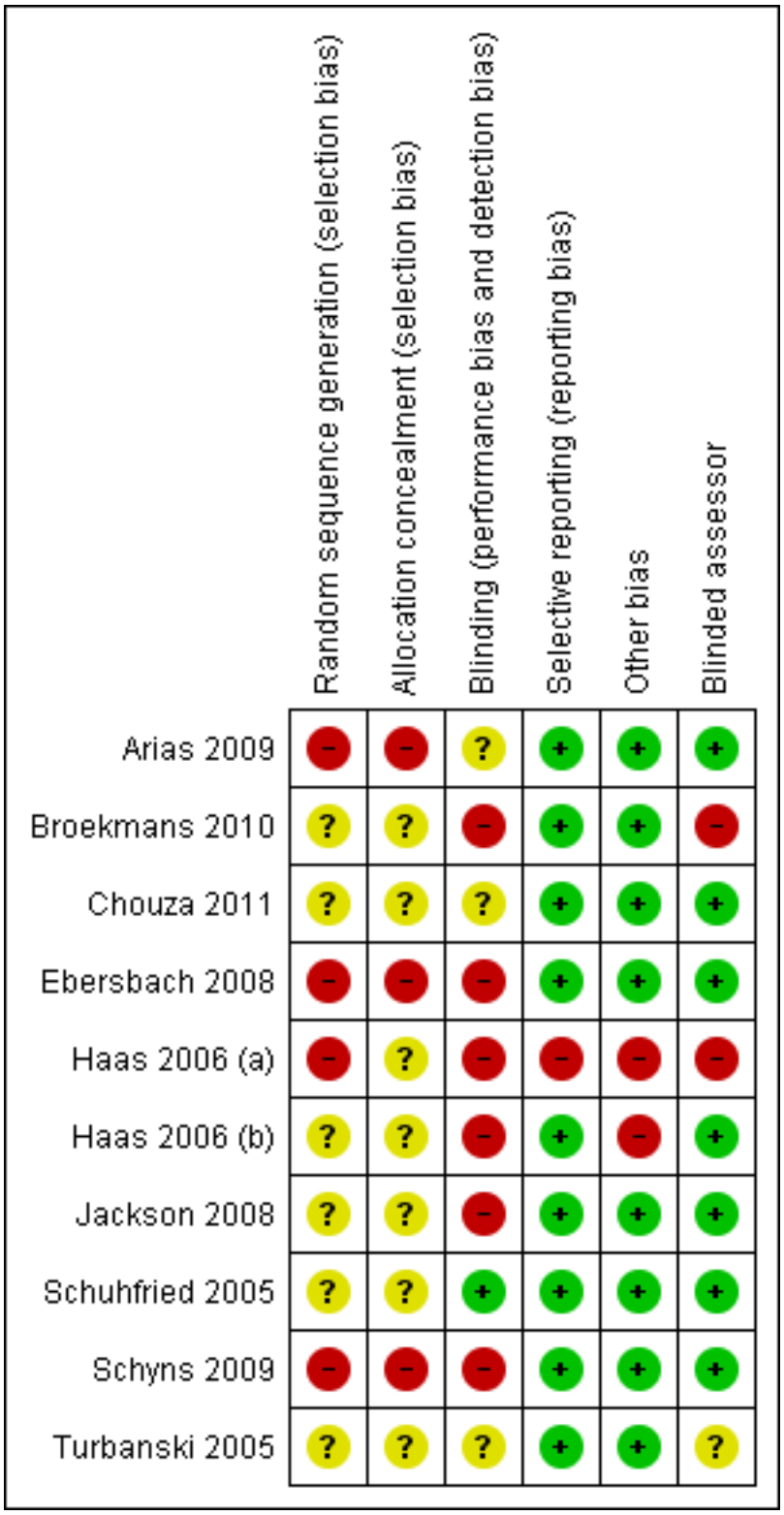


Figure 2.



Overall, the methodological quality of the studies was low. None of the included studies reported an adequate method for randomisation sequence generation or concealed the intervention allocation.

Allocation

Three studies did not use an adequate method of allocation concealment (Arias 2009; Ebersbach 2008; Schyns 2009). The rest of the studies did not provide any information, so were of unclear risk of bias.

Blinding

One study blinded the intervention to the investigator but not to the patient (Schuhfried 2005). Six studies were open (Broekmans 2010; Ebersbach 2008; Haas 2006 (a); Haas 2006 (b); Jackson 2008; Schyns 2009) and three studies did not provide information about the blinded status of participants.

We paid special attention if the studies included a blind assessor because the characteristics of the intervention hamper any strategy to blind the intervention assignment to the investigators or participants. Overall, seven studies used a blinded assessor to evaluate all or some outcomes (Arias 2009; Chouza 2011; Ebersbach 2008; Haas 2006 (b); Jackson 2008; Schuhfried 2005; Schyns 2009). In two studies the outcome assessors were aware of the intervention assignment (Broekmans 2010; Haas 2006 (a)) and one study did not provide enough information.

Selective reporting

In nine studies (Arias 2009; Broekmans 2010; Chouza 2011; Ebersbach 2008; Jackson 2008; Haas 2006 (b); Schuhfried 2005; Schyns 2009; Turbanski 2005) the authors reported data on all outcomes. Nonetheless, in one study (Haas 2006 (a)) the authors reported data from only one of two pre-specified outcomes.

Other potential sources of bias

Seven studies were free of other potential sources of bias (Arias 2009; Broekmans 2010; Chouza 2011; Ebersbach 2008; Jackson 2008; Schuhfried 2005; Turbanski 2005). Two studies (Haas 2006 (a); Haas 2006 (b)) were affected by other sources of bias. In one of them (Haas 2006 (a)) the number of participants in each group was highly unbalanced (19 patients in the intervention group and nine patients in the control group). The second one (Haas 2006 (b)) used a cross-over design but without a wash-out period between intervention phases suggesting a carry-over effect. It is not clear if one study (Schyns 2009) was also affected by a carry-over effect because it had a two-week wash-out period between the four-week intervention phases.

Effects of interventions

See: **Summary of findings for the main comparison** Whole-body vibration compared to an active physical therapy (short-term effects) for neurodegenerative disease; **Summary of findings 2** Whole-body vibration compared to an active physical therapy (long-term effects) for neurodegenerative disease

None of the studies reported results for the primary outcome (functional performance according to basic activities of daily living (ADL)). We present the results for secondary outcomes grouped by type of neurodegenerative disease, by short-term or long-term effects of whole-body vibration (WBV) and finally by comparison group. Not all of the studies provided data on all secondary outcomes. Pooling of data was only attempted when clinical homogeneity was observed, regarding participants, active and control interventions and effect measures.

1. Results for Parkinson's disease

We analysed a total of six studies including 236 participants with Parkinson's disease (Arias 2009; Chouza 2011; Ebersbach 2008; Haas 2006 (a); Haas 2006 (b); Turbanski 2005).

1.1. Short-term effects of WBV

Five trials including 215 participants (Arias 2009; Chouza 2011; Haas 2006 (a); Haas 2006 (b); Turbanski 2005) studied the effects of a single session of WBV.

1.1.1. WBV compared to a passive intervention

Two studies compared the WBV with a passive intervention consisting of a resting period (Haas 2006 (a); Haas 2006 (b)).

Haas 2006 (a) included 26 participants and assessed proprioceptive performance as a measure of body balance using a tracking task based on knee extension and flexion movements. No significant differences were detected either between pre and post-tests or between experimental and control groups (only reported in graphics). Bradykinesia (a symptom of Parkinson's disease) was not properly detailed in the results of the publication.

Haas 2006 (b) included 68 participants and used a cross-over design. The study assessed signs and symptoms of the disease using the Unified Parkinson's Disease Rating Scale (UPDRS) motor score at baseline and after both interventions (WBV or resting period). There was no wash-out period. The UPDRS motor score was significantly reduced ($P < 0.01$, two-way repeated measures ANOVA test) after WBV treatment, whereas no significant changes in UPDRS motor score were detected after the control period.

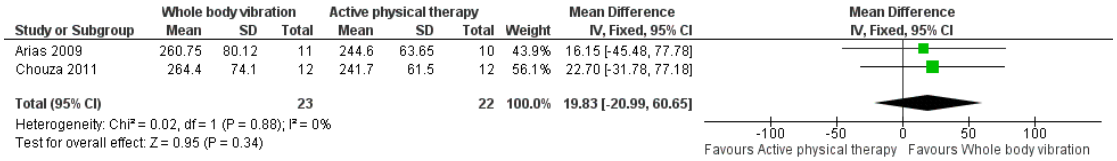
None of the studies reported data on adverse effects.

