

Review Article

The effects of whole body vibration therapy on reducing fat mass in the adult general population: A systematic review and meta-analyses

Maryam Omidvar¹, Seyed Mohammad Alavinia^{1,2}, Beverley Catharine Craven^{1,2}

¹Neural Engineering and Therapeutic Team, Lyndhurst Centre, KITE-Toronto Rehab, University Health Network, Canada; ²Department of Medicine, Division of Physical Medicine and Rehabilitation, University of Toronto, Canada

Abstract

Whole Body Vibration (WBV) is a popular and a purported alternative to physical activity to reduce body fat, but reports of efficacy are inconsistent. We aimed to describe the efficacy of WBV therapy for reducing fat mass in the adult general population. A systematic search was conducted using Medline, Embase, Cochrane, CINAHL, and PubMed up to March 27, 2019. Studies, which evaluated the effects of WBV on fat mass (%/kg) as a primary or secondary outcome, were considered for inclusion. Of 2,418 studies, after title and abstract screening, 45 articles underwent full-text screening. Seven controlled trials with a total of 280 subjects were included in the systematic review. The meta-analyses were performed for six studies based on reported fat mass (%/kg) changes in the intervention and control groups. The mean change for total fat mass per kg and % body fat were -0.76 (95% CI: -1.42, -0.09) and -0.61 (95% CI: -1.51, 0.13) respectively. This systematic review and meta-analyses showed a significant effect of WBV on total fat mass (kg), however clinically insignificant effects of 6-24 weeks of WBV therapy on % body fat. Longer duration studies with adequate sample sizes are required to determine the efficacy of WBV therapy.

Keywords: Whole Body Vibration, Fat Mass, Weight Loss, Exercise, Systematic Review

Introduction

Vibration was applied as a therapy for the first time by a Russian scientist to potentially decrease the severity of declines in bone and muscle mass among cosmonauts and has been used widely thereafter to improve musculoskeletal strength¹. Whole body vibration (WBV) therapy is applied through a motor-driven oscillating platform generating sinusoidal vibration, which is transmitted to the user while standing on the plate². The effects of vibration are strongly dependent on the device type and vibration parameters including the frequency, amplitude and duration³ of WBV

which in combination with the study design may lead to different therapeutic benefits. Artero et al. investigated the effects of 8 weeks WBV on percent fat mass in young adults comparing two groups of placebo plus resistance and WBV plus resistance training. They applied FitVibe® Excel pro (Bilzen, Belgium) plate and vibration parameters of 20 to 40 Hz and 2.5 to 5 mm and reported a 2.1% decrease ($P < 0.001$) in % body fat for the WBV group⁴. Vissers et al. (2010) reported the effects of long-term WBV (12 months, 6 months intervention followed by 6 months follow-up) training on Visceral Adipose Tissue (VAT) in overweight and obese adults comparing four different groups of diet, fitness (diet + fitness), WBV (diet + WBV) and control. They applied vibration parameters of low to high amplitude and frequencies of 30 to 40 Hz using the Power Plate, (Badhoevendorp, the Netherlands). They reported significant decreases in % body fat after 3 months in the fitness and the vibration groups as well as decrease in %body fat from baseline after 6 or 12 months in all three intervention groups. VAT significantly decreased after 3 months in all three intervention groups, but after 6 months, only persisted in the diet and the

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Corresponding author: S. Mohammad Alavinia, Neural Engineering & Therapeutics Team, KITE-Toronto Rehab, University Health Network, Scientific associate, 206 - 520 Sutherland Drive, Toronto, ON, M4G 3V9
E-mail: mohammad.alavinia@uhn.ca

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WBV groups compared to baseline. After 12 months, which is 6 months after stopping all the interventions, only the vibration group showed a significant decrease in VAT compared to baseline. The WBV intervention group reported decreased waist to hip ratio after 3, 6 and 12 months compared to baseline⁵. In contrast, Song et al. investigated the effects of WBV on fat mass in an 8-week intervention trial of postmenopausal healthy obese women using the Body master EOS-6600 (MEDIEOS, Gwangju, Korea) vibration platform and vibration at low amplitude (2 mm) and low frequency (22 Hz). They reported that the effects of WBV on both total fat mass per kg and percent fat were not significant⁶.

The positive effects of WBV therapy on the metabolic consequences of immobilization were first evaluated in 1949 in men with the use of an oscillating bed⁷. WBV therapy has the potential to provide a variety of beneficial effects for people who have limitations to conventional exercise participation⁸. WBV is a popular alternative to physical activity to reduce body fat and increase muscle mass and strength⁹ with results purportedly comparable to moderate walking in terms of energy expenditure¹⁰.

