Iran J Public Health, Vol. 52, No.3, Mar 2023, pp.476-487

Review Article

Whole-Body Vibration Exercise Improves the Functionality in Postmenopausal Women: A Systematic Review

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(Received 22 Aug 2022; accepted 18 Nov 2022)

Abstract

Background: Menopause is a natural phase in a woman's aging process. Menopause leads to the decrease of the estrogen levels, and in consequence the functionality worsening. Physical exercise can improve the functionality of postmenopausal woman. This review aimed to assess the effect of whole-body vibration exercise (WBVE) on the functionality of postmenopausal women.

Methods: PRISMA guideline were used. Only English language were considered. Searches were conducted using relevant keywords for papers prior to Sep 16th, 2021, in Embase, Pubmed, The Cochrane Library, PEDro, SPORTDiscus, Scopus, Web of Science and CINAHL databases.

Results: Eight articles were selected to be in this systematic review. The mean score of methodological quality was moderate, the risk of bias was low for two studies, high for four studies, and unclear for two studies. The level of evidence of the studies was II. Improvements on muscle strength, jump, balance and maximum trunk flexion strength in the post menopause woman were reported.

Conclusion: This systematic review demonstrated the functionality increase in postmenopausal women through WBVE. WBVE has been recommended as a non-pharmacological option relevant to postmenopausal management, helping to control the decline in bone density and symptoms related to osteoporosis and sarcopenia. However, further studies are needed to reinforce these findings.

Keywords: Whole-body vibration exercise; Post menopause; Rehabilitation; Functionality; Strength; Balance

Introduction

The menopause is the permanent cessation of menstruation, around 50 yr of age, due to loss of ovarian follicular function. Clinically, menopause is diagnosed after 12 months of amenorrhea, so the time of the final menses is determined retrospectively. During this transitional period, women experience quite a lot of physical, psychological, and social symptoms (1-3).

Genitourinary symptoms (4) are common, such as vaginal dryness that contributed to pain during intercourse and urinary incontinence that is seen as a normal consequence of aging (5). Women are believed to experience an increase in depression and anxiety during this transformation period. Likewise, problems of memory and cognition are reported (6). Social symptoms such as hot flashes and mood swings that can last for years are most common at this time (7).

Positive attitudes toward menopause can improve women's quality of life and reduce the severity of menopausal symptoms (8), as healthier dietary habits and regular exercise (9). The concern with promoting a healthier life during menopause is even more relevant when considering that this event as a specific cardiovascular disease risk factor for women (10).

The menstrual cycle does not normally stop at once (11). Climacteric is a term used to refer to this period of transition, close to menopause, where ovarian function begins to fail and consequently decreases. This influences the woman's life by decreasing fertility and the consequences of the occurrence of chronic estrogen deficiency (12). The duration of the climacteric varies differently among women. The secretion of ovarian hormones estrogen and progesterone ends with menopause (13).

The estrogen deficiency could be related to the decrease in muscle mass and muscle strength (14) and consequently, there is a risk of falls and fractures in postmenopausal women, which compromises functional performance and quality of life, once muscle strength plays an important role in these two aspects (15).

Physical exercises, nutrition and hormone replacement are considered important contributors to muscle mass, strength, and quality of life (16), being recommended physical exercises based on balance and strength exercises, performed with simple and readily available equipment, for the management of postmenopausal osteoporosis (16-18), and favouring a better quality of life (19).

Due to the increased risk of falls, a safe physical activity is an additional concern in the management of patients (20,21). In this context, whole-body vibration exercise (WBVE) has been suggested. WBVE occurs when mechanical vibrations are transmitted to the patient's body, that is in contact with the base of a vibrating platform (VP) turned on (22). This intervention is safety when appropriate parameters are used, such as frequency (F), amplitude (A), peak-to-peak distance (D) and peak acceleration (23).

WBVE is a relevant non-pharmacological option recommended for the management of postmenopausal women (24) and can be used in counteracting the loss of muscle mass (25). For Fratini, Bonci, and Bull (26), the WBVE can reduce the decline in bone density in postmenopausal women and can potentially be used to reduce some symptoms of aging, such as osteoporosis and sarcopenia. Therefore, this systematic review assessed the effects of WBVE on the functionality of postmenopausal women.