1.1.2. WBV compared to an active physical therapy intervention

Three studies compared WBV to an active physical therapy intervention. One study compared WBV with moderate walking (Turbanski 2005). Another study compared WBV with standing exercises (same set of exercises performed without vibration) (Arias 2009) and assessed both short-term and long-term effects. Finally, the third study compared different frequencies of vibration and standing exercises (same set of exercises performed without vibration) (Chouza 2011).

Two studies comparing WBV with standing exercises including a total of 45 participants assessed body balance with the Functional Reach test. The pooled mean difference for body balance was 19.83 (95% confidence interval (CI) -20.99 to 60.65;P = 0.34; Analysis 1.1; Figure 3) without evidence of statistical heterogeneity (I^2 = 0%). No differences were observed between WBV group in comparison to standing exercise. Both studies had the same vibration parameters (frequency at 6 Hz and amplitude at 13 mm) and a similar protocol intervention.

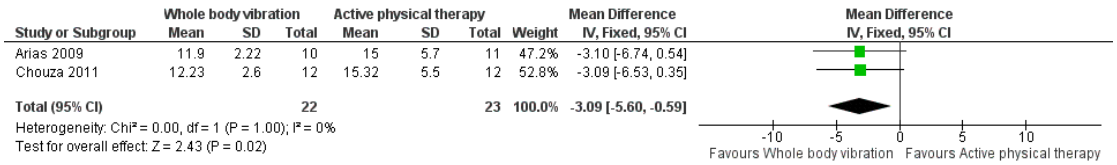
Figure 3. Forest plot of comparison: 1 Whole-body vibration vs an active physical therapy (short-term effects) in Parkinson's disease, outcome: 1.1 Body balance (Functional Reach).



The third study, not included in the pooled analysis, reported the results of body balance using a different assessment measure (postural stability on a moving and unstable platform) (Turbanski 2005). This study included 52 participants assessed in two standardised conditions (narrow and tandem standing) on their ability to maintain postural stability on a moving and unstable platform. Postural stability was improved after WBV treatment in both positions but only significantly in the tandem standing (P = 0.01, from a two-way ANOVA test). Analyses of group differences resulted in a significantly higher postural control improvement in the WBV group (P = 0.04, one-way ANOVA with Bonferroni correction).

The two studies comparing WBV with standing exercises (45 participants) assessed gait with the Timed Up and Go (TUG) test (Arias 2009; Chouza 2011). The pooled mean difference for body gait was -3.09 (95% CI -5.60 to -0.59;P = 0.02; Analysis 1.2; Figure 4) with evidence of statistical heterogeneity (I^2 = 0%). Gait was improved significantly in the WBV group in comparison to standing exercises.

Figure 4. Forest plot of comparison: 1 Whole-body vibration vs an active physical therapy (short-term effects) in Parkinson's disease, outcome: 1.2 Gait (Timed Up and Go test).



None of the studies reported data on adverse effects.

1.2. Long-term effects of WBV

Two studies including 42 participants studied the effects of a long-term WBV intervention (Arias 2009; Ebersbach 2008), both compared to an active physical therapy intervention.

1.2.1. WBV intervention compared to an active physical therapy intervention

Arias 2009 included 21 participants and compared WBV with standing exercises (same set of exercises performed without vibration). Ebersbach 2008 included 21 participants and compared WBV with standard balance exercises performed on a tilt board. These two studies assessed body balance and gait using different tests. We pooled results for these outcomes using a standardised mean difference (SMD).

No differences were found in the meta-analysis between WBV compared to active physical therapy in signs/symptoms of the disease, body balance and gait. The two studies assessed signs and symptoms of the diseases by UPDRS III test (motor score) (Arias 2009; Ebersbach 2008). The pooled mean difference for UPDRS motor score was -0.81 (95% CI -4.68 to 3.07;P = 0.68; Analysis 2.1; Figure 5) without evidence of statistical heterogeneity (I^2= 22%) at the end of the study.(No differences were observed between the two studies in body balance using the Berg Balance Scale (Arias 2009) and the Tinetti test (Ebersbach 2008), presenting a SMD of 0.36 (95% CI -0.26 to 0.97;P = 0.25; Analysis 2.2; Figure 6) without evidence of statistical heterogeneity (I^2 = 0%).

Figure 5. Forest plot of comparison: 2 Whole-body vibration vs an active physical therapy (long-term effects) in Parkinson's disease, outcome: 2.1 UPDRS III motor score.

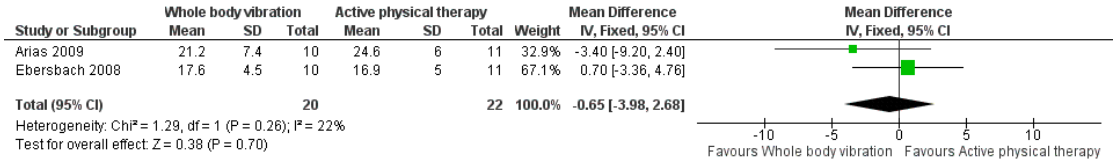
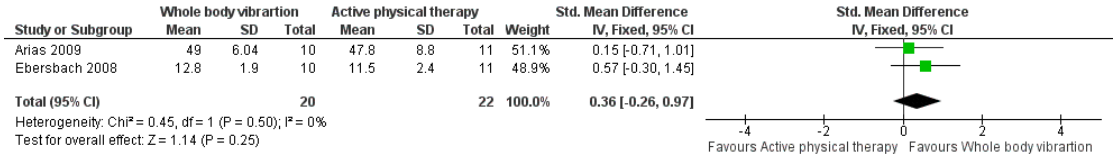
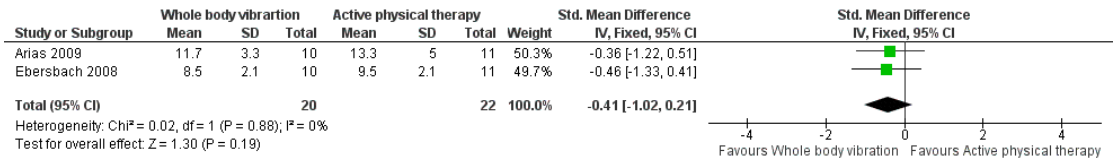


Figure 6. Forest plot of comparison: 2 Whole-body vibration vs an active physical therapy (long-term effects) in Parkinson's disease, outcome: 2.2 Body balance (Berg Balance Scale and Tinetti test).



No differences were observed between the two studies in gait assessed by the TUG test (Arias 2009) and the stand-walk-sit test (Ebersbach 2008). The SMD was -0.41 (95% CI -1.02 to 0.21; P = 0.19;; Analysis 2.3; Figure 7) without evidence of statistical heterogeneity (I^2 = 0%).

Figure 7. Forest plot of comparison: 2 Whole-body vibration vs an active physical therapy (long-term effects) in Parkinson's disease, outcome: 2.3 Gait (TUG test and Stand-walk-sit test).



In addition, Arias 2009 assessed quality of life using the PDQ-39 test (Parkinson's disease questionnaire) in the 21 participants and there were no differences between groups (P = 0.143, two-way ANOVA test).
None of the studies reported data on adverse effects.

2. Results for multiple sclerosis

We analysed a total of four studies including 62 participants with multiple sclerosis (Broekmans 2010; Jackson 2008; Schuhfried 2005; Schyns 2009).

2.1. Short-term effects of WBV

Two trials including 27 participants studied the effects of a single session of WBV (Jackson 2008; Schuhfried 2005). One study compared WBV with an active physical intervention consisting of standing exercises (in a squat position: slight flexion at the hips, knee and ankle joint) while applying a burst-transcutaneous electrical nerve stimulation (TENS) on the non dominant forearm (Schuhfried 2005). The second study compared two WBV modalities with different vibration parameters (Jackson 2008). No trials comparing WBV with passive interventions were identified.

2.1.1. WBV compared to an active physical therapy intervention

Schuhfried 2005 was conducted as a pilot study comparing WBV to standing exercises. A total of 12 participants assessed body balance with the Sensory Organization Test (SOT) and the Functional Reach test (FR). Gait was assessed using the TUG test. Values of change from baseline of these tests were not significantly different between groups (P = 0.18, Mann-Whitney U-test). All patients completed the study without any adverse effects except one patient who experienced increased fatigue (no details on which they group belonged to).