The impact of WBV on body composition and fat mass have been investigated with inconsistent results^{4,6,11-16}. Some reviews evaluated the effects of WBV on body composition or different metabolic pathways related to weight loss¹⁷⁻²¹. Alternatively, one systematic review evaluated the effects of WBV on body composition in obese subjects with medical comorbidities²². To our knowledge, no systematic review and meta-analysis to date has studied the effects of WBV on fat mass in the general population. This systematic review and meta-analyses investigates the effects of WBV therapy on reducing fat mass (%/kg) in the adult (18-50 yr) general population.

Materials and methods

A systematic literature search was conducted to investigate the effects of whole-body vibration therapy on reducing fat mass in the adult general population using Medline, Embase, Cochrane Central Register of Controlled Trials and Cochrane Database of Systematic Reviews via Ovid, CINAHL via Ebsco and PubMed, up to March 27, 2019. Relevant articles were captured applying Medical Subject Headings (MeSH) “Body Composition”, “Adipose Tissue”, “Body Weights and Measures and “Anthropometry” added to the term “Whole body” or “Whole-body” vibration (Vibrator or Vibration plate prior to 2005), including possible adjacencies adjusted consistently for various databases. All study designs were included without restriction. Animal studies, non-English articles, duplicates, study protocols, and conference abstracts were excluded. Relevant abstracts and those requiring further investigation, were considered for full-text review, and eligible studies included in the data extraction. Publication review, screening, and data extraction were done by two investigators (MA and MO) independently in accordance with PRISMA (Preferred

Reporting Items for Systematic Reviews and Meta-Analysis) checklist²³, and disagreements were resolved with the senior author (CC). This systematic review has been registered with an international prospective register of systematic reviews (PROSPERO) (registry number: CRD42017082038)²⁴.

Study population

Studies, which investigated the effects of WBV on fat mass in healthy adults aged 18-50 years, were included in the data extraction and the analysis. Studies reporting the effects on the elderly, overweight or obese general population were excluded.

Outcome measure

Whole body fat mass was considered as the key outcome measure and studies which evaluated the effects of WBV on changing fat mass (kg/%) as a specified primary or secondary outcome of the study were included.

Intervention

All studies, which used synchronous or side-alternating vertical vibration applied to the whole body with no restriction on the type of the device, frequency, amplitude, acceleration, and duration of therapy were included in the study. Studies, which applied local vibration using an externally applied vibrator, were excluded.

Quality assessment

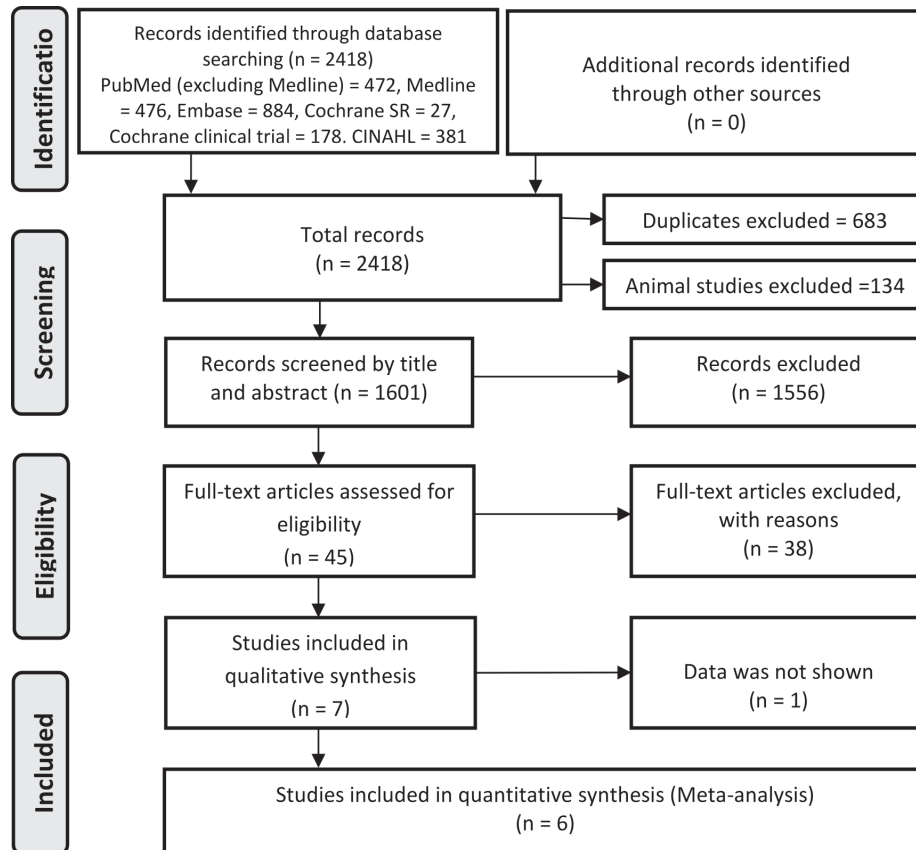
The quality of included studies was assessed using the Cochrane Collaboration’s Risk of Bias tool within the Review Manager Software (Version 5.3. Nordic Cochrane Centre, Cochrane Collaboration, 2011). No scoring system was adopted, rather quality assessments were used for descriptive purposes. The risk of bias assessment was performed for each study in the following domains: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and another category listed as other biases.

