Quality of Life Research (2019) 28:2859–2870
https://doi.org/10.1007/s11136-019-02274-x

REVIEW

The effect of whole body vibration on health-related quality of life in patients with chronic conditions: a systematic review

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Accepted: 12 August 2019 / Published online: 30 August 2019

Abstract

Purpose To identify the effects of whole body vibration (WBV) on health-related quality of life (HRQOL) in patients with chronic conditions.

Methods Five databases (the Cochrane Library, PubMed, Medline, EBSCO, and Web of science) were searched (from inception until April 30, 2019) for original articles. All studies were randomized controlled trials reporting the effects of WBV on HRQOL. Two independent reviewers extracted trial data and assessed the risk of bias using the risk of bias tool recommended by the Cochrane Back Review Group.

Results Of the 349 articles that were screened, 17 articles, including 763 participants with various chronic conditions, met the inclusion criteria. Six studies reported significant improvements in HRQOL. No evidence was observed to suggest that WBV was more effective than other types of exercises. The study participants, exercise protocols, HRQOL instruments, study duration, and frequency as well as amplitude of WBV varied across the studies. Meta-analysis was not conducted due to the heterogeneity of study designs and outcome measures.

Conclusions This study has demonstrated that WBV may improve HRQOL in patients with chronic conditions. However, the evidence was not strong enough to warrant recommendation and thus further high-quality studies with larger sample sizes and longer intervention durations are needed.

Keywords Whole body vibration · Health-related quality of life · Chronic conditions · Systematic review

Introduction

Whole body vibration (WBV) is a type of training that involves the application of a vibratory stimulus to the entire body with the help of a vibration platform [1–3]. During WBV, various exercises can be performed while standing on a platform from which forces with varying frequencies and amplitudes can be transferred into separate body parts using precise joint angles [3, 4]. In recent years, WBV has been widely promoted and has demonstrated favorable outcomes in the rehabilitation of various populations with chronic conditions.

Numerous studies have examined the effects of WBV on muscle strength, balance ability, mobility, pain, lung function, cognitive performance, vasodilatory capacity, and daily activities [1, 4–13]. Previous reviews have reported a positive effect of WBV in older adults, patients with fibromyalgia, chronic obstructive pulmonary disease (COPD), diabetes, osteoarthritis, stroke, spinal cord injury, or cerebral palsy [1, 5, 11, 13–23]. The mechanisms of WBV may be related to certain effects of vibration, such as stimulation of subcutaneous proprioceptors, muscle spindles that cause muscle contraction, and Golgi tendon organs that improve tonic and antagonist vibration reflexes [13, 22, 24].

Chronic conditions in patients usually impact health-related quality of life (HRQOL), which are associated with symptoms such as impaired physical and cognitive function,

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fatigue, pain, sleep disorders, and depression [25–30]. To our knowledge, there is a lack of evidence demonstrating the effects of WBV on HRQOL. Therefore, a systematic review was conducted to summarize and evaluate randomized controlled trials (RCTs) that examined the effects of WBV on HRQOL in patients with chronic conditions.

Methods

Protocol and registration

The review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta Analyses (PRISMA) guidelines. The protocol was not registered prior to conducting the review.

Search strategy

Five databases (the Cochrane Library, PubMed, Medline, EBSCO, and Web of science) were searched (from inception until April 30, 2019) for original articles. The following keywords were used for the search strategy of our review: ("whole body vibration" or "WBV" or "vibration") and ("quality of life" or "heath-related quality of life" or "life quality''). The search was limited to studies performed on human subjects and publications in English. Reference lists of all potentially relevant articles and other reviews in the field were reviewed to identify any studies that were missed in the electronic database search.

Eligibility criteria

The following conditions had to be met in order to include a study in this review:

(1) Types of studies: randomized controlled trials (RCTs) reported in a full paper article were eligible. Observational and other types of studies were excluded in this review.
(2) Types of participants: studies including adults (18 years of age and older) with chronic conditions were eligible. Chronic conditions were defined as generally progressive long-term medical conditions, commonly including heart and lung diseases, diabetes, cancers, and stroke.
(3) Types of interventions: interventions using WBV that clearly described the exercise training were eligible.
(4) Types of outcome measures: studies in which HRQOL was assessed as a primary or secondary outcome were eligible. Acceptable outcome measures were validated measures, e.g., the Short Form 36 Health Survey (SF-36).