2.1.2. WBV compared to WBV with different vibration parameters

Jackson 2008 conducted a cross-over study including 15 participants. Muscle performance was assessed with the maximal isometric torque (of knee extensors and flexors) using an isokinetic dynamometer (Biodex Medical Systems®). There were no significant differences in isometric torque between the 2 Hz and 26 Hz WBV conditions (P value not presented for repeated measures analysis of variance). There were no adverse effects during the study.

2.2. Long-term effects of WBV

Two trials including 35 participants studied the effects of a long-term WBV intervention (Broekmans 2010; Schyns 2009) compared with either passive intervention (usual lifestyle) (Broekmans 2010) or with an active physical therapy intervention (same set of exercises performed without vibration) (Schyns 2009).

2.2.1. WBV compared to a passive intervention

Broekmans 2010 analysed 25 participants during 20 weeks. The assessment of body balance was done with the Berg Balance test and gait was assessed by the TUG test, the two-minute walk test and the 25-foot walk test. Finally, the muscle performance of knee extension was assessed through isokinetic dynamometer (Biodex Medical Systems®). No differences between groups were detected for any of the variables (maximal isometric knee-extensor and knee-flexor torque in both knee angles: group × time effect, knee-extensors: 45°, P = 0.07; 90°, P = 0.23; knee-flexors: 45°, P = 0.64; 90°, P = 0.57); Berg Balance scale, P = 0.15; TUG test, P = 0.26; two-minute walk test, P = 0.25; 25-foot walk test, P = 0.64; all P values from a repeated measures ANOVA). Adverse events were not properly detailed in the publication.

2.2.2. WBV compared to any other active physical therapy intervention

Schyns 2009 included 10 participants in a cross-over study. The authors provided the results by intervention group for the assessment of gait (measured with the TUG test and the 10-metre walk tests), muscle performance (maximal isometric force using a hand-held dynamometer) and quality of life (assessed by the Multiple Sclerosis Impact Scale (MSIS-29)). No statistically significant differences were found for any of these outcomes (TUG test, P = 0.72; 10-metre walk test, P = 0.56; muscle force: quadriceps (right) P = 0.846, hamstrings (right) P = 1.00; MSIS-29: Physical P = 0.760 and Psychological P = 0.634; all P values from Wilcoxon signed rank test). The results of assessing signs and symptoms of the disease with the Multiple Sclerosis Spasticity Scale MSSS-88 and the Modified Ashworth Scale were not provided. Adverse events were not properly detailed in the publication.

ADDITIONAL SUMMARY OF FINDINGS [*Explanation*]

Whole-body vibration compared to an active physical therapy (long-term effects) for neurodegenerative disease

Patient or population: patients with neurodegenerative disease
Settings: hospital and community
Intervention: whole-body vibration
Comparison: an active physical therapy (long-term effects)

Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	No of participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	An active physical therapy (long-term effects)	Whole-body vibration				
Body balance Berg Balance Scale and Tinetti test		The mean body balance in the intervention groups was **0.36 standard deviations higher** (0.26 lower to 0.97 higher)		42 (2 studies)	⊕◯◯◯ **very low**[1,2]	SMD 0.36 (-0.26 to 0.97)
Gait Time Up and Go test and Stand-walk-sit test		The mean gait in the intervention groups was **0.41 standard deviations lower** (1.02 lower to 0.21 higher)		42 (2 studies)	⊕◯◯◯ **very low**[1,2]	SMD -0.41 (-1.02 to 0.21)
UPDRS III UPDRS scale (motor score). Scale from: 0 to 56.	The mean UPDRS III ranged across control groups from **17 to 25 points**	The mean UPDRS III in the intervention groups was **0.65 lower** (3.98 lower to 2.68		42 (2 studies)	⊕◯◯◯ **very low**[1,2]	

		higher)		

*The basis for the **assumed risk** (e.g. the median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).
CI: confidence interval; **SMD**: standardised mean difference

GRADE Working Group grades of evidence
High quality: Further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: We are very uncertain about the estimate.

[1] Both studies used a quasi-random design and had substantial losses to follow-up.
[2] Wide confident intervals.

DISCUSSION

Summary of main results

The aim of this review was to examine the efficacy of whole-body vibration (WBV) to improve functional performance according to basic activities of daily living (ADL)in neurodegenerative diseases. We included 10 studies, only focusing on Parkinson's disease (six trials) and multiple sclerosis (four trials), and assessing either a single training session (short-term effects) or multiple sessions over a period of time (long-term effects). None of the studies reported data on the primary outcome (functional performance) and it was only possible to analyse partial evidence regarding secondary outcomes.

Overall, methodological quality of the studies included in this review was low and inconsistent. Heterogeneity of interventions,outcome measures and units of measurement used in the included studies makes difficult to compare WBV parameters among studies and assess its efficacy. For these reasons, the evidence about its efficacy is weak and no strong conclusions can be derived.

Signs and symptoms

Signs and symptoms were analysed using different scales. For Parkinson's disease studies, bradykinesia was analysed either as a movement velocity of the knee or using the Unified Parkinson's Disease Rating Scale (UPDRS) (specifically the UPDRS motor score) for a general assessment of signs and symptoms. For multiple sclerosis studies, the Multiple Sclerosis Spasticity Scale (MSSS-88) or the Modified Ashworth Scale was used.

Only two studies focusing on Parkinson's disease performed WBV in several training sessions compared to active physical therapy (same exercise programme without vibration or standard balance training). Comparative data from both studies related to signs and symptoms (UPDRS test) (Arias 2009; Ebersbach 2008) were analysed and no differences were found. Bradykinesia was measured in only one trial, but this parameter was not properly detailed in the results (Haas 2006 (b)).

Body balance

Most of the analysed studies have focused on functional mobility as the main outcome measure (most of the included trials assessed balance skill). Balance and gait impairment compromise the ability to perform ADL independently, and these limitations also lead to secondary complications such as falls and social isolation (Zijltra 2010). Body balance is an outcome analysed with different tests such as the Functional Reach test, the Berg Balance Scale, the Tinetti test, posturography (Sensory Organization Test), the Nottingham Sensory Assessment and the Pull test score from the UPDRS score.

Regarding balance in Parkinson's disease and multiple sclerosis, both with single or multiple sessions, the analysis not showed a statistically significant differences between groups.

Gait

Gait was an outcome evaluated using different tests in the studies in this review, such as the Timed Up and Go (TUG) test, the stand-walk-sit test, the two-minute walk test, the 25-foot-walk test and the 10-metre-walk test, and even using a gait recording system analysing gait (m/s), cadence (steps/s), step amplitude (m) and turn time (s).

Our analysis shows an improvement for walking capacity in Parkinson's disease after one session of WBV training compared to active physical therapy (measured by TUG) with a wide confidence interval (from futility to clinical relevance). On the other hand, after multiple sessions of WBV a non significant trend to improvement in Parkinson's disease was registered and no differences among groups were found in multiple sclerosis. Despite this, it is necessary to be careful when drawing conclusions, since these results are based on few studies.

Muscle performance

Although muscle weakness is one of the most common symptoms of neurodegenerative diseases, it has been poorly reported in the studies included in our review. The maximal isometric torque was either recorded by an isokinetic dynamometer (Biodex Medical System) or a hand-held dynamometer (using a 'make test') only for multiple sclerosis, while this outcome was not assessed for Parkinson's disease.

Three of the four studies focusing on multiple sclerosis reported this outcome (Broekmans 2010; Jackson 2008; Schyns 2009) and two of them analysed the effect of multiple sessions of WBV (Broekmans 2010; Schyns 2009). The first one compared five weeks of WBV to an active physical therapy training programme (Schyns 2009). The second one compared 20 weeks of WBV to a passive intervention and analysed muscle performance using a protocol where volume and intensity were increased systematically according to the overload principle (Broekmans 2010). None of the studies showed a significant improvement in muscle capacity. Muscle weakness contributes to gait disturbances and postural instability and compromises the ability to perform ADL independently (Falvo 2008). Extended research is required to analyse this outcome on a long-term basis, in order to provide conclusions that are currently not feasible.

Quality of life

The individual perception of physical, mental and social effects of illness on daily living is one of the most important determinants

of overall quality of life (García 2000). In spite of this, quality of life was only evaluated in two trials. In the Parkinson's disease study, the Parkinson's disease questionnaire (PDQ) test was used (Arias 2009) and in the multiple sclerosis study, the MSIS-29 test (Schyns 2009) was employed. No studies showed a significant improvement after a WBV intervention compared to active physical therapy intervention.