Statistical analysis

Mean body fat mass changes (%/kg) and corresponding standard deviations (sd) were abstracted from the included studies. Three meta-analyses were conducted using a standardized mean difference to show the effects of WBV on body fat mass (%/kg). First, studies that investigated the effects of WBV on fat mass (%) and reported data as mean \pm sd of difference before and after intervention were analyzed. Second meta-analysis was conducted on the effects of WBV on fat mass (kg) as reported by these studies. Finally, the third meta-analysis was conducted using studies on the effects of WBV on percent fat mass stratified by WBV devices. All studies, which reported the outcome of interest as a percentage, reported the mean difference and related

Search strategy:

1. exp "Body Weights and Measures"/
2. Anthropometry/
3. Body Composition/
4. exp Adipose Tissue/
5. (weight adj3 (manag* or loss* or gain* or control* or chang* or fluctuat*)).tw,kw.
6. (body adj3 (compos* or chang* or dimension* or size* or mass* or weight* or fat*)).tw,kw.
7. (fat adj3 (mass* or distribut* or percent* or chang* or abdominal* or intra-abdominal* or viscera* or subcutane*)).tw,kw.
8. ((waist* or hip* or abdominal*) adj3 circumference*).tw,kw.
9. or/1-8
10. ((whole-body or whole body) adj2 vibrat*).af.
11. Vibration/ and (fat or body or plate* or exercise* or training* or therapy*).tw.
12. (vibrat* adj3 body).tw.
13. vibrat* plate*.af.
14. or/10-13

Figure 1. Search strategy according to MEDLINE MeSH database.**Figure 2.** Flow chart, process of article selection for review.

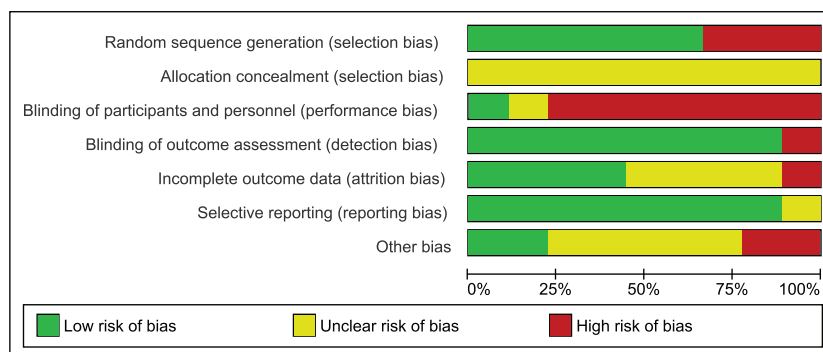


Figure 3. Risk of bias and methodological quality assessment for included studies.

sd or not, were included. Mean difference was calculated by subtracting the mean fat mass (%) before and after the WBV intervention, in both groups. Pooled sd of the mean difference was calculated based on the pooled standard deviation formula²⁵.

The percentage of variability across studies attributable to heterogeneity beyond chance was assessed by the chi-square test and I^2 statistics. The random effects model was used if the heterogeneity test revealed statistical significance ($I^2 > 50\%$, $P < 0.05$). Otherwise, we adopted the fixed effects model. As the number of included studies was insufficient (less than 10), potential publication bias was not assessed. Review Manager (RevMan) software (Version 5.3. Nordic Cochrane Centre, Cochrane Collaboration, 2011) was used for performing meta-analyses considering a significance level at $p < 0.05$. (<http://community.cochrane.org/tools/review-production-tools/revman-5>).

