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Original Article

Whole Body Vibration–A Helpful Treatment for Low Back Pain? A Systematic Review and Meta-analysis

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Abstract

Background and objectives: Although whole body vibration (WBV) has been used to reduce pain, some studies have indicated that WBV can cause low back pain (LBP). This study provides an overview of the current literature on the use of WBV to treat LBP and its effects on muscle strength, postural stability, and quality of life.

Methods: A literature research was conducted using the search terms "Whole Body Vibration" and "Low Back Pain" in the PubMed, PEDro, OVID, Cochrane Library, Web of Science, Google Scholar, and Scopus databases. All articles published up to November 2021 were included. Articles that did not have WBV as a treatment were excluded. The PEDro score was used to test methodological quality.

Results: Of the 1,686 publications identified in the literature search, 21 studies focused on WBV as treatment for LBP, including 18 original studies, two reviews, and one meta-analysis. Ten of these 21 studies had good methodological quality. Five studies had a WBV duration of 12 weeks and were included in the meta-analysis (muscle strength, postural stability, and quality of life). Standardized mean differences and 95% confidence intervals were calculated. The effects range was from −0.86 to 0.84, favoring experimental groups.

Conclusions: Many positive effects of WBV on LBP were found. Given the effect sizes of the high-quality studies, it is reasonable to assume that WBV is effective for treating LBP.

Keywords: Whole body vibration; Low back pain; Rehabilitation.

Abbreviations: CI, confidence interval; EMG, electromyogram; EQ-5D-3L, European Quality of Life Scale; EuroQol, European Quality of Life Scale; FAQ, Freiburger activity questionnaire; GPE, Global Perceived Effect; HADS, Hospital Anxiety and Depression Scale; Hz, Hertz; LBP, low back pain; NASS, North America Spine Society outcome; NRS, numeric rating scale for pain; ODI, Oswestry Disability Index; PDI, Pain Disability Index; PEDro, Physiotherapy Evidence Database Scale; PILE, Progressive Isoinertial Lifting Evaluation test; PSI, Postural Stability Index; RCT, randomized clinical trial; RMI, Roland Morris Index; SD, standard deviation; SF-36, Short-Form-36; SMD, standardized mean difference; VAS, Visual Analogue Scale for pain; WAI, Work Ability Index Questionnaire; WBV, whole body vibration.

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Introduction

Low back pain (LBP) is one of the most common pain conditions in humans. Work-related risk factors such as heavy lifting can promote LBP, and as such LBP is the most common occupational disorder worldwide. Specific and nonspecific LBP are defined by the cause and duration of symptoms: acute (lasting less than 6 weeks), subacute (lasting 6 to 12 weeks), and chronic (lasting more than 12 weeks). Depending on the definition, prevalence can be as high as 84%.[1] In industrialized countries, the lifetime prevalence is estimated to be 60% to 70%.[2] Low back pain refers to pain and discomfort between the lower ribcage and above the inferior gluteal fold. Non-specific low back pain is not due to a recognizable, known specific pathology, whereas specific low back pain has a known pathomorphological cause.[3] Approximately 90% of patients suffer from non-specific LBP, a diagnosis based on exclusion of specific pathology. LBP can be treated with medication (non-steroidal anti-inflammatory drugs), spinal manipulation, ex-

ercise therapy, back training, or local injections.[4]

Whole body vibration (WBV) is a specific exercise therapy used to treat LBP in which a vibration plate is used. During WBV, an individual stands upright on a plate and performs an exercise, such as leg squats. Energy is transferred from the plate to the body through oscillations. A distinction can be made between asynchronous, side-alternating vertical sinusoidal, and synchronous vertical vibration platforms. The vibratory load depends on acceleration, frequency, amplitude, and duration. Many positive effects on various parameters have been reported for WBV, such as increased muscle activity, improved posture, and improved blood circulation in the legs. WBV is now used as a form of therapy for many diseases, such as stroke, multiple sclerosis, and Parkinson's disease. Since WBV is a gentle form of exercise therapy, it can also be used for LBP.[5] There are few side effects of WBV but the following contraindications should be considered: WBV application should be avoided in case of pregnancy, acute thrombosis, serious cardiovascular disease, pacemaker, recent wounds from an accident or surgery, hip and knee implants, acute hernia, discopathy, spondylolysis, severe diabetes, epilepsy, recent infections, severe migraine, tumors, recently placed intrauterine devices, metal pins or plates, kidney stones, or organ failure.[6,7]

However, some studies have indicated that WBV is associated with an increased risk for LBP, sciatic pain, and degenerative changes in the spinal system, including lumbar intervertebral disc disorders.[8] Therefore, it is advisable to x-ray a patient before and after WBV treatment in combination with computerized tomography and magnetic resonance imaging when indicated.

Many studies have already been conducted to understand the positive effects of WBV on LBP, as summarized in two review articles and a meta-analysis.[9–11] However, some of the previous studies had poor to average methodological quality and only addressed the effect of WBV on pain symptomatology and functionality in LBP. Other important aspects concerning daily life, as well as postural stability and muscle strength, were not previously addressed. Since these studies were published, new studies have been added to the literature. Therefore, in this study we aimed to understand if WBV is effective during middle-term treatment of LBP by assessing health related quality of life, postural control, and muscle strength.

Materials and methods

This work followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Supplementary File 1). A literature search was performed using PubMed, PEDro, OVID, Cochrane Library, Web of Science, Google Scholar, and Scopus databases using the search terms "Whole Body Vibration" and "Low Back Pain". Original studies, reviews and meta-analyses that investigated WBV as a treatment for LBP were included. All publications up to November 2021 were included. There were no limitations in language, age of participants, or study characteristics (*e.g.*, vibration frequency, single session, or long term). Studies that did not have WBV as a treatment were excluded. The PEDro score was used to determine methodological quality of the included studies. Selection and data collection were conducted by all authors. The methodological criteria were evaluated and discussed among two authors (AD and GW). In the case of disagreement, the third author (MS) was consulted. Only middle-term studies (12 weeks duration) were included in the meta-analysis (Fig. 1). Studies were grouped by the assessments used, and subgroups were formed to compare WBV vs. no WBV, WBV vs. conventional therapy, and horizontal WBV vs. vertical WBV.