Adverse events

Five studies using a single session did not report adverse events (Arias 2009; Chouza 2011; Haas 2006 (a); Haas 2006 (b); Turbanski 2005) and two studies showed no side effects associated with the WBV intervention (Jackson 2008; Schuhfried 2005). Jackson 2008 reported the case of a participant complaining from muscle fatigue.

Regarding the studies looking for long-term effects of WBV, two of them did not report adverse effects (Arias 2009; Ebersbach 2008), while the other two considered WBV to be safe but did not report this information in a proper way (Broekmans 2010; Schyns 2009).

Overall completeness and applicability of evidence

Participants

Participants' disability ranged from mild to moderate. In these cases, the main goal of the rehabilitation process was to maintain or improve functional capacity according to ADL. WBV seems to be a safe and applicable intervention for people with disabilities, facilitating balance, strength and body posture tasks.

Intervention

People suffering neurodegenerative diseases have physical limitations to the development of independent ADL, both at home and in community environments (Compston 2002). To improve these conditions, conventional physiotherapy modalities involve strength, balance and aerobic exercises, drawing up strategies to improve daily tasks such as gait or other functional actions, and quality of life (Keus 2007; Motl 2005; Rimmer 2010). Although physical exercise is an important element in rehabilitation and seems to be well tolerated in neurodegenerative disease patients, the evidence is poor because it is based on a limited number of studies with low methodological quality (Asano 2009; Dalgas 2008; Falvo 2008; Keus 2007; Rimmer 2010).

Physical exercise programmes applied in neurodegenerative disease patients are usually over 10 weeks (Dalgas 2008). Most of the studies included in this review had short training periods (three to five weeks) (Arias 2009; Ebersbach 2008; Schyns 2009), with the exception of one trial with a 20-week training programme (Broekmans 2010). Most of the studies included in this review are consistent with the currently recommended number of training sessions per week for neurodegenerative diseases (two to three sessions/week) (Dalgas 2008; Falvo 2008). This is an important issue to consider since fatigue is a symptom of functional limitation in neurodegenerative diseases (Compston 2002), especially in people who have lower functional capacity (Garber CE 2003; Friedman 1993; Friedman 2001). In these patients, fatigue induced by the rehabilitation programme can even lead to increased inactivity and facilitate major physical deconditioning (Rimmer 2005). Some studies applying WBV in older people (Merriman 2009) showed that vibration therapy requires a shorter time per session compared to conventional interventions to achieve similar effects on balance and strength. This can be explained by the enhanced muscle activation associated with WBV (Abercromby 2007).Thus vibration platforms allow for important stimuli of proprioceptors when performing exercises in easy positions. This way a training programme can be performed with lower levels of muscle fatigue, achieving better adaptation of functional mobility compared to conventional therapy and with a low risk of negative effects in the workout process.

This review considers all kinds of vibration fluctuations, i.e. vertical, rotational and transversal axis. In a review of WBV, Marín 2010 points out the greater long-term effects of vertical vibration platforms compared to rotational platforms, although the latter have good effects in the short-term. Taking into account the important variability of the interventions and assessments carried out in the analysed studies, our review has not considered a subgroup evaluation by different platforms.

Outcomes

None of the analysed studies assessed functional performance with global scales. All the studies focused on more specific outcomes such as gait, balance, muscle strength and quality of life. Such great variability in testing procedures leads to a complex analysis of the obtained outcomes, which compromises their external validity.

Quality of the evidence

Overall methodological quality of the studies was deficient. In the first place, although all studies considered the use of a random sequence generation, only four declared the method used, which greatly increased the risk of bias.

Secondly, there was a lack of data on allocation concealment in most studies. Only three of them reported information about this item.

In physiotherapy studies it is difficult to blind investigators or participants and it is not possible to avoid performance bias. With the

aim of reducing some methodological limitations, seven studies used a blinded assessor to evaluate all or some outcomes. Eight studies were free of other biases but it should be noted that most studies had a small sample size. Additionally, there was heterogeneity between trials in terms of design (study duration, different tests or scales used) and characteristics of interventions (protocol training, exercises used), and these differences make it difficult to obtain a clinically significant outcome.

Finally, only five studies reported information about withdrawals, dropouts or losses to follow-up. Several studies did not describe adverse events of interest for this review.

Agreements and disagreements with other studies or reviews

There are three recent systematic reviews of WBV in neurodegenerative diseases, two focused on the effects of WBV in the Parkinson's disease population and one in a special population (including Parkinson's disease and multiple sclerosis patients but also in elderly, post-menopausal women and patients with stroke or spastic diplegia).

The most recent review shows the effects of WBV (including a chair providing vibration to the body) on sensorimotor performance in people with Parkinson's disease (Lau 2011). This review summarised the results of the trials in a narrative format with no pooled analysis and considered similar outcomes to our review. Although this review did not find any significant differences between multiple sessions of WBV and conventional exercise, the authors report a trend towards improved body balance with WBV. Another short review (Pinto 2010) summarised the results of the studies on WBV in patients with Parkinson's disease but they did not include authors' conclusions. Finally, a review of WBV in a mixed population (Madou 2008) also considered the effects on body balance, muscle strength and power, stability and gait, and bone mineral density. Although the authors combined the results of different studies they did not carry out a formal meta-analysis and did not disaggregate the results between unique and multiple-session interventions. They concluded that WBV seems to have positive effects on the analysed outcomes overall in special populations compared to resistance training and physiotherapy.

Our review has applied a sound methodology, reducing possible sources of bias and we performed a comprehensive search. Also, to our knowledge, this is the first systematic review of WBV in neurodegenerative disease patients with a meta-analysis. Our results corroborate those of the previous reviews.

AUTHORS' CONCLUSIONS

Implications for practice

There is insufficient evidence to support the use of whole-body vibration (WBV) intervention in neurodegenerative disease patients. This review is based on a limited number of studies with several methodological shortcomings.

Implications for research

This review makes clear that further, longer studies are needed to assess the efficacy of WBV in neurodegenerative diseases, overcoming the limitations in the research so far, namely heterogeneity in trial designs, outcome measures and interventions. Also, future studies should be adequately powered and apply higher methodological standards (good generation random sequence, adequate allocation concealment and blinding of outcome assessment). Additionally, it is recommended that future studies are reported following the CONSORT extension for Non-pharmacological Treatment interventions (Boutron 2008).

It would be appropriate to consider the evaluation of patients' autonomy in future research. Most studies have explored walking and balance capacities with specific outcome measures. It is necessary to investigate further the effects of WBV on more global measures, such as functional health according to activities of daily living (ADL) (e.g. Barthel Scale, Functional Independence Measure, etc.), reduction of signs and symptoms such as fatigue and immobility, and quality of life.

Exercises to be performed should be thoroughly detailed in training protocols (e.g. high, deep, wide, wide stance squat and lunge) and should be performed with closed eyes, or introducing external objects that affect balance (e.g. fit balls, balloons, etc.), or introducing exercises adapting usual movements of daily life (Vreede 2004).

Muscle weakness is one of the contributing factors to postural instability and ability to perform ADL in Parkinson's disease (Corcos 1996). Taking this into account, it would be interesting to assess this parameter in future investigations in both Parkinson's disease and multiple sclerosis disorders.

Following the recommendations of the current evidence, it is important to evaluate the training protocol every four weeks in order to adjust the rehabilitation programme according to the evolution of the disease (Keus 2007). Another important point related to continuous assessment is the need for a fatigue follow-up control, before and after treatment. This last recommendation can be carried out by applying the Borg Test and a visual analogue scale (VAS) in each training session (Broekmans 2010). Finally, our review has not focused on residual effects of WBV training. Keeping in mind the prognosis of neurodegenerative diseases, it would be important to specify the duration of effects.

