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REVIEW

Effects of vibration training on quality of life in older adults: a preliminary systematic review and meta-analysis

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Abstract

Purpose Older adults experience reduced quality of life (QOL). Vibration training has been applied in older adults. However, it remains inconclusive whether vibration training improves QOL in this population. This review summarized the effects of vibration training in changing eight domains of the Short Form-36 (SF-36) among older adults.

Methods Five randomized controlled trials enrolling 212 participants were included. The mean difference (MD) was calculated as the effect size measurement. Meta-analyses were completed for each of the eight SF-36 domains.

Results Relative to control groups, vibration training is more effective in improving five QOL domains: physical function (MD = 15.61, $p < 0.001$), physical role limitations (MD = 12.71, $p = 0.001$), general health (MD = 10.59, $p < 0.001$), social function (MD = 11.60, $p < 0.001$), and vitality (MD = 6.86, $p = 0.002$). Vibration training may not lead to greater improvements for the other three domains (MD = 0.13–3.25, p values = 0.21–0.96) than the control groups. Vibration training showed a low attrition rate of 7.1%.

Conclusion Vibration training programs may significantly improve five of eight SF-36 QOL domains. While three domains did not demonstrate significant improvements, results were slightly in favor of vibration training compared to the control groups. More rigorous studies are necessary to further confirm the effectiveness of vibration training on QOL in older adults.

Keywords Older adults · Physical activity · Quality of life · SF-36 · Vibration training

Plain summary

Older adults often experience a decline in physical and emotional health and social aspects of their lives. Quality of life is a person's perception of these three areas and is a key part of healthy aging. It has been well documented that physical activity positively impacts the quality of life in older adults. However, many seniors may not maintain a traditional exercise training-based physical activity schedule due to various barriers, such as the lack of physical capacity, economic constraints, and access to a training program. To encourage an active lifestyle, alternative physical activity training programs that are easy, safe, and convenient yet still offer the quality of life benefits are needed. Whole-body vibration training is an easy and low-intensity exercise. Although vibration training has been used for older adults to improve their quality of life, studies' findings are still inconsistent. This presents an obstacle to deploying vibration training in older adults to improve their quality of life. This study aimed to better understand the effects of vibration training on quality of life among older adults. Our results, based on five clinical trials, indicate that vibration training may improve some areas of quality of life in older adults. Our findings also demonstrate that vibration training is a safe and easy way for older adults to participate in physical activity, with a low dropout rate of 7.1%. We suggest the quality of life outcomes should be used in future studies concerning vibration training in older adults.

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Introduction

By 2034, 25% of Americans will be at least 65 years old [1]. With older age comes an increase in disability, comorbidity, and disease [2]. Many older adults are unable to undergo traditional modes of physical activity (e.g., running, resistance training, and supervised strength training) due to limited physical capacity or economic constraints [3], and some may be unwilling to maintain a physically active lifestyle due to frailty and fear of falling [4]. Given that 60% of older adults do not meet the guidelines for recommended daily physical activity [5, 6] and aging-related neurophysiological changes can lead to functional decline [7], exercise modes that safely provide benefits while demanding less-intense physical activities must be available to promote an active lifestyle and healthy aging.

Quality of life (QOL) is a key component of healthy aging [1, 2] as it is a multifarious concept assessing the perceived physical, mental, emotional, and social functioning [8]. Physical activity improves QOL among older adults [2, 9], and the resulting improvement in QOL can increase physical and mental functions in older adults. Physical activities positively influence symptoms of depression, anxiety, self-efficacy, and memory-related task performance, all of which can impair QOL [8, 10–12]. Thus, it is important for healthcare clinicians to incorporate physical activities which may positively influence QOL outcomes. As aforementioned, traditional physical activity-based training programs may not be appealing to some older adults. Therefore, easy, safe, and convenient yet effective alternatives are needed to maintain or improve QOL in older adults.

Whole-body vibration training (VT) has emerged as a low-intensity and passive exercise that may benefit people unable to follow complex instructions or tolerate higher activity demands [13–15]. During VT, trainees stand or sit on a vibrating platform that transmits mechanical stimulations to the body [12]. These intense mechanical oscillations stimulate sensorimotor systems, resulting in physiological changes and improved physical functions. It is theorized that the VT-induced increase in muscle strength is related to the vibration stimulating the muscle spindles, leading to muscle contractions, similar to what occurs with *tonic vibration reflex* [16, 17]. An additional theoretical construct accounting for the VT-related physical improvements is that VT inhibits the antagonist muscles through stretch reflexes, altering muscle coordination patterns and forces around the joints [17]. Previous studies documented that VT can enhance muscle strength, mobility, joint range of motion, and sensation among older adults [18, 19]. As these factors are related to QOL, their improvements could result in enhanced QOL [19, 20]. The low mechanical load and short sessions make VT an ideal alternative intervention for older adults to improve their QOL.

A limited number of studies assessing QOL outcomes after VT in older adults reported inconsistent findings. Some studies suggested that VT improves functional capacity, physical fitness, pain, general health, and energy in older adults [10, 11, 17, 21, 22]. Domains of social and emotional aspects and overall mental health were also found to improve in two studies following VT in older adults [10, 11]. However, other research found no VT-induced improvements in QOL measures for older adults [13, 22, 23].