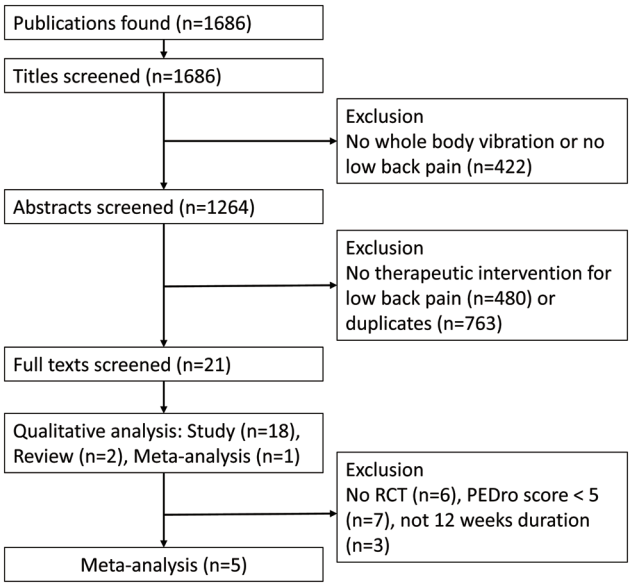

Fig. 1. Flow diagram of the study process. RCT, randomized clinical trial.

RevMan 5.4 software was used for the meta-analysis. Funnel plots using the Egger test for publication bias were created.[12] Standardized mean differences (SMD) and their 95%-confidence intervals (CI) were calculated, and classified as small (SMD < 0.3), moderate (SMD > 0.5), and large (SMD > 0.8) effects.[13] SMD and CI are presented as forest plots. Random-effects model meta-analyses were also used, as the effects varied across studies. I^2 was used to assess heterogeneity between studies because I^2 can be calculated and compared across meta-analyses of different study sizes and types and can include different types of outcome data. The magnitude of heterogeneity was categorized into the following categories: low heterogeneity (I^2 = 25%), moderate heterogeneity (I^2 = 50%), and high heterogeneity (I^2 = 75 %).[14,15]

The following outcomes are used for the meta-analysis:

1. Postural Stability Index (PSI): In the PSI test, the platform remains static in the anterior-posterior and medial-lateral axes, which allows measurement of the anterior-posterior stability index and the medial-lateral stability index. The duration of each trial is 20 s with a 1 m rest between each trial. In each trial, the participant is asked to adopt a single dominant-limb stance while maintaining slight flexion of the knees (15°).[16]
2. European Quality of Life Scale (EuroQol EQ-5D-3L): The EuroQol EQ-5D-3L is a short questionnaire that is cognitively undemanding, taking only a few minutes to complete. It provides a simple descriptive profile and a single summary index value for health status. It has five dimensions, and each dimension is scored from 1 (best possible health state) to 3 (worst possible health state).[17]
3. Work Ability Index (WAI) Questionnaire: The WAI rates an employee's self-assessed work ability. The German version of the WAI consists of a seven-part self-assessment with 23 items overall. The WAI score ranges from 7 to 49 points and four categories are used to describe WAI levels: poor (7–27), moderate (28–36), good (37–43), and excellent (44–49). The WAI is the most commonly used tool for measuring work ability.[18]
4. Short Form-36 (SF-36): The SF-36 questionnaire measures the health-related quality of life in eight subscales (physical functioning, physical role functioning, emotional role func-

tioning, social role functioning, mental health, bodily pain, vitality, and general health perceptions) and two sum scales related to psychiatric and physical aspects. For all scales, a score of 0 indicates maximum disability, and a score of 100 indicates no disability.[19]

Results

A total of 1,686 publications were identified in our initial literature search. After title screening, 422 publications were excluded because neither WBV nor LBP were included in the study. After abstract screening, 763 duplicates were removed, and 480 publications were excluded because they did use WBV as a therapeutic intervention. Following the screening process, 21 publications remained, of which were reviews, one was a meta-analysis, and 18 were original studies.

Table 1[20–37] provides an overview of the 21 included publications and their findings. As Table 1 shows, of the 18 studies, 15 were randomized controlled trials. Between 20[20] and 240 LBP patients[28] participated in the different studies. Different experimental groups were compared with each other in many studies[21,23,24,26,28,31,34] and in one study LBP patients were directly compared with healthy persons.[20] Application frequencies ranged from 3 Hz[26] to 50 Hz.[27] Study durations ranged from a single-session application of WBV[20,32,36] to weekly applications during a whole year.[24] Sessions per week ranged from one[24] to five.[30] The visual analogue scale (VAS)[21,22,26,29,30,33,35,37] and Oswestry Disability Index (ODI)[22,25–27,33,34] were the most investigated variables.

Table 2[20–37] provides an overview of the methodological quality of the included studies, using the PEDro score. In total, 10 studies can be described with good,[21,22,24–26,28,31–33,36] six with fair,[23,27,29,30,34,35] and two with poor quality.[20,37] Five studies[22,25,26,28,33] were middle-term studies (12 weeks duration) and were included in the meta-analysis.

The funnel plots in Figures 2 to 4 show possible publication bias, and the forest plots in Figures 5 to 7 show the subgroup analyses comparing the different treatment conditions.

Heterogeneity: I^2 was significant (93%) for muscle strength in the total and subgroup analyses ($p < 0.001$), not significant (0%) for postural stability in the total and subgroup analyses ($p = 0.69$), and significant about (80%) for health-related quality of life and working ability in the total analysis ($p < 0.001$), but not in the subgroup analysis (0%) ($p = 0.61$).

Risk of bias: The most common risks of bias in the forest plots were criteria B (concealed allocation) and C (blinded participants and personnel).