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* *Indicates the major publication for the study*

CHARACTERISTICS OF STUDIES

Characteristics of included studies *[ordered by study ID]*

Arias 2009

Methods	Quasi-random clinical trial Parallel, unicentric Losses: 2 of 23 (8.7%)
Participants	Setting: community, Spain Randomised = 23; assessed = 21 Demographic characteristics given over 21 participants Age: intervention group: mean 66.5 (SD 5.57) years; comparison group: mean 66.9 (SD 11.11) years Sex: intervention group: female 40%; comparison group: female 45.4% Inclusion criteria: Parkinson's disease (based on medical records); lack of dementia (MMSE $\geq$ 24); lack of artromuscular deficit or joint prosthesis; be able to cope with OFF periods
Interventions	1. 12 WBV sessions over 5 weeks on non-consecutive days. Each session included 5 sets of vibration (6 Hz) 1 minute each and 1-minute rest between sets 2. Comparison: same schedule but standing on platform and vibration was not applied All participants were asked to stand on platform with the knees slightly bent
Outcomes	Body Balance (Berg balance test (score), Functional Reach (mm)) Gait (velocity (m/s), cadence (steps/s), step amplitude(m), turn time(s), TUG test (s)) Signs and symptoms of the disease (UPDRS, total and motor score) Quality of life (PDQ-39 (score)) Others: pegboard test (number of pegs)
Notes	All other physical therapies usually undergone by the patients were cancelled during the duration of the study. Patients did not change their medication and intervention started 30 to 45 min after dose intake (when patients confirmed ON periods) For intra-session evaluation patients (short-term effects) were evaluated during the ON periods. For the effect of the programme (long-term effects) patients were evaluated during their OFF periods, except in the Parkinson's disease questionnaire (PDQ-39) which was evaluated during ON periods

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Patients were allocated to either experimental or placebo group based upon an ABBA (A: experimental; B: placebo) distribution model
Allocation concealment (selection bias)	High risk	ABBA distribution model

Arias 2009 (*Continued*)

Blinding (performance bias and detection bias) All outcomes	Unclear risk	It is not clear if patients were blinded to the intervention because they adopted the same position but vibration was not applied
Selective reporting (reporting bias)	Low risk	All analysed outcomes included in the published report
Other bias	Low risk	No other risks of bias detected
Blinded assessor	Low risk	All evaluations were performed by researchers blind to protocol and group assignment

Broekmans 2010

Methods	RCT Parallel Losses: 2 of 25 (8%)
Participants	Setting: community, Belgium Randomised = 25; assessed = 23 Demographic characteristics given over 25 participants Age: intervention group: mean 46.1 (SE 2.1) years; comparison group: mean 49.7 (SE 3.3) years Sex: intervention group: female 63.6%; comparison group: female 78.6% Inclusion criteria: community-based patients with multiple sclerosis residing in Hasselt region (Belgium) Exclusion criteria: > 3 relapses in the preceding 1 year or > 1.0 Expanded Disability Status Scale (EDSS) increase in the preceding year; corticosteroid treatment 28 days before the study start; pregnancy; severe psychiatric disorders; internal materials for bone fixation and/or total joint replacements; any contra-indication for light to moderately intense physical exercise
Interventions	1. 5 WBV sessions every 2 weeks over 20 weeks. Each session included a progressive series of exercises with a rest period ranging from 2 min to 30 sec between exercises. Vibration was delivered at a range of 20 to 45 Hz and amplitude of 2.5 mm 2. Comparison: usual lifestyle
Outcomes	Body Balance (Berg balance test (score)) Gait (TUG test (s), 2-minute walk test (m), the 25-foot walk test (s)) Muscle performance (maximal isometric torque (Nm), maximal dynamic torque (Nm) , maximal strength endurance (J), maximal speed of movement of knee extension (º/s), all through isokinetic dynamometer - Biodex Medical Systems®)
Notes	Each WBV exercise session lasted for a maximum of 50 min including warming up and cooling down that involved stretching of the major lower limb muscle groups All muscle performance tests assessed maximal voluntary unilateral knee strength of the right leg. Data were available for isometric torque of knee extensors and flexors at 45º and

Broekmans 2010 (*Continued*)

	90º, for dynamic torque of knee extensor at a velocity of 60º/sec, for strength endurance at a velocity of 180º/sec

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	No information provided
Allocation concealment (selection bias)	Unclear risk	No information provided
Blinding (performance bias and detection bias) All outcomes	High risk	Not blinded
Selective reporting (reporting bias)	Low risk	All analysed outcomes included in the published report
Other bias	Low risk	No other risks of bias detected
Blinded assessor	High risk	Only the neurologist who determined the Expanded Disability Status Scale (EDSS) score was blinded

Chouza 2011

Methods	RCT Parallel Losses: none
Participants	Setting: unknown, Spain Randomised = 48; assessed = 48 Demographic characteristics given over 48 participants Age: intervention group 1: mean 68.92 (SD 7.86) years; sex: intervention group 1: female 66.6% Age: intervention group 2: mean 67.7 (SD 10.98) years; sex: intervention group 2: female 50% Age: intervention group 3: mean 74.5 (SD 5.42) years; sex: intervention group 3: female 58.3% Age: intervention group 4: mean 67.42 (SD 6.11) years; sex: intervention group 4: female 50% Inclusion criteria: idiopathic Parkinson's disease Exclusion criteria: had any other disease or impairment potentially affected the validity of the results
Interventions	Group 1: a single WBV session delivered at 3 Hz (amplitude of 13 mm), during 5 sets of 1 min each (interset rest period of 1 min) Group 2: a single WBV session delivered at 6 Hz (amplitude of 13 mm), during 5 sets

Chouza 2011 (*Continued*)

	of 1 min each (interset rest period of 1 min) Group 3: a single WBV session delivered at 9 Hz (amplitude of 13 mm), during 5 sets of 1 min each (interset rest period of 1 min) Group 4: patients performed the same exercises without vibration (with the knees slightly flexed)
Outcomes	Body balance (Functional Reach test (mm)) Gait (TUG test (s))
Notes	All patients were tested in the ON phase This study was published as a letter to the editor

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	No information provided
Allocation concealment (selection bias)	Unclear risk	No information provided
Blinding (performance bias and detection bias) All outcomes	Unclear risk	No information provided
Selective reporting (reporting bias)	Low risk	All analysed outcomes included in the published report
Other bias	Low risk	No other risks of bias detected
Blinded assessor	Low risk	Examiners were blind to protocol and group assignment

Ebersbach 2008

Methods	Quasi-random clinical trial Parallel, unicentric Losses: 6 of 27 (22.2%)
Participants	Setting: hospital, Germany Randomised = 27; assessed = 21 Demographic characteristics given over 21 participants. Age: intervention group: mean 72.5 (SD 6.0) years; comparison group: mean 75.0 (SD 6.8) years Sex: intervention group: female 30%; comparison group: female 36.4% Inclusion criteria: idiopathic Parkinson's disease (diagnosed according to standard clinical criteria); clinical evidence for imbalance, scoring at least 1 point on item 30 of the Unified Parkinson's Disease Rating Scale (UPDRS) while being on optimised and stable medical treatment Exclusion criteria: severe response fluctuations or other conditions requiring modification

Ebersbach 2008 (*Continued*)

	of medication, dementia, balance impairment due to other disease and severe dyskinesia interfering with posturographic assessments
Interventions	1. WBV sessions over 3 weeks (a total of 30): 5 days a week, twice a day. Each session included 15 minutes of vibration, delivered to frequency of 25 Hz and to an amplitude ranging from 7 to 14 mm Patients stand with slightly bended knees and hips while WBV is delivered and are instructed not to hold onto the railing during WBV 2. Comparison: standard balance training including exercises on a tilt board
Outcomes	Body Balance (Tinetti balance scale (score), Pull test score, Posturography (mm)) Gait (time to walk 10 m (s), stand-walk-sit (s)) Signs and symptoms of the diseases (UPDRS motor score)
Notes	All patients received standard therapy comprising 3 sessions a day (5 days a week, 40 minutes a session) including relaxation techniques (group exercises focusing on muscle-stretching, relaxation and body perception), speech therapy and occupational therapy All patients were tested in the ON phase

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	High risk	Alternating allocation
Allocation concealment (selection bias)	High risk	Alternating allocation
Blinding (performance bias and detection bias) All outcomes	High risk	Not blinded
Selective reporting (reporting bias)	Low risk	All analysed outcomes included in the published report
Other bias	Low risk	No other risks of bias detected
Blinded assessor	Low risk	Only Tinetti balance scale and UPDRS tests were measured by a neurologist who was blinded to the group allocation

Haas 2006 (a)