Methods

Protocol and Registration

This systematic review followed the Preferred Reporting Items for Systematic review and Meta-Analysis Protocols (PRISMA) guidelines (27) and was registered in the International Prospective Registry of Systematic Reviews (PROSPERO), CRD42021223727 (28).

Operational definitions

Mechanical vibration produced in a VP is a mechanical stimulus characterized by an oscillatory motion, sinusoidal, deterministic. VP delivers mechanical vibration to the whole body by means of oscillating plates using two main different systems: (a) reciprocating vertical displacements on the left and right side of a fulcrum (alternating); (b) the whole plate oscillating uniformly up and down (vertical) (22,29,30).

Considering the numerous combinations of *A* (amplitude) and *F* (frequency), it is possible to have a wide variety of WBVE protocols that can be used on human beings. However, not only the optimal *A* (amplitude) and *F* (frequency) need to be identified but also the level of muscle activation that would benefit more from vibration stimulation.

Research Question

The strategy PICOS was built for this systematic review: (P)= postmenopausal women; (I)=WBVE; (C)=control group or any type of comparison; (O)=functionality; (S)=randomized controlled trial (RCT), aiming to answer the question: What are the benefits of WBVE on functionality in postmenopausal women?

Search strategy

Three independently reviewers (EOGA, ACGS, and BBMO) assessed the EMBASE, PubMed; The Cochrane Library; Physiotherapy Evidence Database (PEDro); SPORTDiscuss; Scopus; Web of Science and Cumulative index to nursing and allied health literature (CINAHL) databases. Searches were conducted using relevant keywords for papers prior to September 16th, 2021, using the following search strategy: ((postmenopausal women) OR (postmenopause) OR (postmenopausal) AND (whole body vibration) OR (whole-body vibration OR vibration) AND (functionality) OR (function) OR (functional capacity) OR (functional performance) OR (physical functional performance) OR (physical performance)).

As Inclusion criteria were determined randomized clinical trials (RCTs), presenting functionality as the main outcome, published in English. The publications were considered ineligible if they met the following criteria: (i) replies, editorials, letters, abstracts, reviews, book or short communications; (ii) non-RCTs; (iii) pharmacological interventions used as a comparator; (iv) studies with non-postmenopausal women; (v) studies which uses an exercise modality other than WBVE, and (vi) conducted with the animal.

Two independently reviewers exported all the publications found on the databases to an Excel spreadsheet, manually removed the duplicated studies, and applied the eligibility criteria for the inclusion in this systematic review. The disagreements were solved by a third reviewer.

Data Extraction and Synthesis

Data were extracted by two independently reviewers and disagreements were solved by a third reviewer. The data were recorded on a excel spreadsheet and after presented as tables, describing: (i) author and year of the publication; (ii) aim of the studies; (iii) characteristics of the participants (sample size and age), and characteristics of the groups (iv) physical function assessment (v) WBVE programs, (vi) Level of evidence (LE) (National Health and Medical Research Council – NHMRC) (31) and methodological quality using the PEDro scale (32,33) and (vii) physical function outcomes.

Methodological quality, LE and risk of bias

The methodological quality was assessed using the PEDro scale, that consists of ten items established by "expert consensus" and uses a score from 0 to 10 to define quality (32,33). The studies were classified as 'high' methodological quality (≥7); 'fair' methodological quality (5-6) and 'poor' methodological quality (≤4).

NHMRC hierarchy of evidence was used to assess the LE for each of the publications included, as defined in Table 1. The risk of bias was evaluated using the Cochrane Collaboration's tool (34) to classify each domain as low risk, unclear risk and high risk of bias, each judgement was represented, respectively, by the colors green, yellow and red.

The methodological quality, LE and risk of bias were appraised by two reviewers (EOGA and EMM) blinded to each other decisions, and a third reviewer (ACGS) was consulted when there were any disagreements.