Data extraction and quality assessment

For each included trial, two different reviewers independently extracted all relevant data and trial quality information. The quality of each trial was appraised using The Cochrane Collaboration's "Risk of bias" tool. We omitted the domain that assessed the blinding of participants, as we were of the opinion that this domain is related to the nature of the intervention and not the quality of the study. All the data were checked by a third reviewer and any discrepancies were discussed until consensus was achieved.

Results

Description of included studies

A total of 349 articles were initially identified from the database searches, among which 38 articles were candidates. After duplicate removal and title and abstract screening, a total of 17 articles met the inclusion criteria and were included (Fig. 1). The characteristics of the articles are summarized in Table 1. The studies were conducted in Germany ($n=4$), Spain ($n=3$), Brazil ($n=3$), China ($n=3$), Belgium ($n=2$), and Iran ($n=2$). A total of 763 participants met the

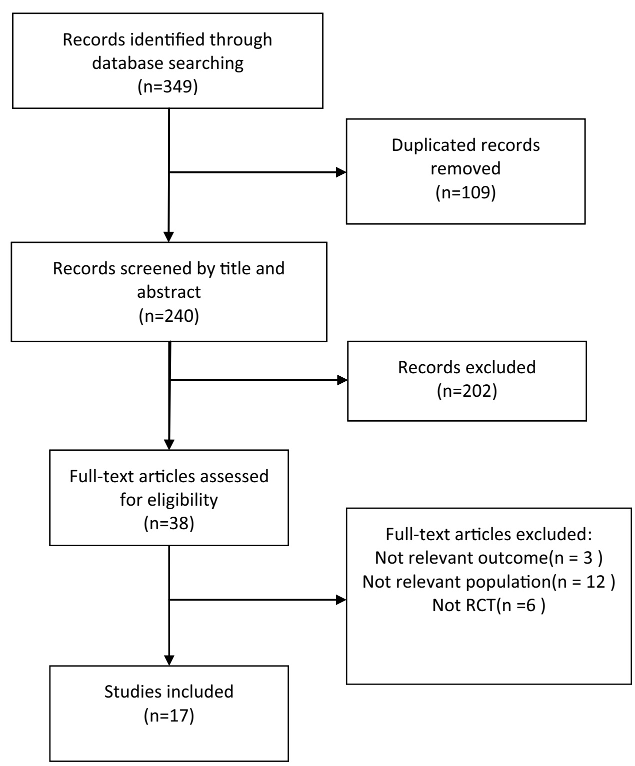

Fig. 1 Flow chart of the study selection process for this review

Table 1 Characteristics of the included studies in this systematic review

Clinical domains	Study(country)		Participants			Intervention	Duration of WBV	Quality-of-life measures	Dropout rate (%)	Adherence rate	Favors WBV
			Sample size	Age	Female (%)						
Chronic obstructive pulmonary disease	Gloeck et al. (Germany) [33]	Exp	42	64 (11)	55	Inpatient rehabilitation + squat exercises on a WBV platform at 24–26 Hz, 6 mm amplitude	3 × 3-min/3 times per week × 3 weeks	CRQ	14.3	–	No
		Con	40	65 (7)	48	Inpatient rehabilitation + squat exercises on the floor			10	–	
	Greulich et al. (Germany) [32]	Exp	20	66.4 (9.93)	30	Standard physiotherapy consisted of mobilization to, respiratory therapy and passive muscle movements+WBVT	3 × 2-min/day of admission—day of discharge	SGRQ/CAT	13	–	No
		Con	20	70.4 (10.1)	40	Standard physiotherapy consisted of mobilization to, respiratory therapy and passive muscle movements			23.1	–	
	Salhi et al. (Belgium) [34]	Exp	31	58	32	Aerobic training + lower body exercises on a WBV platform at 27 Hz, 2 mm amplitude	Progressively increased/3 times per week × 12 weeks	CRQ	16.1	66.7%	No
		Con	31	63	26	Aerobic training + resistance training			19.4	80.6%	
	Spielmanns et al. (Germany) [35]	Exp	14	69	50	WBV at 6–10 Hz, 4–6 mm amplitude	Progressively increased/2 times per week × 12 weeks	SGRQ/CAT	6.7	–	No
		Con	13	70	46	Calisthenics training			7.1	–	
	Braz Júnior et al. (Brazil) [36]	Exp	A total of 11 subjects, crossover study	62.91 (8.82)	27	WBV	Progressively increased/3 times per week × 12 weeks	SGRQ	26.7	100%	Yes
		Con				No intervention			0	–	