Methods	Quasi-random clinical trial Parallel, unicentric Losses: 2 of 28 (7.1%)
Participants	Setting: unknown, Germany Randomised = 28; assessed = 26 Demographic characteristics given over 28 participants Age: in both groups averaged 63.1 years Sex: unknown Inclusion criteria: idiopathic Parkinson's disease Exclusion criteria: dementia; cerebellar signs; abnormal brain imaging; or fundamental co-morbidities like neuropathy, muscle or joint diseases, dyskinesias, sustainable leg or postural tremor, and strong asymmetrical symptom structure
Interventions	Group 1: a single WBV session delivered at 6 Hz (5 vibration series of 1 minute each and 1-minute break between them) Group 2: resting period of 15 min
Outcomes	Body balance: proprioception (°) Signs and symptoms of the disease: bradykinesia (movement velocity to knee flexion and vice versa (timing))
Notes	All patients were tested in the ON phase

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	High risk	Patients were quasi-randomly subdivided into groups
Allocation concealment (selection bias)	Unclear risk	No information provided
Blinding (performance bias and detection bias) All outcomes	High risk	Not blinded
Selective reporting (reporting bias)	High risk	Do not report results of movement velocity
Other bias	High risk	Unbalanced groups (19 patients in intervention group and 9 patients in control group)
Blinded assessor	High risk	Not blinded

Haas 2006 (b)

Methods	RCT Cross-over Losses: none
Participants	Setting: community, Germany Randomised = 68; assessed = 68 Demographic characteristics given over 68 participants Age: mean 65.0 (SD 7.8) years Sex: female 22% Inclusion criteria: diagnosis of Parkinson's disease on the basis of unilateral onset, asymmetric motor symptoms, symptom relief by dopaminergic treatment, and absence of atypical clinical signs such as severe orthostatic hypotension, cerebellar or pyramidal signs, early falls or gaze abnormalities, and normal brain imaging Exclusion criteria: patients with dementia or other diseases impairing gait, stance or co-ordination (e.g. neuropathy, muscle or joint disease), unable to stand unsupported
Interventions	Group 1: a single WBV session delivered at 6 Hz and at an amplitude of 3 mm (5 vibration series of 1 minute each and 1-minute break between them); then a resting period Group 2: received first the resting period and WBV session thereafter (same delivery schedule)
Outcomes	Signs and symptoms of the disease (UPDRS, motor score)
Notes	To exclude the influence of medication all patients were withdrawn from L-DOPA over night (> 12 hours). Patients were not withdrawn from dopamine agonists All patients were tested in the ON phase

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	No information provided
Allocation concealment (selection bias)	Unclear risk	No information provided
Blinding (performance bias and detection bias) All outcomes	High risk	Not blinded
Selective reporting (reporting bias)	Low risk	All analysed outcomes included in the published report
Other bias	High risk	There is no wash-out period between intervention phases that may lead to a carry-over effect
Blinded assessor	Low risk	Scoring was carried out by an assessor blinded to the treatment status of the patient

Jackson 2008

Methods	RCT Cross-over, unicentric Losses: none
Participants	Setting: community, US Randomised = 15; assessed = 15 Demographic characteristics given over 15 participants Age: mean 54.6 (SD 9.6) years Sex: female 80% Inclusion criteria: a confirmed diagnosis of multiple sclerosis, ability to ambulate 10 m with or without assistive device with no more than contact guard assistance, ability to stand for a minimum of 5 minutes with upper extremity support Exclusion criteria: thrombosis, acute inflammation, acute tendinopathy, recent (less than 6 months) fractures, gallstones, implants, surgery, wound/scar, hernia or discopathy, diabetic retinopathy, epilepsy, pacemaker, pregnancy, total joint replacement, or the presence of any other neurological condition
Interventions	Group 1: a single WBV session delivered at 2 Hz first and then at 26 Hz (amplitude of 6 mm), during 30 sec each Group 2: received the alternate vibratory frequency All participants were asked to stand on platform with the knees slightly bent There was a 1-week period between sessions
Outcomes	Muscle performance (maximal isometric torque of knee extensors and flexors (Nm)) all through isokinetic dynamometer - Biodex Medical Systems®
Notes	All assessments were performed at 1, 10 and 20 minutes after intervention

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	No information provided
Allocation concealment (selection bias)	Unclear risk	No information provided
Blinding (performance bias and detection bias) All outcomes	High risk	Not blinded
Selective reporting (reporting bias)	Low risk	All analysed outcomes included in the published report
Other bias	Low risk	No other risks of bias detected
Blinded assessor	Low risk	The investigator responsible for performing the muscle testing was blinded to the type of intervention

Schuhfried 2005

Methods	RCT Parallel, unicentric Losses: none
Participants	Setting: community, Austria Randomised = 12; assessed = 12 Demographic characteristics given over 21 participants Age: intervention group: mean 49.3 (SD 13.3) years; comparison group: mean 46.0 (SD 12.7) years Sex: intervention group: female 83.3%; comparison group: female 66.6% Inclusion criteria: multiple sclerosis with a score ≤5 on Kurtzke's Expanded Disability Status Scale (EDSS), with balance disorders, gait insecurities and/or ataxia. The patients needed to stand independently, without assistive devices or external support Exclusion criteria: pregnancy, electronic implants such as pacemakers, artificial heart valves, epilepsy, malignant tumours, endoprosthesis, recent fracture (less than 6 months) , osteoporosis with vertebral body fracture, thrombosis, therapy with anticoagulant medication, relapse of multiple sclerosis in the last 2 months and refusal to participate
Interventions	Group 1: a single WBV session delivered at 2 to 4.4 Hz and at an amplitude of 3 mm (5 vibration series of 1 minute each and 1-minute break between them) Group 2: standing exercises (with slight flexion at the hips, knees and ankle joints) while transcutaneous electrical nerve stimulation (TENS) in the forearm
Outcomes	Body Balance (posturography through the Sensory Organization Test (points), Functional Reach test (mm)) Gait (TUG test (s))
Notes	All assessments were performed at 15 minutes, 1 and 2 weeks after intervention

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	No information provided
Allocation concealment (selection bias)	Unclear risk	No information provided
Blinding (performance bias and detection bias) All outcomes	Low risk	The interventions were performed by a professional not involved in the study. Patients not blinded
Selective reporting (reporting bias)	Low risk	All analysed outcomes included in the published report
Other bias	Low risk	No other risks of bias detected
Blinded assessor	Low risk	All outcome assessments were obtained in blinded conditions

Schyns 2009

Methods	Quasi-random clinical trial Cross-over study, unicentric Losses: 4 of 16 (25%)
Participants	Setting: community, Scotland (United Kingdom) Randomised = 16; assessed = 12 or 10 (variable depending on the outcome) Age: group 1: mean 45.8 (SD 8.4) years; group 2: mean 45.5 (SD 6.14) years Sex: group 1: female 62.5%; group 2: female 87.5% Inclusion criteria: confirmed diagnosis of multiple sclerosis (disability level between 1 and 6 on the Hauser Ambulation Index); at least 1 of the following symptoms: abnormal muscle tone, lower limb weakness, altered sensation and/or proprioception Exclusion criteria: were receiving ongoing physiotherapy or other types of exercise class; were receiving complementary therapy (e.g. acupuncture, reflexology and aromatherapy) ; had previous or current use of whole-body vibration, or presented with any contraindications of whole-body vibration such as tumour, pacemaker, pregnancy, epilepsy, severe pain, active infection or dizziness
Interventions	Group 1: were randomised to receive 3 WBV sessions a week over 4 weeks and then to perform the same exercises without vibration Group 2: the order of interventions was reversed Each WBV session included several sets of vibration (delivered at 30 to 50 Hz and at an amplitude of 2 to 4 mm) Before cross-over a 2-weeks rest period was considered
Outcomes	Balance (proprioception by Nottingham Sensory Assessment (score)) Gait (TUG test (s), 10-metre walk test (s)) Signs and symptoms of the disease (Multiple Sclerosis Spasticity Scale MSSS-88 (score) , Modified Ashworth Scale (score), subjective perception of symptoms) Muscle performance (maximal isometric force (N), through hand-held dynamometer using 'make test') Quality of life (multiple sclerosis Impact Scale-MSIS-29 (score)
Notes	Detailed information about the intervention protocol is given in paper

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	High risk	Patients were randomised by drawing a number from an envelope
Allocation concealment (selection bias)	High risk	High probability of not being concealed
Blinding (performance bias and detection bias) All outcomes	High risk	Not blinded
Selective reporting (reporting bias)	Low risk	All analysed outcomes included in the published report

Schyns 2009 (*Continued*)

Other bias	Low risk	Statistical analysis excluded a carry-over effect
Blinded assessor	Low risk	All measures were performed by a physiotherapist who was not involved in the training procedure and who was blind to the group allocation