Effect sizes: For lumbar extensor and flexor peak torques, an overall effect of −0.86 was found. For lumbar extensor and flexor average power, the overall effect was −0.18. For muscle strength, combining peak torque and average power, the overall effect was −0.64 (Fig. 5). For postural stability, an overall effect of −0.28 was found (Fig. 6). The effect of WBV on health-related quality of life and working ability was 0.84 (Fig. 7).

Discussion

The studies included in this meta-analysis had many different characteristics. Some compared WBV to a control group without any treatment,[22,24,25,28,30] others compared WBV to other therapeutic modalities,[21,23,28,29,33–36] different WBV conditions,[26,28] or placebo using the plate without vibration,[32] and others compared the results of patients with healthy individuals[20] or lacked a control group.[37] Only two studies[28,36] provided the same WBV treatment parameters as published by Wuestefeld *et al*.[38] Different treatment periods, frequencies, and different populations were studied, thus making it difficult to compare the studies with each other. Nevertheless, all studies reported positive results where the experimental group was significantly different in the pretest in the posttest. Significant group differences in the posttest are rarely found.[21,23,33–36] This would imply that conventional training methods can also effectively reduce LBP. In contrast to conventional methods, WBV has the advantage of requiring less time. However, a disadvantage of WBV is that there are various contraindications.[6,7] It is also difficult to evaluate the reviews/meta-analyses studied. For example, Perraton *et al*. pointed out that one of the included studies did not examine LBP patients and one study was retracted due to incorrect data in PubMed.[9,24,39] Therefore, this review cannot provide meaningful results advocating for the effectiveness of WBV for treating LBP. The work of Dong *et al*.[23] suggests that WBV would have a positive effect on chronic musculoskeletal pain, and a medium duration of WBV (3 to 12 weeks) may be beneficial. Compared to traditional treatment, WBV can have beneficial effects. In contrast, the comparison between exercise with WBV and exercise without WBV showed only a small effect. Further work is needed to determine which parameters of WBV are ideal for pain treatment. In contrast, the works of Dong *et al*.,[11] Perraton *et al*.,[9] and Wang *et al*.[10] showed that some studies had mediocre methodological quality.[21,24,29,30,34,35] Only ten of the above-described studies were of good methodological quality and could be included into the meta-analysis. When considering heterogeneity (I^2), only some studies partly evaluated muscle strength and quality of life. However, this may be due to the fact that different scales are available for the investigated parameters, for example there were differences in measuring muscle strength peak (torque Nm vs. kg) or different versions of the SF-36 (German vs. English). Therefore, heterogeneity can be neglected when interpreting effect sizes. When comparing the effect sizes of the WBV group to the control group, which had no application, a medium effect was found (−0.21 to −0.56 for postural stability and 0.38 to 0.87 for quality of life). When comparing WBV with conventional treatment, a strong effect was observed (−0.60 to −2.44 for muscle strength peak torque). Comparing horizontal with vertical WBV, no effect was observed (−0.16 to 0.02 for muscle strength and postural stability). This shows that WBV can be a beneficial treatment, no matter in which form it is applied. This can be attributed to various biological effects already proven, such as increasing the activity of striated muscles,[40,41] triggering a specific myotatic reflex (tonic vibratory reflex),[42] widening blood vessels, improving blood flow and oxygen uptake,[43] increasing testosterone and growth hormone release, decreasing cortisol concentration,[44] and increasing intramuscular temperature.[45]

Future directions

Since the positive effect of WBV on LBP has been shown, it is now necessary to consider exact application parameters to derive a generally applicable training protocol for LBP. High quality studies comparing different application frequencies, length and number of sets, number of applications per week, and stance positions or exercises should be addressed in future analyses. In addition, it needs to be reviewed over how many weeks or months such treatment should optimally be performed. Those suffering from LBP are limited in many areas, so that the effect of WBV on other parameters besides pain perception and activities of daily living should also be investigated.

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Table 1. Overview of included publications

Author (year)	Kind of publication	Methods	Variables	Results
Boucher *et al*. (2013)[20]	Study	20 Patients, 21 Healthy; Single session, 15 Hz, 10 mm peak-to-peak displacement, 5 × 60 sec WBV, 60 s rest, Standing position; Pre- and posttest	EMG erector spinae L2-L2, L4-L5, lumbopelvic kinematic variables	Increased lumbar EMG activity in flexion and extension phases, no change in standing and fully flexed phases, kinematic data decreased contribution to the movement of lumbar region in second extension quartile. No differences between patients and healthy
Chen (2016)[21]	RCT	46 patients (23 WBV + exercise, 23 exercise); 8 weeks, 3 sessions/week	Body perception (position perception); Static balance (eyes open/closed); Isometric muscle strength; VAS	Significant differences between groups in posttest for body perception, maximum torque, relative peak torque, static balance to advantage for WBV. For all variables greater improvement for WBV, but not significant
Del Pozo Cruz *et al*. (2011)[22]	RCT	50 Patients (25 WBV, 25 control/no WBV); 12 weeks, 24 sessions, 20 Hz, Each 4 weeks: 6 × 60 s, 3 × 120 s, 2 × 180 s, 2 × 240 s, 1 × 360 s, 30 s rest, Standing position; Pre- and posttest	PSI, ODI, RMI, EuroQol 5D-3L, Sens test, VAS, PILE	Significant improvements in all variables between 8.57 % and 25.15 %
Dong *et al*. (2020)[23]	RCT	21 patients; 4 exercises with WBV/without WBV, 5/10/15 Hz, control (no WBV), 4 × 10 s/exercise, 30 s rest, 5 min rest between different exercises; Pre- and posttest	EMG abdominal oblique externus, rectus abdominis, multifidus, erector spinae	Significant increased muscle activity for frequency and exercise in all investigated muscles. Interaction effect frequency*exercise only for multifidus
Dong *et al*. (2019)[11]	Review + meta-analysis	Search: online databases, Published January 1980 – September 2018, Only RCT's in English or Chinese, Musculoskeletal pain in different disorders	Methodological quality: PEDro; Meta-analysis: SMD ± 95 % CI	16 RCT's, of which only 5 treat LBP: Chen (2016)[21]: PEDro = 5, SMD = −.56; Del Pozo-Cruz *et al*. (2011)[22]: PEDro = 6, SMD = −.60; Iwamoto *et al*. (2005)[24]: PEDro = 3, SMD = −.43; Rittweger *et al*. (2002)[29]: PEDro = 3, SMD = .00; Yang *et al*. (2015)[35]: PEDro = 4, SMD = −.68; Overall SMD = −.44 for pain reduction
Iwamoto *et al*. (2005)[24]	RCT	50 patients (25 medication, 25 medication + WBV); 20 Hz, 12 months, 1 session/week, 4 min/session; Pre-, between- and posttest	Self-reported pain scale	Greater reduction in pain in WBV group
Kaeding *et al*. (2017)[25]	RCT	41 patients (21 WBV, 20 control); 3 months, 2.5 sessions/week, 10–30 Hz, amplitude 1.5–3.5 mm, Standing position, 5 × 60–120 s; Pre- and posttest	RMI, ODI, WAI, SF-36, FAQ, Isokinetic test trunk muscles	Significant changes for all variables excepting Work Ability Index
Kim *et al*. (2018)[26]	RCT	28 patients (14 horizontal WBV, 14 vertical WBV); 12 weeks, 3 sessions/week, 30 min/session, 2 × 10 min, 3–5 Hz, 1–48 mm amplitude horizontal, 28–34 Hz, 2.5–5 mm amplitude vertical, standing position; Pre-, between and posttest, 4-week follow-up	VAS, ODI, Lumbar muscle strength and transverse abdominis and multifidus thickness, Standing balance (isokinetic dynamometer, ultrasonography, balance parameters)	Significant changes in both groups for all variables excepting muscle thickness of transverse abdominis and multifidus. No significant group differences
Maddalozzo *et al*. (2016)[27]	RCT	125 patients (70 WBV, 55 control); 20–50 Hz, .6–1.2 mm amplitude; Pre- and posttest	NRS, ODI;	Significant improvements in both groups. No significant group differences