Table 1 (continued)

Clinical domains	Study(country)		Participants			Intervention	Duration of WBV	Quality-of-life measures	Dropout rate (%)	Adherence rate	Favors WBV
			Sample size	Age	Female (%)						
Respiratory cancer	Salhi et al. (Belgium) [37]	Exp	22	60	32	Aerobic training + WBV at 27 Hz	3 × 30 s/3 times per week × 12 weeks	EORTC QLQ-C30	22.7	–	No
		Con 1	24	63	25	Aerobic training + resistance training			16.7	–	
		Con 2	24	64	25	No intervention			12.5	–	
Pulmonary arterial hypertension	Gerhardt et al. (Germany) [38]	Exp	11	65.1 (5.0)	64	Perform exercises on WBV platform at 20 Hz, 20 mm amplitude	16 sessions of 1-hour duration within 4 weeks	SF-36/LPH	0	–	Yes
		Con	11	46.0(3.7)	55	Waiting list			0	–	
Knee osteoarthritis	Wang et al. (China) [39]	Exp	49	61.2 (9.6)	73	Quadriceps resistance training + WBV at 35 Hz, 4–6 mm amplitude	30 min per day/5 times per week × 24 weeks	SF-36	0	–	Yes
		Con	50	61.5 (9.1)	70	Quadriceps resistance training			0	–	
	Bokaeian et al. (Iran) [43]	Exp	15	51.8 (8.37)	100	Strengthening training + WBV at 25–30 Hz, 2 mm amplitude	3 × 2-min/3 times per week × 8 weeks	WOMAC	0	–	No
		Con	13	54.0 (3.9)	69	Strengthening training			15.4	–	
Fibromyalgia	Olivares et al. (Spain) [44]	Exp	18	52.4 (10.8)	100	WBV at 12.5 Hz	Progressively increased/3 times per week × 12 weeks	FIQ/15D	14.3	–	Yes
		Con	18	53.0 (12.0)	100	No intervention			10	–	
	Alentorn-Geli et al. (Spain) [45]	Exp	11	55.2 (3.4)	100	Aerobic training + WBV at 30 Hz, 2 mm amplitude	90 min per day/2 times per week × 6 weeks	FIQ	8.3	93%	Yes
		Con 1	12	53.7 (2.7)	100	Aerobic training			0	92%	
		Con 2	10	59.3 (2.3)	100	No intervention			16.7	–	
Stroke	Liao et al. (China) [41]	Exp 1	28	60.8 (8.3)	29	Exercise on a WBV platform at 20 Hz, 1 mm amplitude	Progressively increased/3 times per week × 12 weeks	SF-12	17.9	–	No

Table 1 (continued)

Clinical domains	Study(country)		Participants			Intervention	Duration of WBV	Quality-of-life measures	Dropout rate (%)	Adherence rate	Favors WBV
			Sample size	Age	Female (%)						
		Exp 2	28	62.9 (10.2)	36	Exercise on a WBV platform at 30 Hz, 1 mm amplitude	Progressively increased/30 training sessions over an average period of 75.5 d		14.3	–	
		Con	28	59.8 (9.1)	14	Exercise standing on the WBV platform, but no WBV was delivered			3.6	–	
Dementia	Lam et al. (China) [42]	Exp	27	79.7 (5.5)	70	Conventional daycare program involved exercise, + WBV at 30 Hz, 2 mm amplitude	Progressively increased/2 times per week × 9 weeks	QOL-AD	3.7	86%	No
		Con	27	79.9 (6.7)	78	Conventional daycare program involved exercise			3.7	–	
Multiple sclerosis	Escudero-Uribe et al. (Spain) [40]	Exp	16	43.1 (10.2)	63	Exercise on WBV at 4 Hz, 3 mm amplitude	Progressively increased/2 times per week × 12 weeks	MusiQol	15.8	80%	No
		Con 1	14	40.3 (8.9)	64	Exercise on balance trainer			22.2	79.5%	
		Con 2	18	43.0 (9.3)	78	Waiting list			0	–	
	Ebrahimi et al. (Iran) [46]	Exp	16	37.06 (8.42)	69	Low-intensity exercise on a WBV platform at 2–20 Hz, 2 mm amplitude	3 times per week × 10 weeks	MSQOL-54	5.9	–	No
		Con	14	40.75 (10.56)	86	No intervention			17.6	–	
Chronic kidney disease	Fuzari et al. (Brazil) [47]	Exp	8	60.50 (9.91)	–	WBV at 35 Hz, 2–4 mm amplitude	Progressively increased/2 times per week × 12 weeks	KDQOL-SF™	0	–	No
		Con	8	53.63 (7.70)	–	Sham exercise			0	–	
Metabolic syndrome	Carvalho-Lima et al. (Brazil) [31]	Exp 1	7	–	–	WBV at 5–14 Hz, 2.5–7.5 mm amplitude	Once per week × 10 weeks	WHOQOL-BREF	0	–	Yes