Given the inconclusive findings among studies, it is important to conduct a meta-analysis to systematically examine the effects of VT on QOL among older adults. To our knowledge, only one other meta-analysis has explored the effectiveness of VT on QOL outcomes in older adults. However, this previous meta-analysis only included *two* studies and focused primarily on the impact of VT on muscle strength [24]. Therefore, an updated meta-analysis including more randomized controlled trials (RCT) is needed to target the effectiveness of VT on improving QOL among older adults. The purpose of this preliminary meta-analysis was to clarify the effects of VT in altering QOL among older adults based on more clinical trials. Based on previous findings, we hypothesized that VT could lead to more improved QOL among older adults than the control group. Our findings could provide meaningful evidence for the rehabilitation field to design VT-based interventions to improve QOL for older adults.

Methods

Research question

The purpose of this meta-analysis was to evaluate the effects of VT on QOL in older adults. The analysis was conducted based on the patient or population, intervention, comparison, and outcome structure (PICO) [25]. The older adults represented the population (P). The intervention (I) was the VT implemented to the experimental group, which was compared (C) to a control group not experiencing VT. The outcomes (O) were identified as the changes in QOL measurements from pre- to post-training assessments (Tables 1, 2, 3).

Data sources and searches

A literature search was performed following the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) statement [26]. The RCT assessing the effects of VT on older adults' QOL were searched for in the following databases for the period of January 2000-February 2022: APA PsycInfo, Cochrane Library, Embase, Google Scholar, PubMed, and Web of Science. MeSH search terms were used: "quality of life," "health related quality of life," "whole body vibration," and "older adults" (Table A1 in the Supplementary file).

Table 1 Summary of methodological quality of the included studies according to the PEDro scale

Study	Physiotherapy Evidence Database items											Total score
	1	2	3	4	5	6	7	8	9	10	11	
Bruyere [10]	Y	Y	N	Y	N	N	N	Y	Y	Y	Y	6
Furness [11]	Y	Y	N	Y	N	N	N	Y	N	Y	Y	5
Marín [36]	N	Y	N	Y	N	N	N	Y	N	Y	Y	5
Pessoa [21]	N	Y	Y	Y	N	N	Y	Y	N	Y	Y	7
Santin-Medeiros [23]	Y	Y	N	N	N	N	N	Y	N	N	Y	3

Physiotherapy Evidence Database (PEDro) items: 1: Eligibility criteria (not counted toward the overall score), 2: Random allocation, 3: Concealed allocation, 4: Baseline comparability, 5: Blind subjects, 6: Blind therapists, 7: Blind assessors, 8: Adequate follow-up, 9: Intention-to-treat analysis, 10: Between-group comparisons, 11: Point estimates and variability

The mean ± standard deviation PEDro score: 5.20 ± 1.48

N no, *Y* yes

Inclusion and exclusion criteria

Studies were screened independently by two authors (RB & FY) based on the following criteria: the study was (1) conducted among older adults (≥ 65 years); (2) an RCT with one group of participants that underwent VT and at least one control group; and (3) published in English (Fig. 1). No restrictions were applied to vibration parameters, including the amplitude, frequency, and dosage. To reduce outcome measurement heterogeneity, only studies adopting the Short-Form-36 (SF-36) as the QOL assessment were included. Studies were excluded if participants had any neurological diagnoses. No abstracts were included to warrant the meta-analysis' rigor.

SF-36 QOL outcomes

The SF-36 is a self-report questionnaire consisting of 36 multiple choice items in eight domains: physical function, role-physical, pain, general health, social function, role-emotional, mental health, and vitality [27]. These questions reflect an individual's perception of their state of health within these domains [28]. The responses to questions in each domain are summed and transformed to generate the domain score ranging from 0 ("poor health") to 100 ("good health"). The SF-36 has shown consistent reliability and validity for health outcome measurements in older adults [27–29].

Study quality assessment

The quality of studies was assessed using scoring records published on the Physiotherapy Evidence Database (PEDro) [30, 31]. PEDro is a specialized methodological assessment tool for randomized controlled trials in physiotherapy [32], with scores ranging from 0 (lowest quality) to 10 (highest quality).

Data extraction

For the meta-analyses, values from each of the eight QOL domains were extracted into a customized spreadsheet recording means and standard deviations (SD), and sample size for both VT and control groups at pre- and post-training assessments. If pre- to post-training change score in QOL domains was not provided, the authors were contacted. If authors did not respond, the mean and SD changes from pre- to post-training sessions were imputed from the identified means and SD according to the recommended approaches [5].

Intervention details of each group were obtained. For the VT group, the frequency (Hz), amplitude (mm), bouts (number of series and period of each series), repetitions (number of sessions/week), and duration (length of the training program) were collected or calculated. The control group information was extracted if available.

Meta-analyses

Review Manager 5.3 (RevMan, The Cochrane Collaboration, Nordic Cochrane Centre, Denmark) was utilized for the meta-analysis. The mean and SD values of the change in the QOL domains and sample size for each group were entered into RevMan to calculate the mean difference (MD). The MD was used as the effect size measurement to quantify the effects of VT on the eight SF-36 domains. The MD was combined across studies to attain a summary statistic, with the 95% confidence interval (CI). A significance level of $p < 0.05$ was used.