Table 1: Level of Evidence - National Health and Medical Research Council Hierarchy of Evidence (NHMRC)

LE	*Definition*
I	The systematic review of level II studies.
II	Randomized controlled trial.
III-1	The pseudo-randomized controlled trial (alternate allocation, as a crossover study or some other similar method).
III – 2	The comparative study with concurrent controls (non-randomized experimental trial, cohort study, case control study, interrupted time series with a control group.
III – 3	The comparative study without concurrent control (historical control, two or more single arm study, interrupted time series without a parallel control group.
IV	The case series with either post-test or pretest/post-test outcomes.

Results

Initially 193 records were identified through database searching. After removing the duplicated studies, 84 records remained, and 8 articles met the criteria to be included in this systematic review. Overall, 1.095 postmenopausal women were included with a mean age of 74.2 ± 7.66 yr in the eight selected studies (Fig. 1).

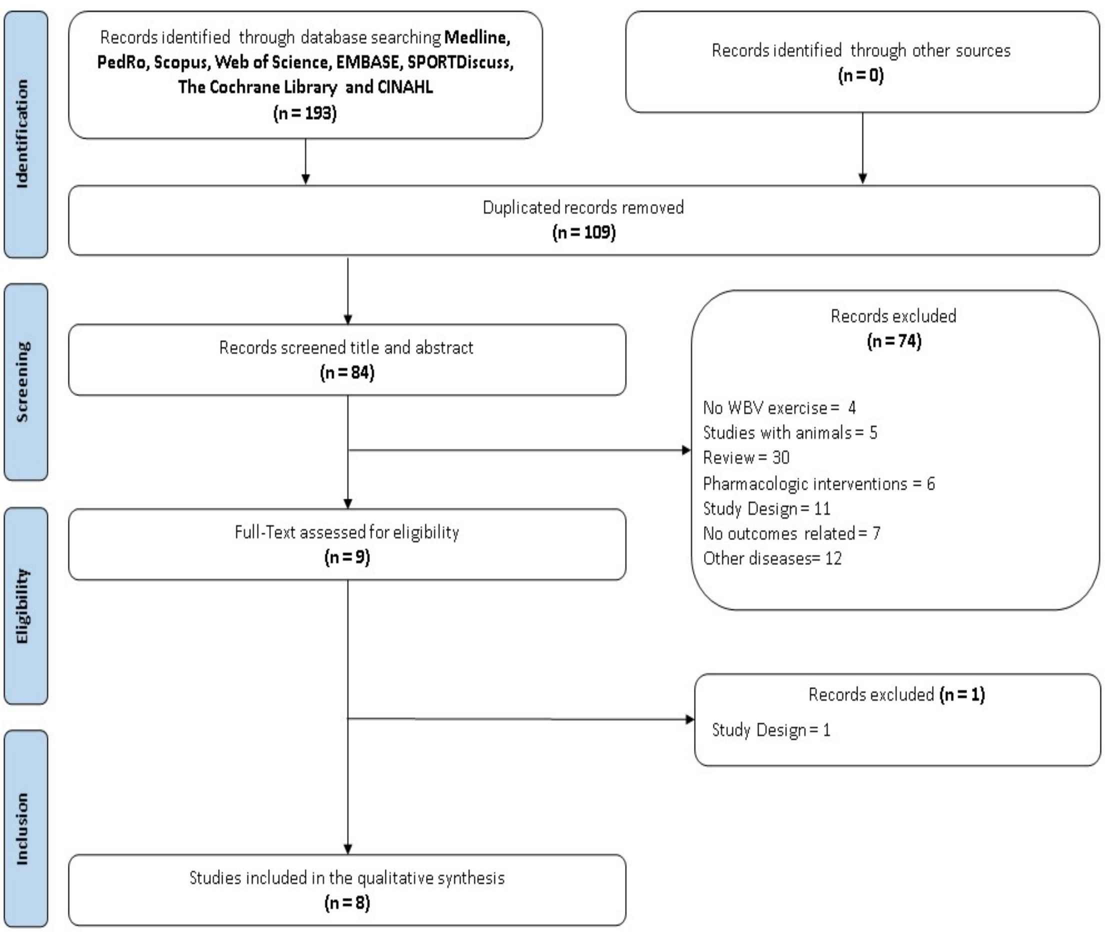

Fig. 1: PRISMA flowchart of the records selection process

The characteristics of the individuals (sample size and age) and characteristics of the groups, WBVE protocols and parameters, assessments and outcomes, methodological quality, and LE, of each study included in this systematic review are summarized in Table 2.