Table 1 (continued)

Clinical domains	Study(country)	Participants				Intervention	Duration of WBV	Quality-of-life measures	Dropout rate (%)	Adherence rate	Favors WBV
			Sample size	Age	Female (%)						
		Exp 2	7	–	–	WBV at 5–14 Hz, 2.5–7.5 mm amplitude	2 times per week × 10 weeks		0	–	
		Con	7	–	–	Exercise standing on the WBV platform, but no WBV was delivered			0	–	

Exp experimental group, *Con* control group, *WBV* whole body vibration, *CRQ* Chronic Respiratory Questionnaire, *SGRQ* Saint George's quality-of-life questionnaire, *CAT* COPD assessment test, *EORTC QLQ-C30* the European Organisation for Research and Treatment of Cancer quality-of-life cancer questionnaire, *SF-36* the short form (36) health survey, *LPH* living with pulmonary hypertension, *WOMAC* Western Ontario and McMaster Universities Osteoarthritis Index, *FIQ* Fibromyalgia Impact Questionnaire, *15D* the 15D instrument of health-related quality of life, *SF-12* the short form 12 health survey, *QOL-AD* quality of life in Alzheimer's disease, *MusiQol* the Multiple Sclerosis International Quality of Life, *MSQOL-54* the Multiple Sclerosis Quality of Life-54 questionnaire, *KDQOL-SF*™ the Kidney Disease Quality of Life–short form, *WHOQOL-BREF* the World Health Organization's quality-of-life questionnaire-brief version

inclusion criteria in the included studies. Sample size per RCT ranged between 11 and 99 participants. The mean age of participants ranged between 37 and 79 years, excluding one study that did not report mean age [31]. The male-to-female ratio was approximately 5:6, although it was not always clearly reported.

The duration of WBV was 3–24 weeks, excluding one study that did not specify [32]. During intervention, the participants either stood or performed exercises on a side-alternating vibration platform. The frequency ranged between 2 and 35 Hz, and the amplitude ranged between 1 and 20 mm. The instruments used to measure HRQOL varied across studies. Nine studies reported that no severe adverse events had been observed in the WBV group [32–40]. One study stated that one participant reported mild knee pain and five reported fatigue in the WBV group [41]. One study stated that two participants reported mild knee pain in the WBV group [42].

Because of the heterogeneity of study designs and outcome measures, a meta-analysis was not feasible. We categorized all included articles into clinical domains and summarized information from each study, including the detailed interventions of WBV, participant information, and quality-of-life outcome measures (Table 1).

Respiratory disease

Seven studies investigated respiratory disease [32–38], including COPD (five studies) [32–36], respiratory cancer (one study) [37], and pulmonary arterial hypertension (one study) [38]. WBV was used as an additional therapy combined with a conventional approach in four studies [32–34, 37], whereas WBV was performed alone in three studies [35, 36, 38]. Two studies demonstrated statistical differences in HRQOL between groups [36, 38].

Five RCTs with a total of 222 participants reported effects of WBV on patients with COPD [32–36]. These studies used the Chronic Respiratory Questionnaire, Saint George's Quality-of-Life Questionnaire, and COPD assessment test, which were designed to measure respiratory disease-related quality of life. Three studies performed WBV as an additional exercise in the experimental group [32–34]. Two studies involved exercise on the WBV platform [33, 34], and three studies involved participants that stood on bent knees on the WBV platform during intervention [32, 35, 36]. The frequency of WBV ranged from 2 to 3 times per week, except one study in which the time interval was between hospital admission and discharge [32]. Squat exercise, physiotherapy, resistance training, calisthenics training, and control were conducted in the control groups. Four studies found a slight improvement of HRQOL in the WBV group [32–34, 36], but only one study showed statistically significant differences [36].