The results of the meta-analyses were presented as forest plots. The heterogeneity of the included studies was examined using the I^2 statistics, which describes the percentage of variation across studies due to heterogeneity. Given the large range of the I^2 values across studies and only five included studies in this meta-analysis, the fixed-effect model was used

Table 2 Participant demographic information and trial characteristics by study included in this meta-analysis

Study (Year, country)	Study setting	Participant information				
		Sample size		Age (years) (mean ± SD)	Female (%)	Health condition inclusion/exclusion
		Pre-training	Post-training			
Bruyere [10] (2005, Belgium)	Nursing facility	T: 22 C: 20	T: 16 C: 20	T: 84.5 ± 5.9 C: 78.9 ± 6.9	T: 81 C: 65	Ambulatory, without cognitive disorders, lower extremity replacements, and high-risk thromboembolism
Furness [11]* (2009, Australia)	Community-dwelling, living independently	T_1:18 T_2:18 T_3:19 C:18	T_1: 18 T_2: 18 T_3: 19 C: 18	Total: 72 ± 8	Total: 52	Independent with daily tasks, pass cognitive, vestibular, and visual acuity screening, and no durable medical equipment with ambulation. Minimum of 90% compliance vibration training. Without falls past 12 months, lower extremity replacement, reactive arthritis, vascular disease, vertigo, high-risk thromboembolism
Marín [36]$^{\Delta}$ (2011, Spain)	Community-dwelling	T_1:11 T_2:12 C: 11	T_1:10 T_2:10 C: 10	Total: 84.3 ± 7.4	Total: 53	Excluded for epilepsy, gallstones, kidney stones, neuromuscular or neurodegenerative diseases, stroke, serious heart sickness/implant/stent
Pessoa [21] (2017, Brazil)	Not reported (sedentary or moderately active)	T: 9 C: 11	T: 9 C: 9	T: 66.4 ± 2.6 C: 68.2 ± 2.4	T: 56 C: 56	Sedentary to moderately active (based upon physical activity questionnaire), able to follow protocol directions. Without self-reported diseases, history of smoking, labyrinthitis, neuromuscular or pulmonary diseases
Santin-Medeiros [23] (2017, Spain)	Adult day-center	T: 25 C: 18	T: 19 C: 18	Total: 82.4 ± 5.7	Total: 100	Failure to attend 80% of sessions. Without diabetes, cardiovascular disease, thrombosis, retinal/eye disease, epilepsy, musculoskeletal diseases that would impact performance

C control group, *T* vibration training group

*For Furness 2009 study: T_1: one session a week of vibration training, T_2: two sessions a week of vibration training, and T_3: three sessions a week of vibration training

$^{\Delta}$For Marín 2011 study: T_1: two sessions a week of vibration training, T_2: four sessions a week of vibration training

Table 3 Vibration training and control intervention information for each trial included in this meta-analysis

Study	Description of intervention program	Vibration intervention information						Adverse events
		Frequency and amplitude	Device	Bouts per session	Duration of bout	Weekly number of sessions	Duration of course	
Bruyere [10]	T: Stood on platform and participated in same PT regimen as control C: Physical therapy regimen: 10 min. of gait, lower extremity strengthening, transfer training, balance exercises	10–26 Hz 3–7 mm	Galileo 900, vertical platform	4	60 s	T: 3 C: 3	6 weeks	T: Two lost due to minor leg tingling C: None
Furness [11] *	T: Stood flat-soled shoes, legs 110° knee extension, stance 16 cm equidistant from center of platform. Handlebar for support C: Did not participate in any vibration training, no sham vibration training indicated	15–25 Hz 0.5 mm	Baldor Electrical, side-alternating platform	5	60 s	T_1: 1 T_2: 2 T_3: 3	6 weeks	No adverse events reported
Marín [36]$^{\Delta}$	T: Exercised for 8 weeks on a vibration platform, following three weeks of detraining. Subjects performed a lower-body-training program consisting of six different types of squats C: No training program	35–40 Hz 1.05–2.11 mm	Power Plate, vertical platform	4–8	30 s	T_1: 2 T_2: 4	8 weeks	No adverse events reported

Table 3 (continued)

Study	Description of intervention program	Vibration intervention information						Adverse events
		Frequency and amplitude	Device	Bouts per session	Duration of bout	Weekly number of sessions	Duration of course	
Pessoa [21] ¥	T: Stood barefoot with knees slightly flexed at 15°. Sham resistance: resistance free movements C: Resistance exercises: ~ 60 min. a session: upper and lower body with weight machine. Sham vibration training: stood on platform	35 Hz 2–4 mm	MY3 (Power Plate), vertical platform	10–20	60 s	T: 3 C: 3	12 weeks	No adverse events reported
Santin-Medeiros [23]	T: Various body position exercises: seated, standing, and squat C: No training program	20 Hz 2 mm	Fitvibe Excel Pro, vertical platform	6	30–35 s	T: 2	8 months–35 weeks	No adverse events reported

C control group, *T* vibration training group

*For Furness study: T_1: one session a week of vibration training, T_2: two sessions a week of vibration training, and T_3: three sessions a week of vibration training

$^{\Delta}$For Marín study: T_1: two sessions a week of vibration training, T_2: four sessions a week of vibration training

¥For Pessoa study: the third arm involving vibration training and resistance training was not used in this meta-analysis