Results

Study characteristics

Using a comprehensive search strategy (Figure 1), we identified 2,418 studies. Following title and abstract screening and excluding duplicates and animal studies, 45 of 1,601 articles were selected for full-text screening. Figure 2 is a flowchart illustrating the study selection process. Of these 45 selected publications after excluding irrelevant studies, seven publications were included in the review. As data was not available for one study, six were included in the meta-analyses.

Risk of bias in included studies

The main observation from the risk of bias and methodological quality assessments are the many “unclear” scores regarding allocation concealment, indicating that this item was not sufficiently reported or that device concealment was not feasible. This could result in an unknown risk of selection bias. One study

was completely blinded, and the others were not blinded to the participants and therapy providers; therefore, the probability of performance bias could be high. Incomplete outcome data were adequately addressed in four studies while in the other three it was not clear and may have resulted in a high risk of attrition bias. Regarding reporting bias, a high risk was identified for one study. All other studies were scored with a low risk of bias on this item. Figure 3 shows the results of the overall risk of bias and methodological quality assessment for all included studies. The result of the risk of bias assessment for each study was presented in the results of the meta-analyses.

Results of the systematic review

Seven studies with a total of 280 subjects were included in the systematic review that used three different WBV devices including Power Plate®, FitVibe® and Galileo® devices. Table 1 shows the results of the studies on the effects of WBV on body fat (%/kg) stratified by three types of vibration plates with the specification of WBV parameters and intervention duration.

1. FitVibe® Excel pro (Bilzen, Belgium), Vertical vibration

Two trials used FitVibe® Excel pro (Bilzen, Belgium), Vertical vibration device for WBV^{4,26}. Artero (2012) conducted a randomized controlled trial among 23 physical education college students for 8 weeks using vibration amplitude of 2.5-5 mm and frequency of 20-40 Hz⁴. The control group (n=10) underwent resistance training and placebo or sham WBV, in addition the intervention group participated in resistance training and WBV (n=13). The change in percent fat was significant among the intervention group (p -value for pre-post test < 0.001).

Rubio-Arias (2015) applied vibration parameters of 2-4 mm and 30-45 Hz for 6 weeks. They reported no statistically significant decrease in percent fat mass in both the experimental and control group (-0.68 in the experimental group vs -0.64 in control) with a non-significant difference between groups²⁶.

Table 1. Summary of selected studies by vibration plate, with specification of WBV parameters and intervention duration.

FitVibe® Excel pro (Bilzen, Belgium), Vertical vibration									
	First Author / Year	Setting	Sample size (at baseline)	Vibration				Study Design	Result
				Amplitude	Frequency	Duration	Posture		
1	Artero et al. / 2012	Department of Medical Physiology, University of Granada, Spain	23 Physical Education college students recreationally active (21 men and 2 women, aged 21.8±1.5)	2.5-5 mm	20-40 Hz	8 weeks	Standing position on a synchronous (also called vertical) vibrating platform	Controlled Clinical Trial; 2 groups: placebo plus resistance training (PL+RES= 10), whole body vibration plus resistance training (WBV+RES = 13)	Fat Mass (%): WBV+RES Pre: 22.4 ± 5.4 Post: 20.3 ± 5.8 P-value: <0.001 PL+RES Pre: 20.5 ± 5.0 Post: 19.2 ± 6.1 P-value: 0.116
2	Rubio-Arias et al. / 2015	Faculty of Physical Activity and Sports Sciences, UCAM, Catholic University San Antonio, Murcia, Spain	64 healthy young adults (35 men and 29 women aged 18-25 years)	2-4 mm	30-45 Hz	6 weeks	In the first exercise, the subjects remained with one of their legs in front of the other, at a distance of one meter between the support points of the feet (toes) and with the knees semi-flexed at about 110-120°. In the second exercise they remained in the squat position, on their toes, with their feet separated by about 50 cm and the knees flexed at approximately 110-120°. The third position as similar to the second one but stood on one foot.	Single-blind Randomized Controlled Trial; 2 groups: experimental group (EG=38, 19 male & 19 female), control group (CG = 26, 16 males and 10 females)	Fat Mass (%) EG Pre: 23.67 ± 8.33 Post: 22.99 ± 8.10 P-value: 0.151 CG Pre: 21.98±7.07 Post: 21.34±7.77 P-value: 0.295 Inter groups P: 0.073
Galileo® Sport, (Novotec Medical GmbH, Pforzheim, Germany), Side-alternating vibration									
	First Author / Year	Setting	Sample size	Vibration				Study Design	Result
				Amplitude	Frequency	Duration	Posture		
1	Connolly et al. / 2014	NIHR Exeter Clinical Research Facility, University of Exeter Medical School, Exeter, UK	44 women (aged 29-46 years)	1.5-4 mm	12-27 Hz	16 weeks	Stand on the plate with slightly bent knees and heels touching the board and bring their feet a little wider than shoulder width apart. Foot position was standardized for all subjects.	Randomized Controlled Trial; 3 groups: soccer group (SG = 13), WBV group (VG = 17) and control group (CO = 14)	Fat Mass (%) VG Pre: 38.97 ± 6.93 Δ: 0.36 ± 1.81 CO Pre: 35.49 ± 8.28 Δ: -0.23 ± 2.04 Fat Mass (kg) VG: Pre: 28.92 ± 9.99 Δ: 0.37 ± 1.92 CO Pre: 24.90 ± 9.90 Δ: -0.17 ± 1.98
Power Plate® Next Generation (Power Plate North America, Northbrook, IL, USA), Vertical vibration									
	First Author / Year	Setting	Sample size	Vibration				Study Design	Result
				Amplitude	Frequency	Duration	Posture		
1	Lamont et al. / 2011	Department of Health, Exercise Science, and Recreation Management, University of Mississippi, Oxford, Mississippi	30 men, aged 18-30 with at least 6 months of recreational weight training	2-4 mm 4-6 mm	50 Hz	6 weeks	Subjects stood on a WBLFV platform holding an isometric quarter squat position (knee angle 135 ± 5°) with their feet a little wider than shoulder width apart. Foot position was standardized for all subjects.	Randomized Controlled Trial; 3 groups: control (CON=6), resistance training plus vibration (SQTV = 13) and Training only (SQT=11)	Difference for fat mass was not significant, data was not shown (this publication was excluded from the meta-analyses)