One study conducted a three-armed study to investigate the effects of 12-week WBV performed in addition to aerobic training in patients with radically treated respiratory cancer, compared to aerobic and resistance training alone or control [37]. Participants in the WBV group were instructed to perform specific exercises on the platform. The European Organisation for Research and Treatment of Cancer Quality-of-Life Cancer Questionnaire was used to measure HRQOL. Both exercise groups exhibited improved HRQOL, but no significant differences were found when compared with the control.

Gerhardt et al. evaluated the effectiveness of four-week WBV in patients with pulmonary arterial hypertension [38]. The SF-36 and Living with Pulmonary Hypertension surveys were used. The results demonstrated that WBV substantially improved HRQOL and physical performance compared to the control group.

Musculoskeletal disease

Four studies with a total of 196 patients evaluated the effectiveness of WBV in musculoskeletal diseases [39, 43–45], including knee osteoarthritis (two studies) [39, 43] and fibromyalgia (two studies) [44, 45]. Three studies demonstrated that WBV significantly improved all or partial domains of HRQOL [39, 44, 45].

One RCT assessed the effects of WBV associated with quadriceps resistance exercises versus quadriceps resistance exercises alone in patients with osteoarthritis [39]. Participants were instructed to stand on the platform with bent knees in the WBV group during intervention. SF-36 was used to measure life quality. WBV together with quadriceps resistance exercises demonstrated significantly greater improvement in HRQOL and physical functions. Another study investigated the effects of WBV associated with strengthening training versus strengthening training alone in patients with osteoarthritis [43]. The Western Ontario and McMaster Universities Osteoarthritis Index was used to measure HRQOL and demonstrated no significant differences.

Two studies evaluated the effects of WBV on female patients with fibromyalgia [44, 45]. One study compared a 12-week course of WBV to a control group [44] and the HRQOL was assessed using the Fibromyalgia Impact Questionnaire (FIQ) and 15D instrument of HRQOL (15D). The results revealed that WBV therapy was associated with improvements in FIQ scores but not in the 15D questionnaire. Another RCT conducted a three-armed study to investigate the effectiveness of 6-week WBV together with aerobic training, compared to aerobic training alone or control [45]. HRQOL was assessed using FIQ and the pain and fatigue scores were significantly reduced from baseline in the WBV group, but not in the other two groups.

Neurological diseases

Four studies evaluated the effectiveness of WBV for patients with stroke [41], dementia [42], and multiple sclerosis [40, 46]. None of the studies showed any statistical differences in HRQOL between groups.

One study investigated the effects of different WBV intensities in individuals with stroke [41]. There were three groups: low-intensity WBV, high-intensity WBV, and control group. The two WBV groups performed leg exercises on a WBV platform following the same exercise protocol but with different frequencies, repetitions, and durations, whereas in the control group, participants were performing the same exercises on the platform but WBV was not delivered. The HRQOL results were not significant.

One study evaluated the effects of WBV in addition to a routine activity program that included exercise and group activities among community-dwelling individuals with mild or moderate dementia, compared with the routine program alone [42]. Participants performed static and dynamic semi-squats in the WBV group. The HRQOL results were not significant.

Two studies evaluated the effects of WBV in patients with multiple sclerosis [40, 46]. One study compared the effects of exercise on a WBV platform, exercise on a Balance trainer, and control [40]. The other study compared the effects of low-intensity exercise on a WBV platform versus control [46]. Neither study demonstrated any significant differences in HRQOL.

Urological diseases

One study assessed the efficacy of WBV on hemodialysis in the interdialytic period in patients with chronic kidney disease, compared with sham exercise [47]. The results showed no significant differences between groups.

Metabolic diseases

A three-armed study was conducted to evaluate the effects of WBV in metabolic syndrome patients [31]. The WBV groups that were treated with WBV once or twice per week exhibited statistical differences compared to the control group.

Synthesis of results

Seven studies [36–38, 40, 44–46] compared WBV with non-intervention groups and four of them [36, 38, 44, 45] reported statistically significant differences in HRQOL. Thirteen studies [31–35, 37, 39–43, 45, 47] compared

WBV with alternative intervention groups and three of them [31, 39, 45] reported statistically significant differences in HRQOL.