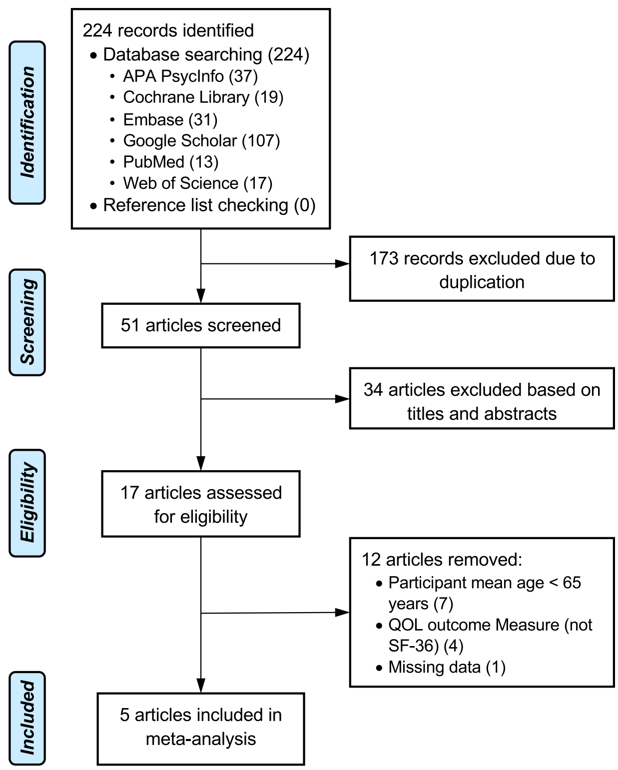


Fig. 1 A flow diagram of the number of studies identified, the number excluded and exclusion rationale, and the final number of studies included in this systematic review and meta-analysis. One study presented three comparisons [11], and another study presented two comparisons [36]

[33, 34]. Publication bias was not investigated with funnel plots since there were fewer than 10 publications for each QOL domain in the meta-analyses, as test power is typically too low to distinguish the change from real asymmetry [35].

Results

Study selection

The literature search of online databases identified 224 studies (Fig. 1). Two independent reviewers (RB & FY) screened all studies. Duplication removal eliminated 173 records, and an additional 34 articles were removed based on titles/abstracts. Seventeen full-text articles were assessed, and 12 studies were excluded pertaining to inclusion/exclusion criteria or missing data. As a result, five studies were included in this meta-analysis. One study utilized three different VT frequencies, so the three groups were considered and analyzed individually [11]. Another study included two VT groups and one control group, so these VT groups were also compared separately [36]. Therefore, *eight* comparisons from five studies were included.

Study characteristics

The studies were conducted in four countries: Australia [11], Belgium [10], Brazil [21], and Spain [23, 36] (Table 2). Intervention programs adopted for the control groups included no intervention [11, 23, 36], sham vibration (stood on a vibration platform with sound, but no vibration) [21], 10 min of maintenance physical therapy [10], and a 60-min resistance exercise regimen using a weight machine [21]. For control groups that performed an activity and/or sham vibration, the weekly number of sessions and training course duration were matched to the respective vibration treatment groups [10, 21].

The training sessions repeated 1 to 3 times per week over 6 to 35 weeks (Table 3). For the vibration intervention, the training included the following: VT only [11], VT combined with physical therapy [10], VT with body movement exercises without resistance [21], and simultaneous VT with resistance-free exercises [23, 36]. The vibration frequency and amplitude varied from 10 [10] to 35 Hz [21], and from 0.5 [11] to 7 mm [10], respectively.

Participant characteristics

The five studies included a total of 212 participants: 140 females and 72 males (Table 2). The average participant age ranged from 66.4 to 84.5 years. Study settings included a nursing facility [10], an adult day-center [23], and community-dwelling conditions [11, 36]. One study did not report a specific setting [21].

Among studies, 134 participants were in the VT groups, and 78 were allocated to control groups initially. For the VT group, 15 subjects were lost by the post-intervention assessment [10, 23, 36]. Among the 15 VT dropouts, two were due to reported adverse events [10], seven to personal reasons [10, 36], and six to unknown reasons [23]. Five control group participants withdrew across studies. Specifically, two participants dropped out due to relocation [21], and one withdrew for personal reasons [36]. Therefore, the attrition rate for the VT group across all studies was ~ 7.1% (15/212).

Quality assessment

The mean PEDro score for the five studies was 5.20 ± 1.48 with scores ranging from 3 [23] to 7 [21] (Table 1). The primary reason for the low quality of the included studies was the lack of a proper concealed group allocation [10, 11, 23, 36] and the blinding for subjects, therapists, and assessors [10, 11, 21, 23, 36].