Table 1. (Cont. from previous page).

Power Plate® Next Generation (Power Plate North America, Northbrook, IL, USA), Vertical vibration									
	First Author / Year	Setting	Sample size	Vibration				Study Design	Result
				Amplitude	Frequency	Duration	Posture		
2	Martinez-Pardo et al. / 2013	UCAM Research Center for High Performance Sport, Catholic University of San Antonio, Spain	38 recreationally active subjects (30 men and 8 women aged 21.2±3.3 years)	2 - 4 mm	50 Hz	6 weeks	Uniform vertical oscillations, subjects stood on the platform holding an isometric quarter squat position with the feet shoulder width apart	Quasi-experimental pretest/posttest (randomized); 3 groups: low amplitude (GL=11), high amplitude (GH=16) and control (CG=11)	Fat Mass (%) GH Pre: 18.3 ± 6.8 post: 17.6 ± 7.7 Δ: -0.8 ± 1.7 CG Pre: 20.6 ± 7.6 Post: 21.1 ± 7.3 Δ: 0.6 ± 1.9 Fat Mass (kg) GH Pre: 13.1 ± 5.9 Post: 12.6 ± 6.9 Δ: -0.5 ± 1.4 CG Pre: 13.1 ± 4.1 post: 13.8 ± 3.9 Δ: 0.7 ± 1.4
3	Martinez-Pardo et al. / 2014	UCAM Research Center for High Performance Sport, Catholic University of San Antonio, Spain	41 recreationally active students (32 men and 9 women aged 21.4±3.0 years)	4 mm	50 Hz	6 weeks	Uniform vertical oscillations, Subjects stood on the platform holding an isometric quarter squat position with the feet shoulder-width apart	Quasi-experimental pretest/posttest (matched design); 3 groups: 2 days training (G2 = 16), 3 days training (G3 = 14) and control (CG = 11)	Fat Mass (%) G3 Pre: 20.7 ± 7.3 Post: 19.8 ± 7.4 Δ: -0.8 ± 1.9 CG Pre: 20.6 ± 7.6 post: 21.1 ± 7.3 Δ: 0.6 ± 1.9 Fat Mass (kg) G3 Pre: 14.6 ± 4.9 Post: 14.2 ± 5.8 Δ: -0.4 ± 1.3 CG Pre: 13.1 ± 4.1 post: 13.8 ± 3.9 Δ: 0.7 ± 1.4
4	Roelants et al. / 2004	Faculty of Physical Education and Physiotherapy, Katholieke Universiteit Leuven, Belgium	40 untrained women (aged 21.3±2.0 years)	2.5-5 mm	35-45 Hz	24 weeks	Unloaded static and dynamic leg and arm exercises (high squat, deep squat, lunge, biceps curl...)	Controlled Trial; 3 groups: vibration (WBV = 13), fitness (FIT = 15) and control (CO = 12)	Fat Mass (%) WBV Pre: 28.3 ± 1.1 Post: 28.6 ± 1.3 CO Pre: 26.8 ± 1.3 Post: 26.5 ± 1.4