Risk of bias in the included studies

The risk of bias in the included studies was assessed and found to be unclear or low (Table 2). All but five studies [31, 33, 38, 45, 46] were assessed as exhibiting a low risk of random sequence generation bias. Nine studies did not describe allocation concealment [31, 33, 35, 38, 40, 42, 44–46]. Blinding of participants and personnel was challenging due to the nature of the intervention, and thus was not evaluated. Outcome assessors were blinded in eight studies [32, 36, 39–42, 44, 47]. All but one study [36] were assessed as exhibiting a low risk of incomplete outcome data bias due to low dropout rate, and reasons for exclusions were reported or a sensitivity analysis was conducted. Common reasons for dropouts included illness, lack of transportation, lack of motivation, lack of time, deterioration, or death. These reasons were similar in all the studies. All of the studies lacked information to assess selective reporting bias and none of the studies were assessed for other risks of bias.

Discussion

Physical activity is important as it prevents or slows down functional and psychological deterioration and impacts HRQOL [48–50]. Previous reviews of the effects of WBV on HRQOL have revealed inconsistencies. One review suggested WBV could improve the HRQOL in the elderly [51], whereas one study demonstrated no clinically important effects of WBV on the HRQOL in women with fibromyalgia [52]. The main goal of this study was to summarize and evaluate RCTs that investigated the effect of WBV on HRQOL in patients with chronic conditions.

This systematic review included 17 studies, of which 12 [31–34, 36–39, 41, 43–45] found significant differences within groups from the pre- to the post-test, but only six studies [31, 36, 38, 39, 44, 45] demonstrated significant differences in improving total or partial dimensions of HRQOL between groups. Among these six studies reporting significant differences, four studies [36, 38, 44, 45] compared WBV with a non-intervention group and three studies [31, 39, 45] compared WBV with an alternative intervention group. From all the included studies, 13 studies [31–35, 37, 39–43, 45, 47] compared WBV with other forms of exercise. Seven studies [36–38, 40, 44–46] compared WBV with a non-intervention group. Therefore, the pooled results of our review suggest that WBV might have positive effects on HRQOL in patients with chronic conditions when compared

Table 2 The risk of bias assessment of the included studies using the Cochrane risk of bias tool

Study	Bias						
	Random sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data	Selective reporting	Other sources of bias
Gloeck et al. [33]	Unclear	Unclear	–	Unclear	Low	Unclear	Low
Greulich et al. [32]	Low	Low	–	Low	Low	Unclear	Low
Salhi et al. [34]	Low	Low	–	Unclear	Low	Unclear	Low
Spielmanns et al. [35]	Low	Unclear	–	Unclear	Low	Unclear	Low
Braz Júnior et al. [36]	Low	Low	–	Low	High	Unclear	Low
Salhi et al. [37]	Low	Low	–	Unclear	Low	Unclear	Low
Gerhardt et al. [38]	Unclear	Unclear	–	Unclear	Low	Unclear	Low
Wang et al. [39]	Low	Low	–	Low	Low	Unclear	Low
Bokaeian et al. [43]	Low	Low	–	Unclear	Low	Unclear	Low
Olivares et al. [44]	Low	Unclear	–	Low	Low	Unclear	Low
Alentorn-Geli et al. [45]	Unclear	Unclear	–	Unclear	Low	Unclear	Low
Liao et al. [41]	Low	Low	–	Low	Low	Unclear	Low
Lam et al. [42]	Low	Unclear	–	Low	Low	Unclear	Low
Escudero-Uribe et al. [40]	Low	Unclear	–	Low	Low	Unclear	Low
Ebrahimi et al. [46]	Unclear	Unclear	–	Unclear	Unclear	Unclear	Low
Fuzari et al. [47]	Low	Low	–	Low	Low	Unclear	Low
Carvalho-Lima et al. [31]	Unclear	Unclear	–	Unclear	Low	Unclear	Low

with a blank control, but has no additional value when compared with other forms of exercise interventions.

These inconsistencies might be the result of the large variability of the included studies. The instruments to assess HRQOL varied, as both generic- and disease-specific instruments were used to measure different dimensions of HRQOL. In addition, different chronic conditions can cause complex changes in physical performance, mental state, and lifestyle, thus contributing differently to HRQOL [50]. Previous reviews have demonstrated positive impacts of WBV on HRQOL [13, 52]. Therefore, the heterogeneity of our study might have impacted our results, as it questions the validity of comparing such different studies.