(continued)

Table 1. *(continued)*

Author (year)	Kind of publication	Methods	Variables	Results
Micke *et al*. (2021)[28]	RCT	240 patients (80 WBV, 80 WBV-EMS, 80 conventional training); 12 weeks, WBV: 2 × /week, 5 exercises/session, 2 sets/exercise, 60 s/exercise, 30 s rest, 5–10 Hz, WBV-EMS: 1 session/week, 6 exercises/session, 3 sets/exercise, 3 repetitions/set, bipolar 85 Hz, 350µs, 6 s stimulation, 4 s rest, Conventional: 1 ×/week, 30 min/session 10 exercises, 2 sets, 50 s exercise, 25 s rest; Pre- and posttest	Mean back pain intensity (diary), Trunk extension and flexion strength (Back Check)	Significant improvement in pain and muscle strength in all groups. No interaction effects
Perraton *et al*. (2009)[9]	Review	Search: online-databases, no restrictions in year, language, design, Suitability: PICO	Methodological quality: PEDro	3 RCT's of which only 2 treat LBP: Iwamoto *et al*. (2005),[24] PEDro 6; Rittweger (2002)[29]: PEDro 3
Rittweger *et al*. (2002)[29]	RCT	60 patients (30 WBV, 30 control); 12 weeks, WBV: 18 Hz, 6 mm amplitude, semi squat movements, 4–7 min/session, 2 sessions/week (week 1–6), 1 ×/ week (week 7–12), Control: isodynamic lumbar extension; Pre- and posttest, 6-month follow-up	Lumbar extension torque, VAS, PDI	Significant improvements in both groups. No correlation between gain in lumbar torque and pain relief/pain-related disability
Ruan *et al*. (2008)[30]	Study	94 patients (51 WBV, 43 control); 6 months, 5 sessions/week, 10 min/session, 30 Hz, 5 mm amplitude, Standing position; Pre- and posttest	VAS	Significant improvement in VAS after 3 months of WBV and in posttest. Group differences are not investigated
Sajadi *et al*. (2019)[31]	RCT crossover	24 patients (group 1 50 Hz/30 Hz, group 2 30 Hz/50 Hz); Semi-squat position, 2 sessions, 5 min/session, 2 weeks rest between sessions; Pre- and posttest	Lumbar repositioning error at 30 % and 60 % of lumbar full flexion and neutral position (electrogoniometer)	Improvements in both conditions, effect in 30 Hz-treatment significantly higher
Shargh *et al*. (2020)[32]	RCT	50 patients (25 WBV, 25 control, placebo); Single session, 20 Hz, 3–17 g acceleration, 6 × 60 s; Pre- and posttest	Trunk repositioning error at 30 %, 60 % of lumbar full flexion and neutral position (Dual Digital inclinometer)	Significant differences from pre- to posttest for WBV and for interaction group*time, significant difference between groups in posttest
Wang *et al*. (2019)[33]	RCT	89 patients (45 WBV, 44 control); 12 weeks, 3 sessions/week, 15 min exercises with WBV; control: general exercises; Pre- and posttest	VAS, ODI, Lumbar joint position sense, SF-36, GPE	Significant improvements in experimental group in all variables compared to control group
Wang *et al*. (2020)[10]	Review	Search: online databases up to December 2019, Inclusion: RCT's effect of WBV on pain intensity and/or functional ability	Methodological quality: PEDro	7 RCT's that treat LBP: Del Pozo-Cruz *et al*. (2011),[22] PEDro 7; Kaeding *et al*. (2017),[25] PEDro 6; Rittweger *et al*. (2002),[29] PEDro 4; Ruan *et al*. (2008),[30] PEDro 4; Wegener *et al*. (2019),[34] PEDro 4; Wang *et al*. (2019),[33] PEDro 8; Yang, & Seo (2015),[35] PEDro 5
Wegener *et al*. (2019)[34]	RCT	44 patients (22 control exercises, 22 WBV); 18 weeks, 2 sessions/week, 5 exercises/session, 1/1.5/2 min/exercise, WBV: 5–12 Hz/12–20 Hz/20 Hz; Pre- and posttest	MFT-S3 Check (STI, SMI, SI), SF-36, NASS lumbar, ODI, HADS (depression)	Significant improvements in control group in STI and SMI. Significant group difference only in NASS (neurol. Symptoms)