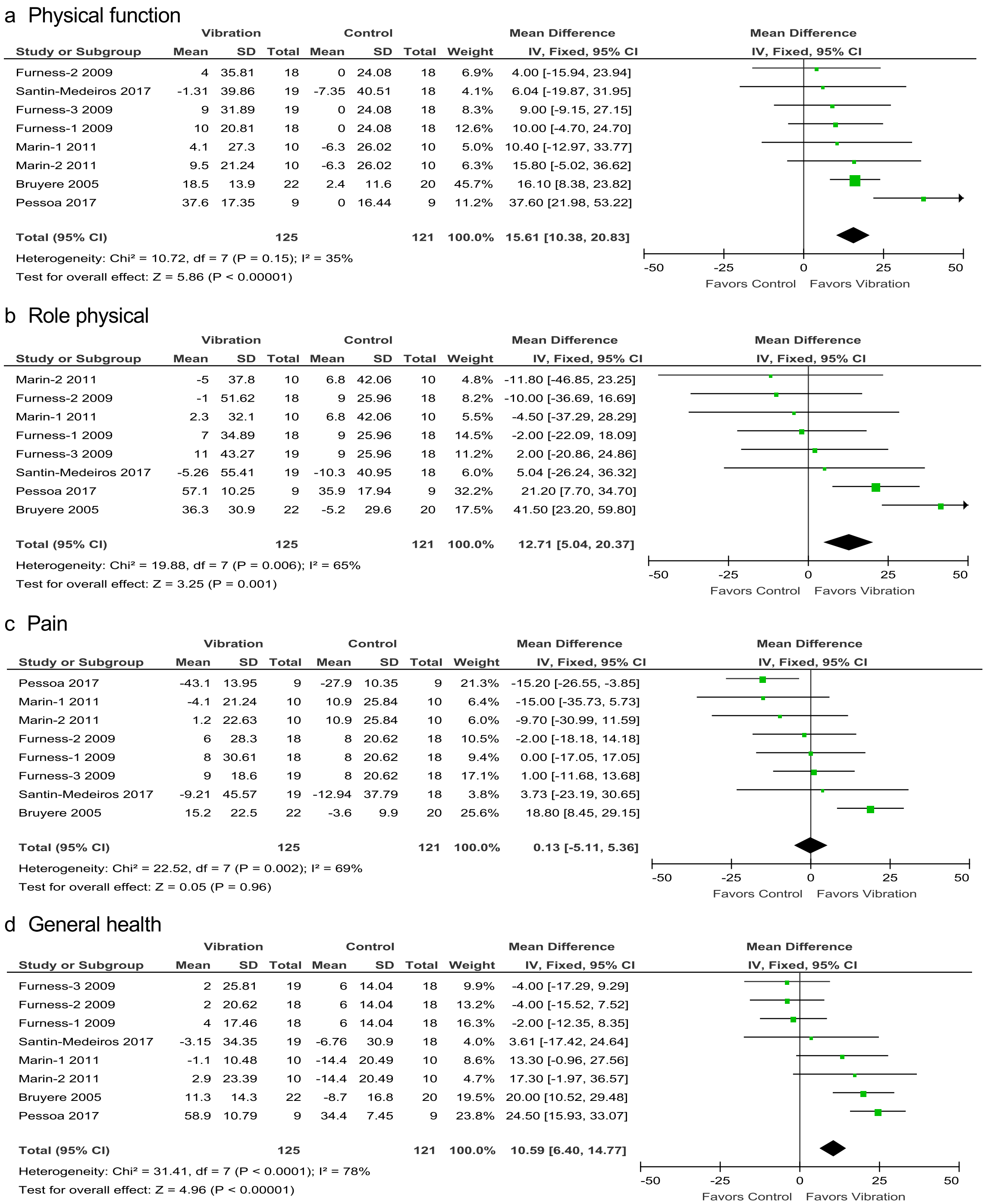


Fig. 2 Forest plot of effect sizes from eight comparisons in five studies that assessed the effects of whole-body vibration training (VT) on four physical health components of the Short-Form-36 (SF-36) Quality of Life assessment: **a** physical function, **b** role-physical, **c** pain, and **d** general health. Studies labeled as Furness-1, Furness-2, Furness-3 correspond to the once through thrice weekly sessions of VT received by these groups [11]. The study labeled as Marin-1 corresponds to VT training 2 days a week, and Marin-2 corresponds to VT training 4 days a week [36]. Please refer to Tables 2 and 3 for more details

Effect of VT intervention on SF-36 domains

Physical function

Variation was observed among the studies investigating the effect of vibration on the physical function QOL aspect with MD ranging from 4.00 to 37.60 (Fig. 2a). While all studies exhibited positive effects of VT on physical function, research by Pessoa and colleagues [21] was the most favorable for VT. Overall meta-analysis for the SF-36 physical function domain of the five studies yielded a statistically significant MD = 15.61, 95% CI [10.38, 20.83], $p < 0.001$, favoring VT.

Role-physical

The influence of VT on the physical role domain had varying results with an MD interval of − 11.80 to 41.50 (Fig. 2b). Four comparisons did not favor VT [11, 36]. The remaining four comparisons displayed positive effects of VT compared to the control group [10, 11, 21, 23]. The SF-36 physical role component summary results revealed a significant MD = 12.71, 95% CI [5.04, 20.37], $p = 0.001$, supporting VT improving the role-physical domain.

Pain

Considerable variation was seen in the effect of VT on the pain domain. Specifically, the MD varied from − 15.20 to 18.80 (Fig. 2c). One comparison strongly favored VT [10], while three other comparisons favored the control [21, 36]. The remaining comparisons showed a neutral effect [11, 23]. Though overall slightly in favor of VT, the pain meta-analysis was non-significant with an MD = 0.13 (95% CI [− 5.11, 5.36], $p = 0.96$).

General health

The findings of the effect of VT on the general health outcome of QOL demonstrated a relatively large MD span of − 4.00 to 24.50 (Fig. 2d). Four comparisons reported VT positively influenced participants with large effect sizes [10, 21, 36], one comparison suggested a slight benefit [23], and three comparisons minimally favored the control [11]. Collectively, the comparison of the general health domain between treatment and control groups reached an overall effect size of MD = 10.59 (95% CI [6.40, 14.77], $p < 0.001$), favoring VT.

Social function

A significant difference was noted in the effects of VT on the SF-36 QOL social function domain among studies. The MD ranged − 6.98 to 24.70 (Fig. 3a). Three comparisons [10, 21, 36] demonstrated strong favorability for VT, while three comparisons were minimally to moderately in favor of VT [11, 36]. Two comparisons [11, 23] favored the control group. Overall, the meta-analysis for the social function domain yielded a statistically significant MD = 11.60, 95% CI [6.17, 17.04] ($p < 0.001$).