The HRQOL of patients with chronic diseases is related to their physical and psychological conditions [53–55]. Among the six studies [31, 36, 38, 39, 44, 45] reporting significant differences in HRQOL, three studies [36, 38, 39] found significant improvements in physical outcomes in WBV groups, whereas the other three studies [31, 44, 45] did not report physical outcomes. The results showed that WBV might improve HRQOL by improving physical function. On the other hand, five studies [32, 35, 40, 43, 46] demonstrated that WBV improved physical outcomes, but not HRQOL. One explanation is that the improvements in physical functions were not sufficient to improve HRQOL. Another possible explanation is that WBV has insufficient effects on a patient's mental quality of life. None of the included studies reported psychological outcomes. Therefore, future studies should investigate the effectiveness of WBV on the psychological well-being of patients with chronic diseases.

The dropout rates were similar between WBV and control groups. In the WBV and control groups, the dropout rates ranged from 0 to 27% and 0 to 23%, respectively. There was no indication that the dropout rate was related to the intervention or study duration. The adherence rates were reported in five included studies [34, 36, 40, 42, 45] and ranged between 67 and 100%. Among these five studies, two studies found significant differences between groups in HRQOL and reported 93–100% adherence rates. Therefore, participants with higher adherences might exhibit better results. Nevertheless, the evidence was insufficient to demonstrate the effects of attrition and adherence on intervention outcomes. Engaging in exercise training was an important factor that affected exercise training effects [50]. Further studies are needed to identify the factors associated with attrition and adherence of participants during WBV intervention.

There are currently no guidelines for WBV training. WBV was performed alone or together with other exercises in the included studies. During WBV training, participants were instructed to stand with their knees bent or to exercise on the WBV platform, and WBV was delivered with various frequencies and amplitudes. However, there was no evidence that either approach was more effective in improving HRQOL. Future research needs to compare the effects of different protocols of WBV training, such as different exercise intensities, exercise frequency, and vibration frequency. Furthermore, only one study performed a 24-week WBV intervention [39]. The durations of WBV were no more than 12 weeks in the other included studies. Additional studies are needed to investigate the potential benefits of prolonged time durations of WBV, which might lead to more significant results.

In all the included studies, WBV was performed under supervision in center-based settings. Findings have supported WBV as a safe and effective intervention for patients with various chronic conditions. However, on the other hand, there is a lack of evidence focusing on home-based WBV. Previous studies found that home-based exercise exhibits equal effects on improving HRQOL compared with center-based exercise [56, 57]. With no restrictions regarding transportation, cost, or time, home-based exercise may improve adherence rates and therefore effectiveness. Future studies need to evaluate the effectiveness and safety of WBV under low levels of supervision.

There are several limitations of this systematic review. First, most of the included studies consisted of relatively small sample sizes. Studies with limited sample sizes are at risk of being underpowered and may result in less reliability [50]. Second, the included studies contain methodological limitations that may limit their conclusions. Due to the nature of the intervention, blinding participants and interventionists was not possible. We assessed the individual risk of bias of most of the included trials as unclear or low. Third, meta-analysis was not performed due to the heterogeneity between the included studies.

Conclusion

This systematic review evaluated the effects of WBV on HRQOL in patients with chronic conditions. Our findings demonstrated that four out of seven RCTs showed significant improvements in HRQOL when comparing WBV with a non-intervention group, and three out of 13 RCTs showed significant improvements in HRQOL when comparing WBV with an alternative intervention group. Overall, WBV may improve HRQOL in patients with chronic conditions. However, the evidence is not strong enough to warrant recommendation. Further studies should use well-designed RCTs with larger sample sizes, longer intervention durations, different exercise intensities, different WBV protocols, and different settings (f.e. at home) with the goal to develop WBV training guidelines.

Funding This study was funded by the 13th 5-Year Plan Science and Technology Research Project of the Education Department of Jilin Province (Grant Number: JJKH20190006KJ) and the Industrial Technology Development Project of the Development and Reform Commission of Jilin Province (Grant Number: 2019C047-4).

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Research involving human and animal participants This article does not contain any studies with human participants or animals performed by any of the authors.

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