2. Galileo® Sport, (Novotec Medical GmbH, Pforzheim, Germany), side-alternating

In one trial, the Galileo® WBV device was used²⁷. Connolly et al (2014) conducted a randomized controlled trial among 44 women. The study consisted of three groups, a soccer group (SG=13), WBV group (VG=17), and control group (CO=14). They applied WBV with vibration parameters of 1.5-4 mm amplitude and 12-27

Hz frequency for 16 weeks. There was no statistically significant change in the WBV group after 16 weeks of intervention. The results for the control group were not significant however, a statistically significant change in percent fat was noted in the soccer group. The absolute change in fat mass weight (kg) in the vibration group and control group was 0.37±1.92 and -0.17±1.98 respectively. These within-group differences were not statistically significant.

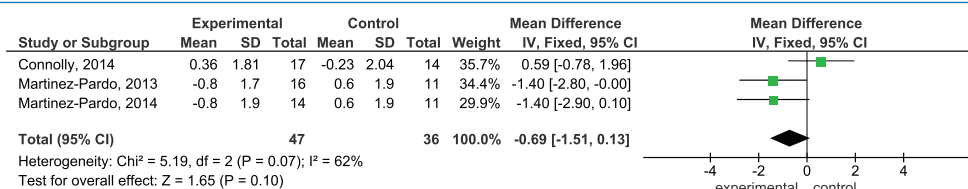


Figure 4. The effects of WBV therapy on percent body fat.

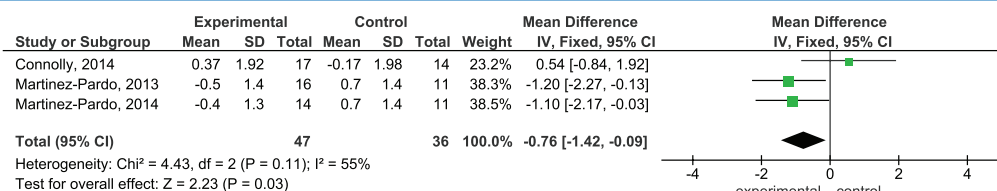


Figure 5. The effects of WBV therapy on body fat per kg.

3. Power Plate® Next Generation (Power Plate North America, Northbrook, IL, USA), Vertical vibration

Four studies used the Power Plate® for WBV intervention^{9,11,28,29}. Lamont et al. (2011) examined the effects of a 6-week, periodized squat training program with or without whole-body low-frequency vibration (WBLFV) among thirty men with at least six months of recreational weight training experience. Subjects were randomly assigned to either one of two training groups, or to an active control group¹¹. The first active control group ($n=6$) did not participate in the training protocol but participated only in the testing sessions. The Second training group ($n=13$) performed 6 weeks of squat training while receiving WBV (50 Hz), before and in-between sets. The third training group ($n=11$) performed 6 weeks of squat training for 12 weeks. There was no significant change in total fat mass among the experimental groups.

Martinez-Pardo et al. (2013) used different amplitudes for the WBV intervention and compared the results with the control group²⁸. They reported that fat mass (kg) in the high-frequency group decreased by $-0.5 (\pm 1.4)$, but this reduction was not statistically significant. In the low-frequency group, fat mass (kg) was increased insignificantly by $0.1 (\pm 1.4)$ kg. The change in percent body fat was not statistically significant. In another randomized clinical trial, Martinez-Pardo (2014) studied the effects of WBV on 41 recreationally active (32 men and 9 women) subjects²⁹. The intervention group was divided into two experimental groups, one group underwent two sessions per week (G2) and the second intervention group underwent three WBV sessions per week (G3). The frequency of vibration (50 Hz), amplitude (4 mm), time of work (60 seconds), and time of rest (60 seconds) remained the same for both experimental groups. They compared the results with a third control group. Martinez-Pardo (2014) found no statistically significant differences in percent body

fat and fat mass (kg) between the pretest and posttest in G2 and G3.