Role-emotional

Variation in the effect size was observed among studies examining the effect of VT on the emotional role outcome of QOL. The MD spanned between − 21.00 and 30.00 (Fig. 3b). In five comparisons [11, 23, 36], the control group was favored over VT, while three comparisons favored VT [10, 21, 36]. The role-emotional domain meta-analysis revealed a small combined MD of 0.69 (95% CI [− 8.78, 10.16], $p = 0.89$).

Mental health

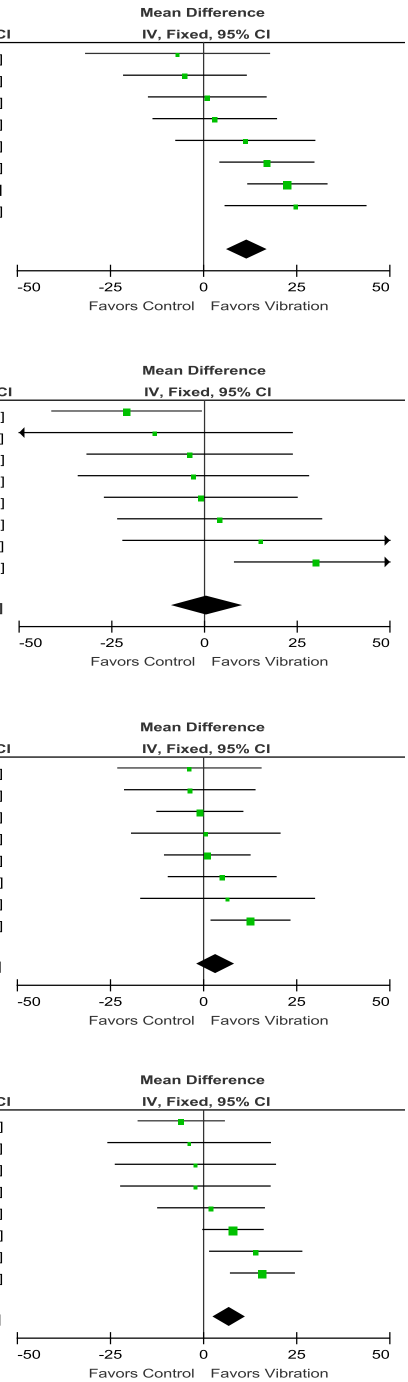
Some degree of difference was noted among studies investigating the effect of VT on the mental health domain, with the MD varying from − 3.80 to 12.60 (Fig. 3c). Five comparisons exhibited slight positive effects of VT on mental health [10, 11, 23, 36]. The pooled MD across comparisons was 3.25 (95% CI [− 1.80, 8.30], $p = 0.21$), in slight favor of VT.

Vitality

Four comparisons demonstrated positive effects of VT on the vitality dimension of QOL, with MD ranging between 2.00 and 15.80 (Fig. 3d) [10, 11, 21]. The other four comparisons suggested slightly negative effects of vibration on vitality [11, 23, 36]. Altogether, the meta-analysis produced a significant composite MD = 6.86 (95% CI [2.58, 11.14], $p = 0.002$).

Discussion

The purpose of this meta-analysis was to determine if VT can improve QOL among older adults by summarizing the relevant RCT. As the first meta-analysis to synthesize SF-36 QOL outcomes in older adults following VT, our study indicated that VT could significantly provide health benefits in improving QOL domains of physical function, physical role limitations, general health perception, social function, and vitality. However, VT seems no more effective than the control group in improving the other three SF-36 domains: bodily pain, role-emotional, and mental health. Although the findings from this meta-analysis



a Social function

Study or Subgroup	Vibration Mean	Vibration SD	Vibration Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Fixed, 95% CI
Santin-Medeiros 2017	-3.16	44.86	19	3.82	30.76	18	4.9%	-6.98 [-31.65, 17.69]
Furness-3 2009	-1	24.04	19	4	26.83	18	10.9%	-5.00 [-21.45, 11.45]
Furness-2 2009	5	21.1	18	4	26.83	18	11.9%	1.00 [-14.77, 16.77]
Furness-1 2009	7	23.77	18	4	26.83	18	10.8%	3.00 [-13.56, 19.56]
Marin-2 2011	-1.3	19.4	10	-12.5	22.99	10	8.5%	11.20 [-7.44, 29.84]
Pessoa 2017	62.8	13.45	9	45.8	13.86	9	18.6%	17.00 [4.38, 29.62]
Bruyere 2005	19.9	17.6	22	-2.6	17.5	20	26.2%	22.50 [11.87, 33.13]
Marin-1 2011	12.2	19.99	10	-12.5	22.99	10	8.3%	24.70 [5.82, 43.58]
Total (95% CI)			**125**			**121**	**100.0%**	**11.60 [6.17, 17.04]**

Heterogeneity: Chi² = 15.46, df = 7 (P = 0.03); I² = 55%
Test for overall effect: Z = 4.18 (P < 0.0001)

b Role emotional

Study or Subgroup	Vibration Mean	Vibration SD	Vibration Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Fixed, 95% CI
Furness-1 2009	-5	23.85	18	16	36.5	18	22.1%	-21.00 [-41.14, -0.86]
Marin-2 2011	-13.4	38.2	10	0	46.01	10	6.5%	-13.40 [-50.46, 23.66]
Furness-2 2009	12	47.51	18	16	36.5	18	11.7%	-4.00 [-31.68, 23.68]
Santin-Medeiros 2017	8.78	49.82	19	11.77	46.53	18	9.3%	-2.99 [-34.04, 28.06]
Furness-3 2009	15	43.91	19	16	36.5	18	13.3%	-1.00 [-26.96, 24.96]
Pessoa 2017	33.7	24.04	9	29.6	34.54	9	11.9%	4.10 [-23.39, 31.59]
Marin-1 2011	15.2	38.52	10	0	46.01	10	6.5%	15.20 [-21.99, 52.39]
Bruyere 2005	31.7	38.2	22	1.7	34.2	20	18.7%	30.00 [8.10, 51.90]
Total (95% CI)			**125**			**121**	**100.0%**	**0.69 [-8.78, 10.16]**