Table 2: Description of the characteristics of the selected studies

Author/year	*Aim*	*Sample Size – N Age – Mean ± SD Groups*	*Functionality assessment*	*WBV protocol*	*Frequency peak-to-peak displacement* a_{peak}	*NHMRC PEDro score*	*Functionality outcomes*
Roelants et al., 2004 (35)	To investigate the effects of 24 wk of WBVE on knee-extension strength and speed of movement and on countermovement jump performance.	N: 89 Age: WBVE (64.6 ± 0.7 yr), Resistance (63.9 ±0.8 yr), Control (64.2 ±0.6 yr) Groups: WBVE, resistance and control.	Isometric and dynamic strength of Knee extensors and speed of movement (dynamometer) Countermovement jump performance.	VP – vertical Thrice a week for 24 wk Up to 30 min including warm-up and cool-down. Static and dynamic exercises (high squat and deep squat, wide-stance squat, and lunge).	F: 35 – 40 Hz D: 2.5 – 5.0 mm a_{peak}: 2.28 – 5.09g	LE: II 4/10 (poor)	Muscle strength and speed of movement of knee extensors and countermovement jump performance increased significantly.
Beck and Norling, 2010 (39)	To determine and compare the effects of low-intensity WBVE versus high-intensity WBVE on risk factors for hip fracture (bone strength parameters, muscle function and balance).	N: 47 Age: 71.5 ± 9.0 yr Groups: Control, LWBV and HWBV	Wall squat test Chair rise test Single leg stance test Tandem walk test	Twice a week for 8 months LWBV: VP – Vertical 15 min Stand-up position HWBV: VP - Side alternating 2 bouts of 3 min and 1 min of rest Stand-up position	LWBV: F: 30 Hz D: not mentioned a_{peak}: 0.3g HWBV: F: 12.5 D= ~2mm a_{peak}: ~1g	LE – II 6/10 (fair)	No effects in muscle, or balance measures.
Sañudo et al., 2010 (40)	To investigate the effectiveness of a 6 wk of a traditional exercise program with supplementary WBVE in improving strength and health status in women with fibromyalgia	N: 30 Age: 59 ± 7.90 yr Groups: WBVE + exercises and exercise group	FIQ Maximal power output FI	VP – Side alternating Thrice a week for 6 wk 3 bouts of 45s and 4 bouts of 15s with 120s of rest Unilateral or bilateral static squats (knees in 120°)	F:20 Hz D: 2–3mm a_{peak}: not mentioned	LE – II 6/10 (fair)	Significant improvements in FIQ score. No significant differences in maximal power output or FI between groups.
Klarner et al., 2011 (36)	To determine the effects of different types of WBVE on neuromuscular performance and body composition.	N: 108 Age: 65.8 ± 3.5 yr Groups: Control, vertical, and side-alternating	Muscular strength (leg and trunk flexion) Muscular power	Thrice a week for one year VP: Vertical and side-alternating 7 bouts of 90s with 40s of rest. Active exercises with one leg or both legs on the VP.	Vertical Group: F: 35 Hz D: 1.7 mm a_{peak}: ~8g Side-alternating Group: F: 12.5 Hz D: 12 mm a_{peak}: ~8g	LE – II 8/10 (high)	Maximum leg strength and maximum trunk flexion strength significantly increased in both vibration groups. Jumping ability improved in both vibration groups but with no statistical significance.