In a randomized clinical trial by Roelants et al. (2004), the effects of 24 weeks of WBV and fitness training on body composition and muscle strength was investigated among 48 untrained females⁹. They randomly assigned the subjects into three groups, the WBV group performed unloaded static and dynamic exercise on a vibration platform, the fitness group followed a standard cardiovascular and training program (three times weekly), and the control group did not participate in any training. They concluded that 24 weeks WBV training did not reduce weight, total body fat, or subcutaneous fat in previously untrained females.

Results of the meta-analyses

Six clinical trials with a total of 194 subjects were included in three meta-analyses:

1. Three clinical trials reported the effects of WBV on percent fat mass as a mean difference and corresponding standard deviation (Figure 4). The overall mean change and 95% CI were $-0.69 (-1.51, 0.13)$. There was no evidence of heterogeneity across the studies ($I^2=62\%$, $P\text{-value}=0.07$).
2. The effects of WBV on fat mass per kg reported in the second meta-analysis shown in Figure 5. There was a statistically significant effect of WBV on total fat mass per kg with the overall mean change of -0.76 (95% CI, $-1.42, -0.09$; $P\text{-value}=0.03$). There was no evidence of heterogeneity across the studies ($I^2=55\%$, $P\text{-value}=0.11$).
3. The third meta-analysis was conducted to describe the effects of WBV on percent fat mass based on a subset of three different WBV devices. The mean changes in percent body fat for each category, as well as overall mean difference, are depicted in a forest plot (Figure 6) including the results of the risk of bias assessment for each study.

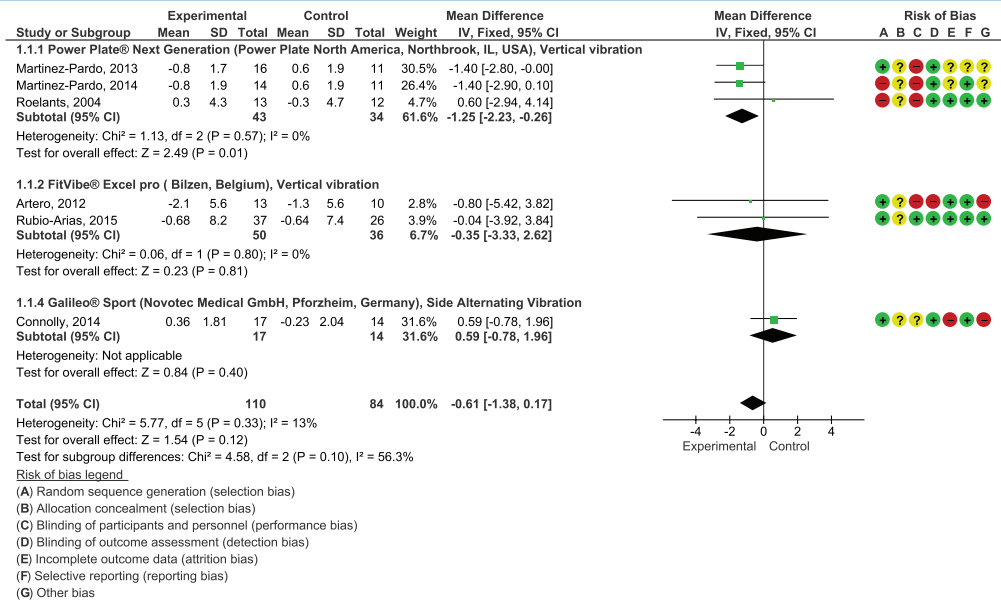


Figure 6. The effects of WBV therapy on percent body fat stratified by WBV devices, & risk of bias Summary.

The results of the Martinez-Pardo 2013 and 2014 studies were entered for the high amplitude WBV, and three days of intervention. The combined effects of WBV on percent fat mass in the first three studies which used Power Plate® was -1.25 (95% CI: -2.23, -0.26) that is clinically significant. The total effects of WBV on percent fat mass in the second group of studies which used FitVibe® was -0.35 (95% CI: -3.33, 2.62) that is not significant. The overall mean change was -0.61 (95% CI: -1.38, 0.17) and p-value of overall effect was 0.12 for all three groups of devices. The estimate from these trials showed no statistically significant difference in mean change in percent body fat. There was no evidence of heterogeneity across the studies within the device groups and in total ($I^2=13\%$, $P\text{-value}=0.33$).