Heterogeneity: Chi² = 12.72, df = 7 (P = 0.08); I² = 45%
Test for overall effect: Z = 0.14 (P = 0.89)

c Mental health

Study or Subgroup	Vibration Mean	Vibration SD	Vibration Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Fixed, 95% CI
Marin-1 2011	-2.1	19.14	10	1.7	24.37	10	6.9%	-3.80 [-23.01, 15.41]
Pessoa 2017	0.1	10.91	9	3.8	24.44	9	8.3%	-3.70 [-21.19, 13.79]
Furness-2 2009	1	16.28	18	2	18.87	18	19.2%	-1.00 [-12.51, 10.51]
Marin-2 2011	2.3	20.97	10	1.7	24.37	10	6.4%	0.60 [-19.33, 20.53]
Furness-1 2009	3	16.13	18	2	18.87	18	19.4%	1.00 [-10.47, 12.47]
Furness-3 2009	7	25.61	19	2	18.87	18	12.2%	5.00 [-9.44, 19.44]
Santin-Medeiros 2017	-2.95	39.9	19	-9.41	32.21	18	4.7%	6.46 [-16.85, 29.77]
Bruyere 2005	10.1	17.1	22	-2.5	17.8	20	22.8%	12.60 [2.02, 23.18]
Total (95% CI)			**125**			**121**	**100.0%**	**3.25 [-1.80, 8.30]**

Heterogeneity: Chi² = 4.99, df = 7 (P = 0.66); I² = 0%
Test for overall effect: Z = 1.26 (P = 0.21)

d Vitality

Study or Subgroup	Vibration Mean	Vibration SD	Vibration Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Fixed, 95% CI
Furness-2 2009	0	19.11	18	6	16.13	18	13.7%	-6.00 [-17.55, 5.55]
Santin-Medeiros 2017	-5.79	29.92	19	-1.91	37.12	18	3.9%	-3.88 [-25.68, 17.92]
Marin-2 2011	1.5	22.09	10	3.7	26.71	10	4.0%	-2.20 [-23.68, 19.28]
Marin-1 2011	1.5	18.22	10	3.7	26.71	10	4.6%	-2.20 [-22.24, 17.84]
Furness-1 2009	8	26.4	18	6	16.13	18	9.0%	2.00 [-12.29, 16.29]
Pessoa 2017	67.4	7.93	9	59.5	9.52	9	27.9%	7.90 [-0.19, 15.99]
Furness-3 2009	20	21.93	19	6	16.13	18	12.0%	14.00 [1.64, 26.36]
Bruyere 2005	15	15.7	22	-0.8	12.5	20	25.0%	15.80 [7.25, 24.35]
Total (95% CI)			**125**			**121**	**100.0%**	**6.86 [2.58, 11.14]**

Heterogeneity: Chi² = 13.15, df = 7 (P = 0.07); I² = 47%
Test for overall effect: Z = 3.14 (P = 0.002)

Fig. 3 Forest plot of effect sizes from five studies that assessed the effects of vibration training on four mental health components of the Short-Form-36 (SF-36) Quality of Life instrument: **a** social function, **b** role-emotional, **c** mental health, and **d** vitality

partially support our hypothesis, they could have important implications for health interventions aimed at older adults. Our findings implied that interventions, which simultaneously promote positive changes of both physical and mental aspects of health, provide an opportunity to significantly improve overall QOL outcomes with a minimal societal burden for older adults.

VT is associated with significant positive changes in five of the eight domains of QOL measures from the SF-36: physical functions, physical role limitations, general health perceptions, social functions, and vitality. The physical functions domain relates to perceived physical performance and the role-physical domain corresponds to perceived limitations due to physical health problems [27, 37]. These two subjective domains closely correspond to the objective physical performance of older adults [21, 38]. As an alternative exercise, VT improves physical functions in older adults, such as muscle strength and power, range of motion, balance, and mobility [18, 39]. Therefore, it is plausible to associate the improvements in the physical functions and physical role limitations domains with VT. This finding indicates that the subjective assessment is consistent with the objective evaluation of the VT-induced improvements in physical capacity.

With a propensity to a more sedentary lifestyle, the lack of physical activity among older adults negatively impacts mental health [38, 40]. The overall results of the vitality (or energy and fatigue) domain indicated positive benefits of VT. Though exact reasons for this QOL domain improvement are unknown, a few theoretical constructs offer possible explanations. For example, it is postulated that the improvement in perceived energy levels is a result of sensory information caused by vibration stimulation [20]. Specifically, skin mechanoreceptors sensitive to vibratory stimuli may activate an excitatory sensory response, which ultimately results in an excitatory response to the brain [41], theoretically producing a perceived decrease in fatigue. Another explanation is that by refining muscle coordination patterns and increasing strength through tonic vibration reflex, vibration can effectively lead to enhanced neuromuscular efficiency, thereby reducing muscular fatigue [16, 17, 42]. In turn, the perceived fatigue reduction can improve the perceptions of general health, thus enhancing the QOL outcomes in older adults.