Stolzenberg et al., 2013 (41)	To investigate the effect of resistive exercise with either WBVE or coordination/ balance training on neuromuscular function	N: 60 Age: WBVE (67.5 ± 3.8) and Balance (65.5 ±4.3) Groups: WBVE and Balance	Countermovement jump Multiple 1-leg hopping Sit-to-stand test	VP: side-alternating 2 bouts of 1.5 min and 1 bout of 1 min with 1 min of rest Semi-squat, active squat, and continuous stance	F: 22-26 Hz D: 2-4 mm a_{peak}: not mentioned	LE – II 5/10 (fair)	Significant increases in jump power, peak force and acceleration were seen in the WBVE group. Hop force and acceleration improved in both groups on the left leg and in the WBVE group only on the right leg. Hop power did not decrease in the WBVE group. Peak hop power decreased significantly in both groups. No significant differences were seen between groups in the STST.
Leung et al., 2014 (37)	To investigate the long-term effects of low magnitude high-frequency vibration on fall and fracture rates, muscle performance and bone quality.	N: 661 Age: WBVE (74.5 ± 7.1 yr) / Control: (71.3 ± 7.2 yr) Groups: WBV and Control	Balancing ability Quadriceps muscle strength SF-36(physical health component score)	VP: vertical 5 days/week for 18 months 20 min Stand-up position	F: 35 Hz D < 0.1 mm a_{peak}: 0.3 g	LE – II 8/10 (high)	Significant improvement on the quadriceps muscle strength and balancing ability. The change of SF-36 (physical health component score) was greater in the vibration group, with no statistical difference.
Liphardt et al., 2015 (43)	To monitor changes in bone microarchitecture and bone strength of the distal radius and tibia in osteopenic women	N: 42 Age: WBVE (58.5±3.3 yr) and Control (59.1±4.6) Groups: WBVE and Control	Maximal isometric knee extension torque Isometric strength of the hand Static postural stability tests	VP – side alternating 11 sessions/month for 12 months 10 bouts of1 min and 1 min of rest 30-degree knee flexion angle position	F: 20 Hz D: 2-3 mm a_{peak}: not mentioned	LE – II 6/10 (fair)	No detected benefits for muscle strength or balance performance.
Sen et al., 2020 (38)	To prevent bone loss, reduce the fall risk, increase the HRQoL, and reduce the depressive symptoms by administering different exercise programs.	N: 58 Age: WBVE (55.0 ± 4.6 yr), high-impact training (53.1 ± 4.4 yr), control (54.5 ± 6.0 yr) Groups: WBVE, high-impact training and control.	TUG test	VP – side alternating Thrice a week for 24 wk One bout of 30s, 3 bouts of 45s and 3 bouts of 60s with 60s of rest 5 static positions	F: 30–40 Hz D:2-4mm a_{peak}: 3.6 to 9.8g	LE – 2 5/10 (fair)	WBVE and high impact exercises provided a significant improvement in the TUG test scores when compared to the control group, however, no significant differences were observed between the exercise's modalities.

Abbreviations: SD – standard deviation; WBVE – whole body vibration exercise; a_{peak} – peak acceleration; NHMRC –National Health and Medical Research Council; PEDro score – (a) 'high' methodological quality ≥7, (b) 'fair' methodological quality = 5 or 6, (c) 'poor' methodological quality ≤4; VP – vibrating platform; F – frequency; D – peak-to-peak displacement; LE – level of evidence; LWBV – low-intensity whole-body vibration; HWBV – high intensity whole-body vibration; FIQ – fibromyalgia impact questionnaire; FI – fatigue index; FTSTS test – five times sit to stand test; SF-36 –36 Item short form health survey; HRQoL – health-related quality of life; TUG – Timed up and go test

The mean score of the methodological quality used in this systematic review, according to the PEDro scale, was six points, it was considered moderate (Table 2). One study (35) obtained a score of 4 and was classified as fair and three studies (36-38) obtained a score of 8, being considered as high quality. The LE of this systematic review was considered II, as all the eight (35-42) articles were classified as RCT.

The risk of bias of included studies was assessed with the Cochrane risk of bias tool. Two articles (39,40) were considered low risk of bias, three articles (36-38) were classified as high risk of bias, and two articles (41,42) were considered unclear risk of bias (Fig. 2).