(continued)

Table 1. *(continued)*

Author (year)	Kind of publication	Methods	Variables	Results
Yang, & Seo (2015)[35]	RCT	40 patients (20 WBV, 20 control); 6 weeks, 3 sessions/ week, WBV: 30 min stability training + 5 min WBV, control: 30 min stability training; Pre- and posttest	Tetrax (static balance); 3D tomography (Spinal curvature), VAS, ODI	Significant improvements in all variables for WBV, significant improvements in pain and disability. Significant group differences in fall index and VAS in posttest
Zheng *et al.* (2021)[36]	RCT	40 patients (20 WBV, 20 control); Single session, 6 exercises, 2 sets/exercise, 20 s/set, 15 s rest, WBV: 20 Hz, 2 mm amplitude; Pre- and posttest	sEMG (relative muscle activation time) deltoid, erector spinae, multifidus, rectus abdominis, transversus abdominalis/ internal oblique	Significant improvements for WBV in multifidus, transversus abdominalis/internal oblique. Significant group differences in posttest in right transversus abdominalis/ internal oblique and left rectus abdominis
Zheng *et al.* (2019)[37]	Single group	42 patients (WBV); 12 weeks, 3 sessions/week, 6 exercises/session, 2 sets/exercise, 60 – 90 s/exercise, 30 s rest, 9 Hz, 2 mm amplitude; Pre- and posttest	Con-Trex Multi-Joint System (Joint position sense/lumbar proprioception), VAS	Significant improvements in all variables

CI, confidence Interval; EMG, electromyogram; EuroQol, European Quality of Life Scale; FAQ, Freiburger activity questionnaire; GPE, Global Perceived Effect; HADS, Hospital Anxiety and Depression Scale NASS, North America Spine Society outcome; NRS, numeric rating scale for pain; ODI, Oswestry Disability Index; PDI, Pain Disability Index; PEDro, Physiotherapy Evidence Database Scale; PILE, Progressive Isoinertial Lifting Evaluation test; PSI, Postural Stability Index; RCT, randomized clinical trial; RMI, Roland Morris Index; SF-36, Short-Form-36; SMD, standardized mean difference; VAS, Visual Analogue Scale for pain; WAI, Work Ability Index Questionnaire.

Table 2. Methodological quality of the included studies

Study (Author, year)	1	2	3	4	5	6	7	8	9	10	11	Total PEDro score
Boucher *et al*. (2013)[20]	n/a	0	0	0	0	0	0	1	1	1	1	3
Chen (2016)[21]	n/a	1	0	1	0	0	1	1	0	1	1	6
Del Pozo Cruz *et al*. (2011)[22]	n/a	1	0	1	0	0	1	1	1	1	1	7
Dong *et al*. (2020)[23]	n/a	1	0	0	0	0	0	1	0	1	1	4
Iwamoto *et al*. (2005)[24]	n/a	1	0	1	0	0	0	1	1	1	1	6
Kaeding *et al*. (2017)[25]	n/a	1	0	1	0	0	0	1	1	1	1	6
Kim *et al*. (2018)[26]	n/a	1	0	1	1	0	1	1	0	1	1	7
Maddalozzo *et al*. (2016)[27]	n/a	0	0	1	0	0	0	1	0	1	1	4
Micke *et al*. (2021)[28]	n/a	1	1	0	0	0	1	1	0	1	1	6
Rittweger *et al*. (2002)[29]	n/a	1	0	1	0	0	0	0	0	1	1	4
Ruan *et al*. (2008)[30]	n/a	1	0	1	0	0	0	0	0	1	1	4
Sajadi *et al*. (2019)[31]	n/a	1	0	1	0	0	1	1	0	1	1	6
Shargh *et al*. (2020)[32]	n/a	1	0	1	0	0	1	1	0	1	1	6
Wang *et al*. (2019)[33]	n/a	1	1	1	0	0	1	1	1	1	1	8
Wegener *et al*. (2019)[34]	n/a	1	0	1	0	0	0	0	0	1	1	4
Yang, & Seo (2015)[35]	n/a	1	0	1	0	0	0	1	0	1	1	5
Zheng *et al*. (2021)[36]	n/a	1	0	1	0	0	1	1	0	1	1	6
Zheng *et al*. (2019)[37]	n/a	0	0	0	0	0	0	1	0	0	1	2

*0: criterion not fulfilled; 1: criterion fulfilled; n/a: not applicable. The items are listed as follows: 1: eligibility criteria were specified; 2: subjects were randomly allocated to groups or to a treatment order; 3: allocation was concealed; 4: the groups were similar at baseline; 5: there was blinding of all subjects; 6: there was blinding of all therapists; 7: there was blinding of all assessors; 8: measures of at least one key outcome were obtained from more than 85% of the subjects who were initially allocated to groups; 9: intention-to- treat analysis was performed on all subjects who received the treatment or control condition as allocated; 10: the results of between-group statistical comparisons are reported for at least one key outcome; 11: the study provides both point measures and measures of variability for at least one key outcome. Total score: each satisfied item (except the first) contributes 1 point to the total score, yielding a PEDro scale score that can range from 0 to 10. Level of evidence: 6–8 indicates good quality, 4–5 indicates fair quality, and <4 indicates poor quality.