Turbanski 2005

Methods	Controlled trial (not clear if randomised) Parallel, unicentric Losses: none
Participants	Setting: unknown, Germany Randomised = 52; assessed = 52 Age: mean 69.1 (SD 8.9) years Sex: female 29.9% Inclusion criteria: idiopathic Parkinson's disease Exclusion criteria: dementia, heart diseases, neurological diseases apart from Parkinson disease, significant dyskinesias and orthopaedic injuries
Interventions	Group 1: a single WBV session delivered at 6 Hz and at an amplitude of 3 mm (5ve vibration series of 1 minute each and 1-minute break between them) Group 2: moderate walk (15 min)
Outcomes	Body balance (postural stability on a movable and instable platform, Coordex®, Germany) on both narrow and tandem standing positions
Notes	All patients were tested in the ON phase

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Participants were divided equally into experimental and control groups
Allocation concealment (selection bias)	Unclear risk	No information provided
Blinding (performance bias and detection bias) All outcomes	Unclear risk	No information provided
Selective reporting (reporting bias)	Low risk	All analysed outcomes included in the published report
Other bias	Low risk	No other risks of bias detected

Turbanski 2005 (*Continued*)

Blinded assessor	Unclear risk	No information provided

L-Dopa: Levadopa
MMSE: Mini-Mental State Examination
min: minute
PDQ: Parkinson's disease questionnaire
RCT: randomised controlled trial
SD: standard deviation
SE: standard error
sec: second
TUG: Timed Up and Go test
UPDRS: Unified Parkinson's Disease Rating Scale
WBV: whole-body vibration

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Bautmans 2005	Types of participants did not include persons with any type of neurodegenerative illness; the study was performed in older persons
Bedient 2009	Types of participants did not include persons with any type of neurodegenerative illness; the study was performed in moderately trained recreational athletes
Bogaerts 2007 (a)	Types of participants did not include persons with any type of neurodegenerative illness; the study was performed in older persons
Bogaerts 2007 (b)	Types of participants did not include persons with any type of neurodegenerative illness
Bogaerts 2009	Types of participants did not include persons with any type of neurodegenerative illness; the study was performed in older persons
Bogaerts 2011	Types of participants did not include persons with any type of neurodegenerative illness; the study was performed in older persons
Brooke-Wavell 2009	The study design was not a randomised controlled trial
Bruyere 2005	Types of participants did not include persons with any type of neurodegenerative illness; the study was performed in older persons
Cheung 2007	Types of participants did not include persons with any type of neurodegenerative illness; the study was performed in older persons

(*Continued*)

Corrie 2007	Types of participants did not include persons with any type of neurodegenerative illness; the study was performed in older persons
Cronin 2004	Types of participants did not include persons with any type of neurodegenerative illness; the study was performed in healthy young people
Edwards 2009	Types of participants did not include persons with any type of neurodegenerative illness
Feland 2008	Types of participants did not include persons with any type of neurodegenerative illness
Feys 2006	The study applied an intervention with tendon vibration, did not include an intervention of whole-body vibration
Furness 2009	Types of participants did not include persons with any type of neurodegenerative illness
Furness 2010	Types of participants did not include persons with any type of neurodegenerative illness; the study was performed in older adults
Ghoseiri 2009	The study did not include an intervention of whole-body vibration. The intervention was performed by a vibratory orthosis on lumbar spine
Gusi 2006	Types of participants did not include persons with any type of neurodegenerative illness; the study was performed in postmenopausal women
Holland 1965	The study did not include an intervention of whole-body vibration
Hornick 1962	The study did not include an intervention of whole-body vibration
Iwamoto 2005	Types of participants did not include persons with any type of neurodegenerative illness; the study was performed in postmenopausal women
Jin 2007	Types of participants did not include persons with any type of neurodegenerative illness; the study was performed in postmenopausal women
Johnson 2007	Types of participants did not include persons with any type of neurodegenerative illness; the study was performed in patients with total knee arthroplasty
Kawanabe 2007	Types of participants did not include persons with any type of neurodegenerative illness; the study was performed in older persons
King 2009	Vibrations were applied using a Physioacoustic method
Machado 2010	Types of participants did not include persons with any type of neurodegenerative illness; the study was performed in older persons
Raimundo 2009	Types of participants did not include persons with any type of neurodegenerative illness; the study was performed in postmenopausal women

(*Continued*)

Rees 2007	Types of participants did not include persons with any type of neurodegenerative illness; the study was performed in older persons
Rees 2008	Types of participants did not include persons with any type of neurodegenerative illness; the study was performed in postmenopausal women
Rees 2009	Types of participants did not include persons with any type of neurodegenerative illness; the study was performed in postmenopausal women
Roelants 2004	Types of participants did not include persons with any type of neurodegenerative illness; the study was performed in postmenopausal women
Rubin 2004	Types of participants did not include persons with any type of neurodegenerative illness; the study was performed in postmenopausal women
Russo 2003	Types of participants did not include persons with any type of neurodegenerative illness; the study was performed in postmenopausal women
Savelberg 2007	Types of participants did not include persons with any type of neurodegenerative illness; the study was performed in healthy young people
Trans 2009	Types of participants did not include persons with any type of neurodegenerative illness; the study was performed in women diagnosed with osteoarthritis
Verschueren 2004	Types of participants did not include persons with any type of neurodegenerative illness; the study was performed in postmenopausal women
Verschueren 2011	Types of participants did not include persons with any type of neurodegenerative illness; the study was performed in postmenopausal women
Wigg 1999	Types of participants did not include persons with any type of neurodegenerative illness
Wunderer 2010	The study design was not a randomised controlled trial; there was a single patient experimental design

DATA AND ANALYSES

Comparison 1. Whole-body vibration vs an active physical therapy (short-term effects) in Parkinson's disease

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Body balance (Functional Reach)	2	45	Mean Difference (IV, Fixed, 95% CI)	19.83 [-20.99, 60.65]
2 Gait (Timed Up and Go test)	2	45	Mean Difference (IV, Fixed, 95% CI)	-3.09 [-5.60, -0.59]

Comparison 2. Whole-body vibration vs an active physical therapy (long-term effects) in Parkinson's disease

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 UPDRS III motor score	2	42	Mean Difference (IV, Fixed, 95% CI)	-0.65 [-3.98, 2.68]
2 Body balance (Berg Balance Scale and Tinetti test)	2	42	Std. Mean Difference (IV, Fixed, 95% CI)	0.36 [-0.26, 0.97]
3 Gait (TUG test and Stand-walk-sit test)	2	42	Std. Mean Difference (IV, Fixed, 95% CI)	-0.41 [-1.02, 0.21]

Analysis 1.1. Comparison 1 Whole-body vibration vs an active physical therapy (short-term effects) in Parkinson's disease, Outcome 1 Body balance (Functional Reach).

Review: Whole-body vibration training for patients with neurodegenerative disease

Comparison: 1 Whole-body vibration vs an active physical therapy (short-term effects) in Parkinson's disease

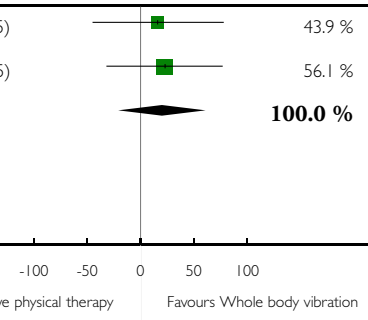
Outcome: 1 Body balance (Functional Reach)

Study or subgroup	Whole body vibration N	Mean(SD)	Active physical therapy N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Weight	Mean Difference IV,Fixed,95% CI
Arias 2009	11	260.75 (80.12)	10	244.6 (63.65)		43.9 %	16.15 [-45.48, 77.78]
Chouza 2011	12	264.4 (74.1)	12	241.7 (61.5)		56.1 %	22.70 [-31.78, 77.18]
Total (95% CI)	**23**		**22**			**100.0 %**	**19.83 [-20.99, 60.65]**

Heterogeneity: Chi^2 = 0.02, df = 1 (P = 0.88); I^2 =0.0%

Test for overall effect: Z = 0.95 (P = 0.34)

Test for subgroup differences: Not applicable



Analysis 1.2. Comparison 1 Whole-body vibration vs an active physical therapy (short-term effects) in Parkinson's disease, Outcome 2 Gait (Timed Up and Go test).