Although our results did not suggest that VT groups exhibit significantly more improvements than the control groups in three QOL domains (bodily pain, limitations due to emotional problems, and mental health), there remains some uncertainty regarding the effect of VT. Specifically, the effect size for mental health (MD = 3.25) is positive, and the bodily pain (MD = 0.13) and role-emotion (MD = 0.69) domains are close to the “null effect.” Given such a wide range of MD and the small number of studies included, it is premature to draw a definitive conclusion about VT’s effect on these three domains. The MD heterogeneity could be attributed to the large variation in the VT protocol, such as the vibration parameters, number of bouts per session, number of sessions per week, and the training duration (Table 3). For example, the treatment duration in one study [23] was two to three folds longer than other studies, and their findings are inconsistent [10, 11, 21]. Notably, the study with a longer training duration reported significant positive changes in QOL in older adults, whereas studies adopting shorter treatment durations did not [23]. The evidence suggests that the length, intensity, and repetition of the vibration intervention could impact the efficacy of VT. This finding aligns with a previous meta-analysis that reported a positive correlation between the training dosage (determined by the duration of vibration exposure and the vibration intensity) and the effect size of VT [15].

VT could be well-tolerated and accepted by older adults, as indicated by the low attrition rate (7.1%) over the entire study period. This rate is drastically lower than the attrition for other types of exercise-based interventions [40, 43]. The high adherence rate could be because VT is a simple, safe, and convenient intervention and well-suited for use in clinics, nursing homes, community centers, and even homes to train older adults [44, 45]. Moreover, VT could be an attractive alternative to engage older adults in physical activity when other options are limited due to a public health crisis, such as the global COVID-19 pandemic.

A strength of this study is the use of SF-36 as the outcome measurement of QOL and that each SF-36 domain was considered individually. Previous studies indicated that the SF-36 appears to be sensitive to changes in clinical manifestations of both physical and mental health conditions [46, 47]. Therefore, it can detect minimal functional changes relevant to independent living. Furthermore, the adoption of SF-36 in the current study reduces the heterogeneity in QOL measurement and thus the selection bias. As the eight SF-36 domains reflect both physical and mental components of health-related QOL, an overall SF-36 QOL composite score is not recommended [28]. Conversely, the separate analysis of each SF-36 domain can provide us insights into the effect of VT on the QOL in a more specific and meaningful way.

The present findings extend our understanding of the application of VT in rehabilitation among different populations. A recent study reported that a 6-week VT course improves SF-36 QOL physical domains among people with multiple sclerosis [48]. Another 6-week VT study found that SF-36 QOL domains of general health, pain, vitality, and social and physical functions improved in older adults with diabetic peripheral neuropathy [38]. Finally, a recent systematic review that evaluated the effects of VT on QOL outcomes in people with chronic health conditions indicated that four out of seven RCT demonstrated significant improvement in QOL measures as a result of VT compared to a non-intervention group [49].

As stated, the PEDro scale rates RCT between 0 and 10, with 6 presenting the cut-off score for high-quality studies [32]. Two included studies were good quality (score: 6–7) [10, 21], two were fair quality (5) [11, 36], and one was poor quality (3) [23]. The mean PEDro score of included studies was 5.20 ± 1.48, indicating a fair to good quality, which is comparable to the overall quality of 5.27 ± 1.63 for RCT in the physical therapy field [50]. In addition, our PEDro score is similar to or higher than the average PEDro scores reported in review articles regarding QOL in older adults [51, 52]. Furthermore, removing the poor quality trial [23] from meta-analysis did not change our overall findings. However, more studies with higher methodological quality investigating VT and QOL in older adults are needed.

This meta-analysis has limitations. First, RCT using instruments other than SF-36 for QOL measurements were excluded. This was done to reduce inconsistency in the structure of the QOL instruments and control heterogeneity among studies but could limit our capability to comprehensively evaluate the effects of VT on QOL in older adults. Second, the number of studies included was small. This small sample may partly explain the high diversity in our meta-analyses. Provided the small sample size, this meta-analysis should be considered preliminary but can provide some guidance for designing more rigorous RCT with large samples to further determine the efficacy of VT on improving QOL among older adults. Third, the VT training protocols varied widely between studies, leading to wide-ranging training volumes and dosages. More high-quality RCT are needed to conduct sub-group analyses to inspect the dosage effects of VT improving QOL in older adults. Fourth, our analysis does not provide a direct comparison of QOL with more objective measures of physical performance, such as strength, power, and balance. Fifth, tests for funnel plot asymmetry, indicative of potential publication biases, were not conducted owing to the small sample size. Lastly, articles not published in English were removed, possibly excluding some studies concerned about VT's effects on improving SF-36-based QOL in older adults. Our findings should be interpreted while considering these limitations.

It should be noted that although small sample size did not allow for sub-group analysis, an informal inspection of VT parameters of the included studies suggests that a VT protocol with a weekly frequency of three sessions, bouts longer than 60 s, and vibration amplitude larger than 2-mm could lead to health benefits and QOL improvements in older adults. While this observation can provide some preliminary guidance for designing future VT interventions to improve QOL in older adults, additional analyses based on more rigorous studies are required to validate and confirm these findings.

Conclusion

This preliminary meta-analysis indicated that VT programs, relative to the control groups, may significantly improve SF-36 domains of physical function, physical role limitations, general health perception, social function, and vitality among older adults. Although domains of bodily pain, role-emotional, and mental health did not demonstrate significant improvements, results were still slightly in favor of VT over the control group. More high-quality research to investigate the effectiveness of VT on improving QOL in older adults is needed.

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Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose.

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