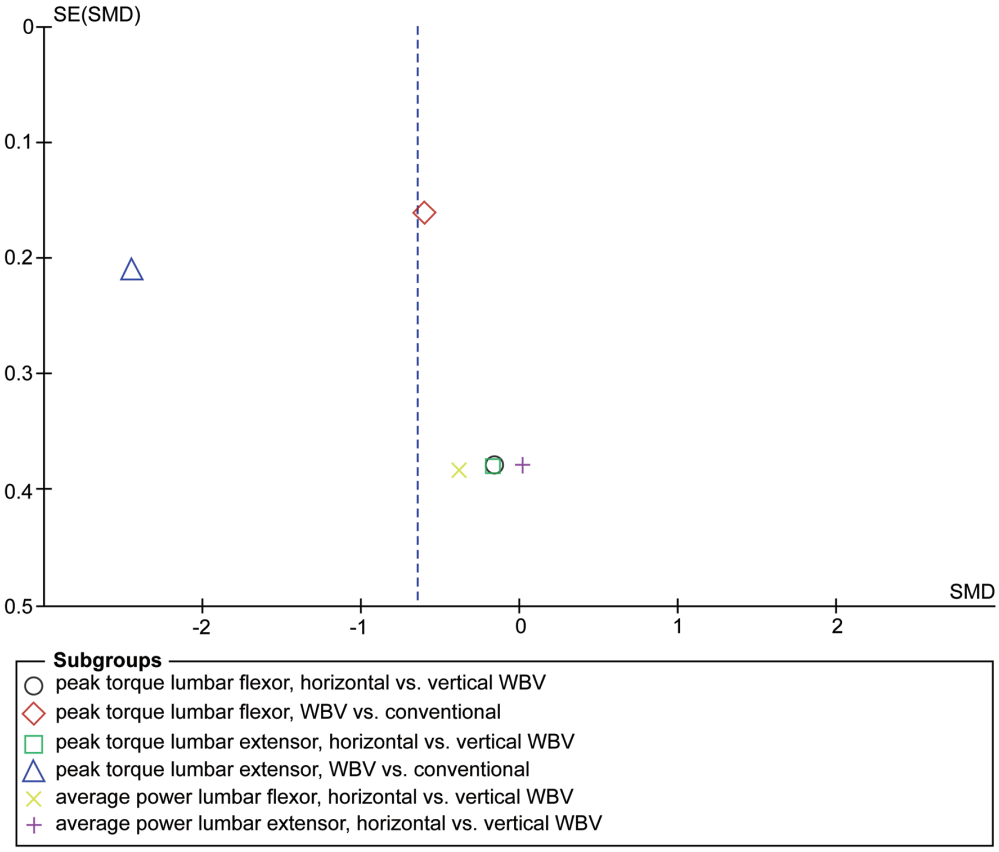

Fig. 2. Funnel plot for muscle strength (peak torque and average power).

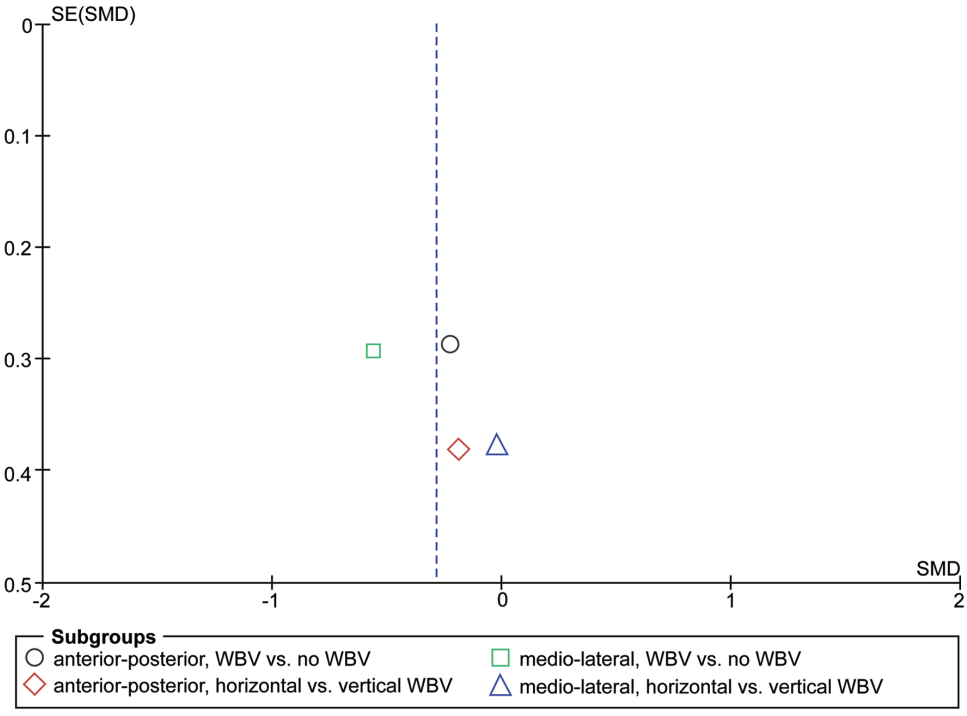

Fig. 3. Funnel plot for postural stability. SMD, standardized mean difference; WBV,whole body vibration.