Review: Whole-body vibration training for patients with neurodegenerative disease

Comparison: 1 Whole-body vibration vs an active physical therapy (short-term effects) in Parkinson's disease

Outcome: 2 Gait (Timed Up and Go test)

Study or subgroup	Whole body vibration N	Mean(SD)	Active physical therapy N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Weight	Mean Difference IV,Fixed,95% CI
Arias 2009	10	11.9 (2.22)	11	15 (5.7)		47.2 %	-3.10 [-6.74, 0.54]
Chouza 2011	12	12.23 (2.6)	12	15.32 (5.5)		52.8 %	-3.09 [-6.53, 0.35]
Total (95% CI)	**22**		**23**			**100.0 %**	**-3.09 [-5.60, -0.59]**

Heterogeneity: $Chi^2 = 0.00$, df = 1 (P = 1.00); $I^2 = 0.0\%$

Test for overall effect: Z = 2.43 (P = 0.015)

Test for subgroup differences: Not applicable

Analysis 2.1. Comparison 2 Whole-body vibration vs an active physical therapy (long-term effects) in Parkinson's disease, Outcome 1 UPDRS III motor score.

Review: Whole-body vibration training for patients with neurodegenerative disease

Comparison: 2 Whole-body vibration vs an active physical therapy (long-term effects) in Parkinson's disease

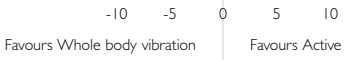
Outcome: 1 UPDRS III motor score

Study or subgroup	Whole body vibration N	Mean(SD)	Active physical therapy N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Weight	Mean Difference IV,Fixed,95% CI
Arias 2009	10	21.2 (7.4)	11	24.6 (6)		32.9 %	-3.40 [-9.20, 2.40]
Ebersbach 2008	10	17.6 (4.5)	11	16.9 (5)		67.1 %	0.70 [-3.36, 4.76]
Total (95% CI)	**20**		**22**			**100.0 %**	**-0.65 [-3.98, 2.68]**

Heterogeneity: Chi² = 1.29, df = 1 (P = 0.26); I² =22%

Test for overall effect: Z = 0.38 (P = 0.70)

Test for subgroup differences: Not applicable



Analysis 2.2. Comparison 2 Whole-body vibration vs an active physical therapy (long-term effects) in Parkinson's disease, Outcome 2 Body balance (Berg Balance Scale and Tinetti test).

Review: Whole-body vibration training for patients with neurodegenerative disease

Comparison: 2 Whole-body vibration vs an active physical therapy (long-term effects) in Parkinson's disease

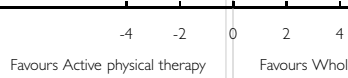
Outcome: 2 Body balance (Berg Balance Scale and Tinetti test)

Study or subgroup	Whole body vibrartion N	Mean(SD)	Active physical therapy N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Weight	Std. Mean Difference IV,Fixed,95% CI
Arias 2009	10	49 (6.04)	11	47.8 (8.8)		51.1 %	0.15 [-0.71, 1.01]
Ebersbach 2008	10	12.8 (1.9)	11	11.5 (2.4)		48.9 %	0.57 [-0.30, 1.45]
Total (95% CI)	**20**		**22**			**100.0 %**	**0.36 [-0.26, 0.97]**

Heterogeneity: Chi² = 0.45, df = 1 (P = 0.50); I² =0.0%

Test for overall effect: Z = 1.14 (P = 0.25)

Test for subgroup differences: Not applicable



Analysis 2.3. Comparison 2 Whole-body vibration vs an active physical therapy (long-term effects) in Parkinson's disease, Outcome 3 Gait (TUG test and Stand-walk-sit test).

Review: Whole-body vibration training for patients with neurodegenerative disease

Comparison: 2 Whole-body vibration vs an active physical therapy (long-term effects) in Parkinson's disease

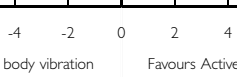
Outcome: 3 Gait (TUG test and Stand-walk-sit test)

Study or subgroup	Whole body vibartion N	Mean(SD)	Active physical therapy N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Weight	Std. Mean Difference IV,Fixed,95% CI
Arias 2009	10	11.7 (3.3)	11	13.3 (5)		50.3 %	-0.36 [-1.22, 0.51]
Ebersbach 2008	10	8.5 (2.1)	11	9.5 (2.1)		49.7 %	-0.46 [-1.33, 0.41]
Total (95% CI)	**20**		**22**			**100.0 %**	**-0.41 [-1.02, 0.21]**

Heterogeneity: $Chi^2 = 0.02$, df = 1 (P = 0.88); $I^2 = 0.0\%$

Test for overall effect: Z = 1.30 (P = 0.19)

Test for subgroup differences: Not applicable



APPENDICES

Appendix 1. EMBASE (Ovid) search strategy

1 exp Whole Body Vibration/ OR whole body vibration.mp. OR wbv.mp.
2 random:.tw. or clinical trial:.mp. or exp treatment outcome/
3 1 AND 2

Appendix 2. PeDro (website) search strategy

1 Abstract & Title: whole body vibration
2 Abstract & Title: wbv
3 1 or 2

Appendix 3. CENTRAL (CLib) Search strategy

1 (whole next body next vibration)
2 wbv
3 1 or 2

Appendix 4. CINAHL (EBSCOhost) search strategy

1 (MH "Vibration/AE/TU")
2 whole body vibration
3 wbv
4 1 or 2 or 3
5 random* OR trial OR blind*
6 compare* OR comparison*
7 alocat*
8 group*
9 5 or 6 or 7 or 8
10 4 and 9

Appendix 5. PsycINFO (Ovid) search strategy

1 whole body vibration.mp.
2 wbv.mp.
3 1 or 2
4 (control: or random:).tw. or exp treatment/
5 4 and 3

CONTRIBUTIONS OF AUTHORS

Mercè Sitjà-Rabert (MSR) conceived, designed and co-ordinated the review. She screened titles and abstracts of references identified by the search, selected and assessed trials, extracted trial and outcome data, carried out quality assessment and data extraction, contacted trial lists about unpublished data, entered data into RevMan, wrote the review, provided a clinical perspective and contributed to and approved the final manuscript of the review.

David Rigau (DR) conceived and designed the review. He screened titles and abstracts of references identified by the search, located, selected and assessed trials, extracted trial and outcome data, assessed the methodological quality of selected trials, contacted trial lists about unpublished data, entered data into RevMan, provided a methodological perspective and contributed to and approved the final manuscript of the review.

Azahara Fort-Vanmeerhaeghe (AFV) screened titles and abstracts of references identified by the search, located, selected and assessed trials, extracted trial and outcome data, assessed the methodological quality of selected trials. She provided a physical training perspective, commented on drafts of the review and contributed to and approved the final manuscript of the review.

Carme Santoyo Medina (CSM) commented on drafts of the review, provided a clinical perspective and contributed to and approved the final manuscript of the review.

Marta Roqué i Fíguls (MRF) extracted trial and outcome data, carried out statistical analysis, helped with the interpretation of the data, drafted the review and approved the final manuscript of the review.

Dani Romero-Rodríguez (DRR) commented on drafts of the review, provided a physical training perspective, and contributed to and approved the final manuscript of the review.

Xavier Bonfill Cosp (XBC) provided a methodological and clinical perspective, commented on drafts of the review, and contributed to and approved the final manuscript of the review.

DECLARATIONS OF INTEREST

None known.

SOURCES OF SUPPORT

Internal sources

- None, Not specified.

External sources

- None, Not specified.

DIFFERENCES BETWEEN PROTOCOL AND REVIEW

There are some differences between the protocol and the review briefly described below. We have extended the background with the aim of providinga broader context for the topic of interest.

We decided to change the outcome 'Functional capacity according to basic activities of daily living (ADL)' to 'Functional performance according to basic activities of daily living (ADL)'. Additionally, we included muscular strength and muscular power in the outcome 'Muscle performance', as this term is more global.

In the methods section, we simplified the comparisons as we compared WBV to control and WBV to active physical therapies. We also included comparisons of different WBV modalities because we have extended the objective of the review. We incorporated an analysis for subgroups as we decided to include the studies that analysed the short-term effects of WBV. We considered that combining the results with single and multiple sessions could lead to non comparable results.

INDEX TERMS

Medical Subject Headings (MeSH)

Activities of Daily Living; Exercise Therapy [methods]; Gait; Multiple Sclerosis [*rehabilitation]; Muscle Strength; Neurodegenerative Diseases [rehabilitation]; Parkinson Disease [*rehabilitation]; Postural Balance; Randomized Controlled Trials as Topic; Vibration [*therapeutic use]

MeSH check words

Aged; Female; Humans; Male; Middle Aged