Discussion

The findings of this systematic review and meta-analyses showed a significant effects of WBV on total fat mas per kg with small and statistically non-significant effects of WBV on percent body fat among the adult general population. Despite the overall effects of WBV on percent fat mass, the observed changes were not statistically significant due to a potential lack of power secondary to small sample size, however the Power Plate® device showed significant results for the effects of WBV on changes in percent fat mass. Although the effects of WBV on the percent fat mass and total fat mass per kg in some studies was not significant, other indices indicated a significant change in favor of WBV. For example, in the study by Roelants et al.⁹ the changes in percent fat were not significant, but the investigators reported significant differences in fat-free mass within the vibration group with a 2.2% increase

after 24 weeks of training. A similar result was obtained in the study by Martinez-Pardo et al.³ who evaluated the effects of WBV by varying the training frequency (2 or 3 sessions per week). They did not report any statistically significant changes in the total fat mass or percent fat in any of the groups. Martinez-Pardo et al. (2013) also reported no statistically significant difference in the change in fat mass after WBV training. However, lean mass increased significantly in the group that trained with a high amplitude between the pretest and posttest, without significant changes in the experimental group that participated in low amplitude vibration, nor the control group. Therefore, the beneficial effects of WBV in the normal weight adult population are reflected as increasing lean body mass via muscle hypertrophy instead of decreasing percent body fat. A prior study reported WBV has a greater potential to reduce visceral adipose tissue, compared to a conventional exercise program consisting of combined aerobic and resistance training in obese adults⁵. Milanese et al. investigated the effects of whole-body vibration (WBV) alone and in association with localized radiofrequency on fat deposits in the young non-obese participants and found that eight weeks of WBV decreases leg and total body fat mass in young non-obese women¹³.

The insignificant effects of WBV on body fat in each study may be due to the chosen WBV parameters (posture, amplitude and frequency). The cardiovascular benefits produced by WBV are moderate, and energy expenditure is comparable to moderate intensity walking¹⁰. In the included studies, the WBV duration ranged from 6 to 24 weeks with twice or thrice-weekly intervention. Da Silva et al. (2007) analyzed the influence of WBV on energy expenditure, during both the active exercise phase and the short-recovery phase and found that in young men (18.3 ± 0.24 years), WBV therapy significantly increased energy consumption¹⁶.

Another study in a population with the same age group showed that the rate of oxidation of fats and carbohydrates, and oxygen consumption were positively affected with WBV therapy⁶. Thus, it could be concluded that for the effects of WBV on percent body fat, the duration of the intervention is key to assuring a positive outcome. Despite the increased energy consumption and oxidation of fat, Rittweger (2010) stated that a person weighing 70 kg while performing WBV would consume approximately 20 L h⁻¹, of oxygen assuming an energy equivalent of 20.9 kJ L⁻¹ of oxygen, and a caloric equivalent of 39 kJg⁻¹ of fat, implying a weight loss of 10 g of fat per hour.² Thus, it is reasonable to conclude that this type of exercise produces no loss of fat mass, as the duration of WBV is insufficient to elicit the desired reductions in body fat.

As a potential strength of these meta-analyses, all included studies were controlled trials including four randomized control trials. Some limitations should be considered prior to generalizing the results of this systematic review and meta-analyses including the following issues. First, most studies had a small sample size and a high risk of bias, resulting in a lack of power and internal validity. Second, the search strategy was restricted to articles published in English, which literally lead to excluding some significant publications. On the other hand, the low number of studies included for meta-analyses, make it impossible to assess the risk of publication bias. Third, the standard deviation of the mean difference for the third meta-analysis was calculated based on the reported standard deviation across different populations and vibration plates, when it should be paired standard deviation provided by the data calculation. The reason for this calculation was due to a lack of necessary information regarding paired sds reported in the selected studies. Although the overall mean change of the third meta-analysis based on calculated values was very close to the overall mean change of the first meta-analysis that conducted based on data provided in three studies. Fourth, the overall effects of WBV on total fat mass per kg as well as the significant effects of WBV on percent fat mass reported by power plate could be affected by the similarities in the two studies by Martinez-Pardo (2013 & 2014). Finally, some studies have investigated the effects of WBV on women or men and we did not do data analysis based on sex subgroups.

Conclusions and future studies

This systematic review and meta-analyses provides evidence for the effects of WBV on total fat mass per kg but the lack of effects of 6-24 weeks WBV therapy on percent body fat. Due to the small effect size, potential lack of power and considering the limited number of studies, small sample sizes and short duration of the intervention, the effects of WBV on percent fat mass was not statistically detectable. Future research may address alternate vibration parameters and the role of longitudinal WBV for addressing fat mass reduction in large homogeneous trials.

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