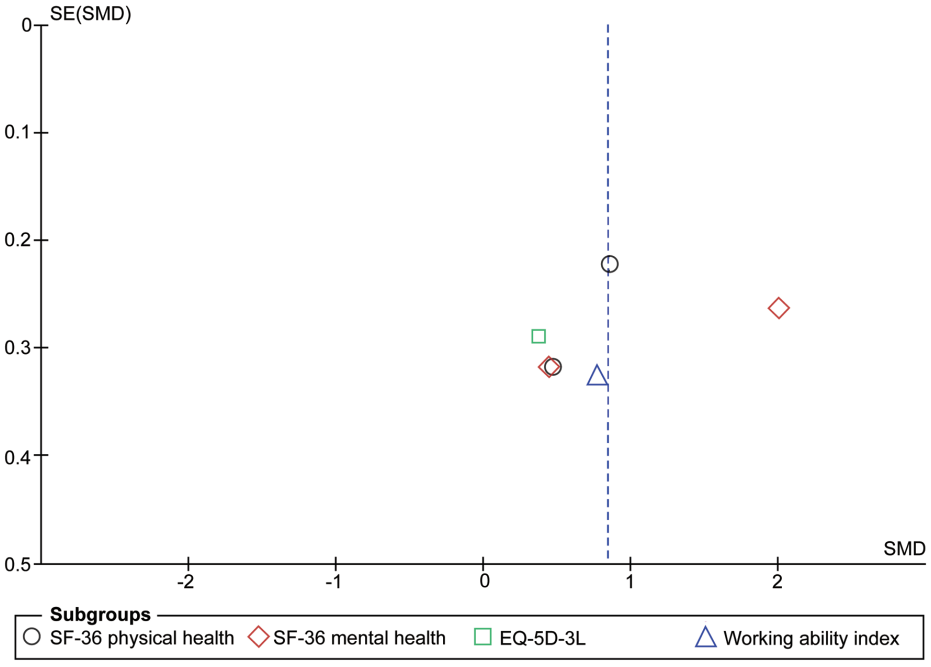

Fig. 4. Funnel plot for health-related quality of life and working ability. EQ-5D-3L, European Quality of Life Scale; SF-36, Short-Form-36; SMD, standardized mean difference; WBV,whole body vibration.

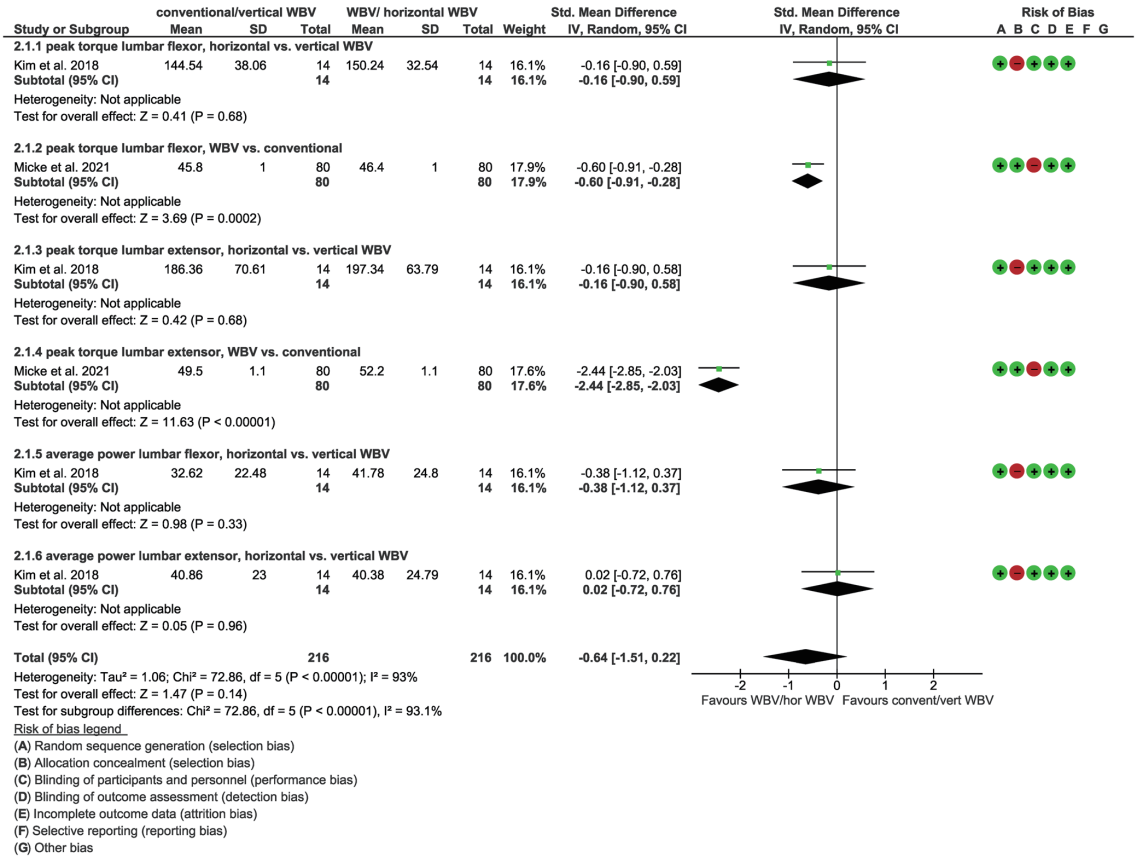

Fig. 5. Forest plot for muscle strength, lumbar flexor, and extensor peak torques and average power, comparing WBV vs. conventional therapy and vertical vs. horizontal WBV. CI, confidence intervals; SD, standard deviation; WBV,whole body vibration.