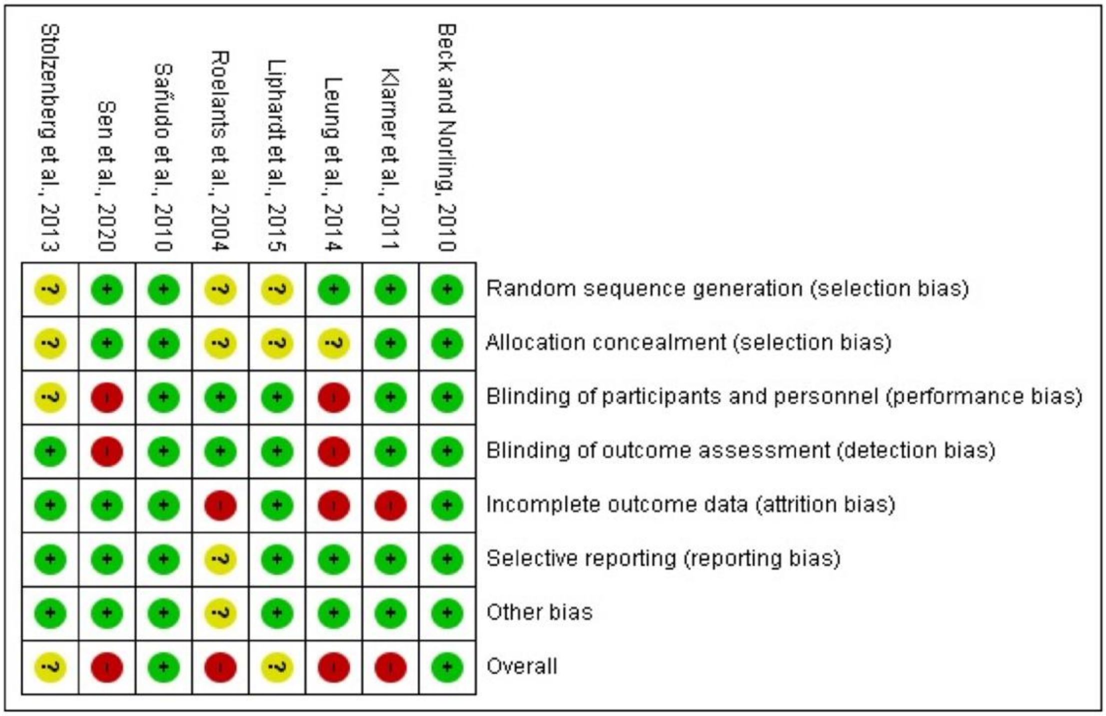

Fig. 2: Summary indicating the risk of bias of each domain in each study
(Green for low risk of bias, yellow for unclear risk of bias and red for high risk of bias)

All the eight studies were designed as RCT with the women in stand-up position. The protocols presented dynamic exercises such as: high squat and deep squat, wide-stance squat, and lunge (35), unilateral or bilateral static squats (40), active exercises with one leg or both legs on the VP (36), semi-squat, active squat, and continuous stance (41). Moreover, protocols static exercises such as: 30-degree knee flexion angle position (42), 5 static positions (38), stand-up static position (39).

WBVE Protocols

The intervention proposed through the WBVE protocols in the studies varied in duration, in training frequency, session duration, number of repetitions, biomechanical parameters, type of vibration (vertical and site alternating), modality of exercises included (static or static and dynamic), and number of exercises per session. Patients were standing in all studies, in position squat or semi squat.

The timing of implementation of the WBVE protocol also greatly varied between studies. The studies presented protocols with sessions 2 times a week (39-42), 3 times a week (35,38,42) and 5 times a week (37). These sessions ranged from 6 wk (36,40), 24 wk (35,38), 8 months (39), 9 months (41), 12 months (42) and 18 months (37). Several outcomes were assessed in these select studies: muscle strength (35-37,42); muscle performance (38,39); speed of movement (35); balance performance (37,39,42); jump performance (35,36,41); maximum trunk flexion strength (36); high impact exercises (38).