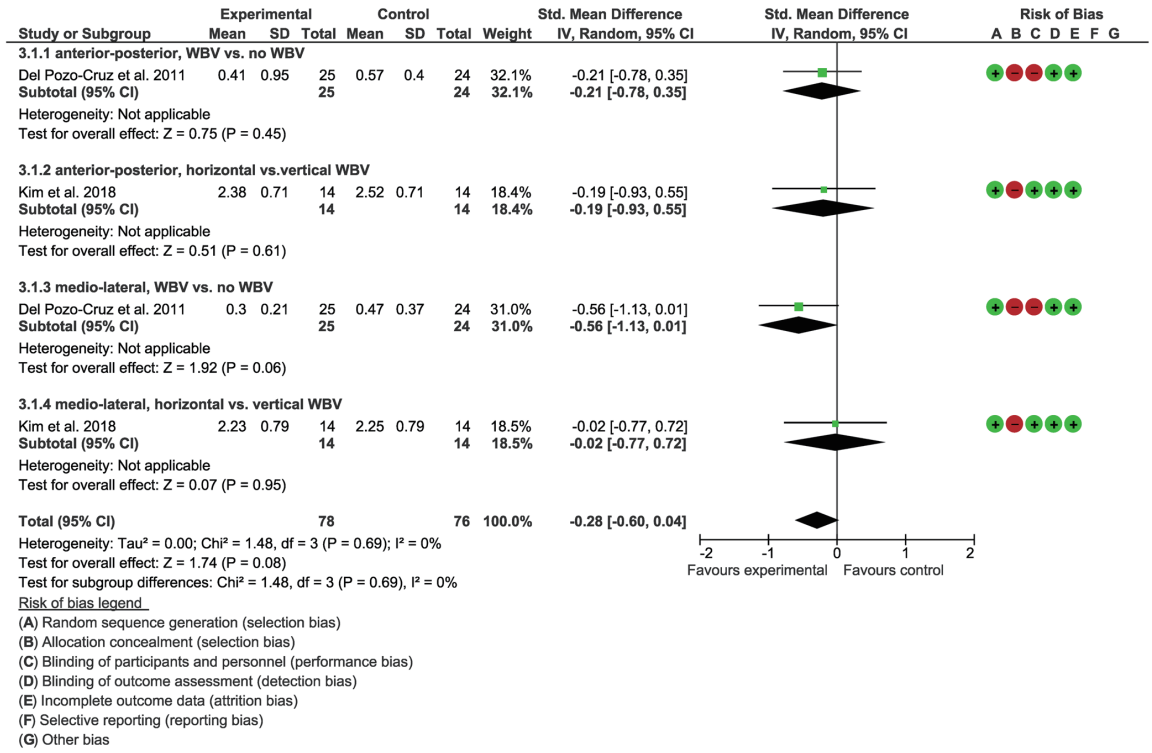

Fig. 6. Forest plot for postural stability test for anterior-posterior and medio-lateral, comparing WBV vs. no WBV and horizontal vs. vertical WBV. CI, confidence intervals; SD, standard deviation; WBV,whole body vibration.

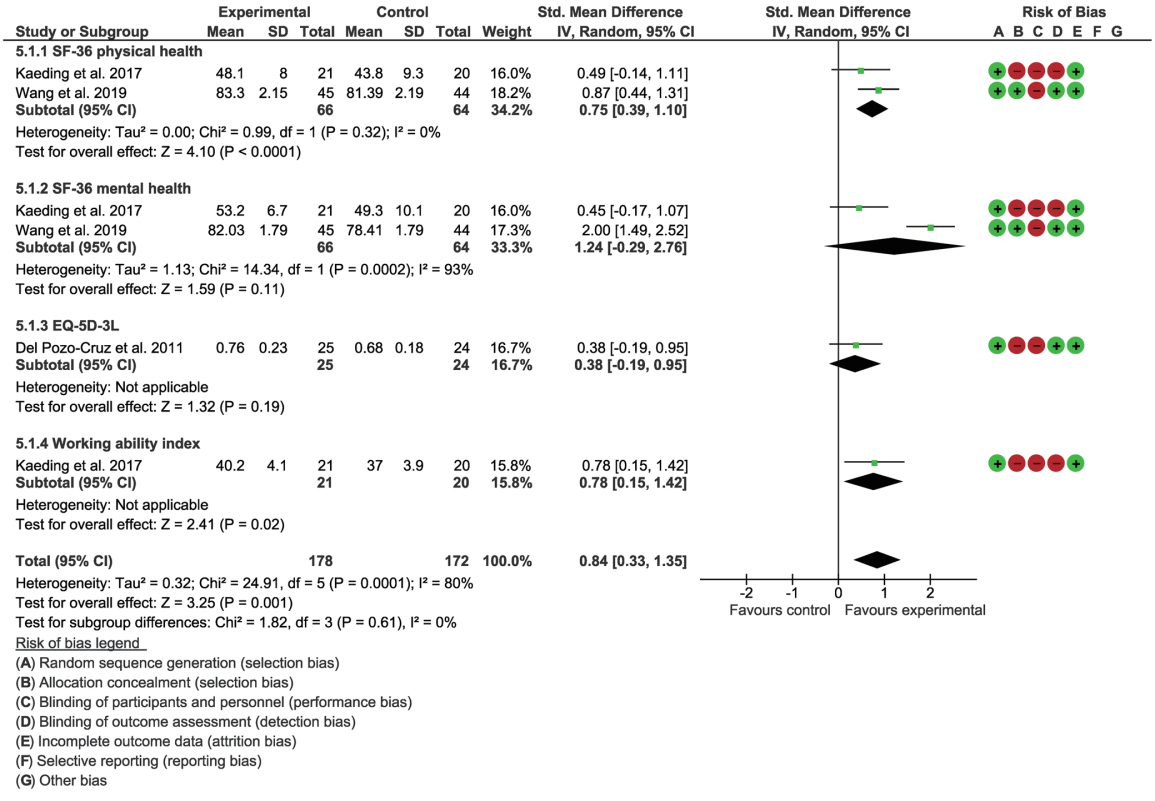

Fig. 7. Forest plot for health-related quality of life and working ability. CI, confidence intervals; SD, standard deviation.

Conclusions

This work shows that WBV can have a positive effect on different muscle strength parameters (SMD = −0.64), postural stability (SMD = −0.28), and health related quality of life and working ability (SMD = 0.86), even though the included studies used different training parameters (*e.g.*, application frequency or sessions per week). Therefore, this meta-analysis indicates that WBV is a beneficial treatment for medium-term therapy of LBP. However, due to the wide variation in application frequencies (range from 3 to 34 Hz), set durations (range from 60 s to 15 m, in some cases increasing over the course of the study), and body positions (standing position vs. static exercises), no generally applicable training protocol can be derived. It is possible that an individual device setting is necessary for each patient based on his or her well-being.

Supporting information

Supplementary material for this article is available at https://doi.org/10.14218/ERHM.2021.00070.

Supplementary File 1. PRISMA checklist.

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Conflict of interest

The authors have no conflicts of interest related to this publication.

Author contributions

Draft and translation (AD), selection and data collection process (AD, GW, MS), evaluation of methodological criteria (AD, GW), in disagreement consultation (MS), and correction notes on formulations and illustrations (GW, MS). All authors have made a significant contribution to this study and have approved the final manuscript.

Data sharing statement

No additional data are available.

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