The studies demonstrated several effects of WBVE intervention: the increase of muscle strength (35-38) and knee extensor strength (35-38,41); maximum trunk flexion strength (36).

The isometric maximum strength of the trunk flexors and extensors were used with the SCHNELL M3 system (SCHNELL Trainingsgeräte GmbH, Peutenhausen, Germany). Rehn et al. (43) verified muscle performance through the wall squat and chair rise tests and observed that there is moderate to strong evidence that long-term WBVE improves lower limb muscle performance in older cohorts.

Sanudo et al. (40), investigated the effectiveness of supplementary WBVE in improving strength and health status in women with fibromyalgia through Fibromyalgia Impact Questionnaire (FIQ) to assess functional capacity and the SF-36 to assess quality of life. A 5% improvement from baseline in total FIQ score was observed in the exercise groups ($P \leq 0.05$) and was accompanied by reductions in SF36 scores of 9.8% ($P<0.001$) and 7.9% ($P<0.001$) in the WBVE group and non-vibration group, respectively. Improvements were also observed in muscle strength in both groups but greater in the WBVE group.

The jump performance increased significantly in older women after 24 wk of WBVE (35).

Static balance was measured using the single leg stance test. Stolzenberg et al. (41) verified the effect of resistive exercise with either WBVE or coordination/ balance exercise (BAL) on neuromuscular function. All subjects conducted 30 min of resistance exercise each exercise day. The WBVE group performed additional exercise on the Galileo vibration exercise device. The BAL group performed balance exercise. Both groups improved in the sit-to-stand test. Short-duration WBVE can have a greater impact on some aspects of neuromuscular function in postmenopausal women with low bone density than proprioceptive exercise.

Some authors used functional tests in the evaluations (37-40). Wall squat test, Chair rise test, Single leg stance test and Tandem walk test. Wall squat time and Chair rise time improved significantly in vibration groups.

Sen et al. (38) verified the effects of exercise programs such as WBVE and high impact exercises in fall risk and fracture rates through of Timed Up and Go (TUG). TUG test scores were significant improved, although no significant differences were observed between the exercise's modalities.

Beck et al. (39) observed the effect of brief low and higher intensity WBVE on risk factors for hip fracture in postmenopausal women. WBVE women improved wall squat (up to 120%, P=0.004) and chair rise performance (up to 10.5%, P=0.05).

Leung et al. (37) investigated the long-term effects of low-magnitude high-frequency vibration (LMHFV) on fall and fracture rates through of stability test using the Basic Balance Master System. LMHFV is effective in reducing fall incidence. Balancing ability in the vibration group significantly improved compared with the control group and the incidence rate of falls also was significantly lower in the vibration group.

Discussion

The main objective of the current systematic review was to assess the effect of WBVE on the functionality of postmenopausal women. After analyzed the studies included, WBVE can be a valid intervention in this population and can be effective in the reducing of the signs of post menopause, increase the functionality and improve the quality of life of these women.

Muscle strength, jump performance and balancing ability

Lifelong exercise is an effective way to sustain bone health in women and the use of WBVE as a form of exercise has increased over the years (43). WBVE can induce significant improvement on the quadriceps muscle strength, on jump performance and balancing ability. According to Stolzenberg et al. (41) strength training combined with WBVE was associated with improvements in some measures of postural control in postmenopausal women with low bone density. Likewise, low-intensity vibration improved balance, motility, and muscle strength in the upper and lower limbs in postmenopausal women (44).

Klarner et al. (36) found the maximum trunk flexion strength significantly increased in WBVE groups. The WBVE can bring about improvement in muscles strength, power, and flexibility (43,44). The main factors associated with the improvement in muscles performance are range of A and F, type of vibration and its application method, training intensity, exercise protocol and the characteristics of the participants (45).

For Moxley et al. (46), functional testing is useful to monitor the natural history of several neuromuscular disorders, and to measure the efficacy of therapeutic agents in clinical trials. However, a major limitation of functional testing is that a single test is often not appropriate throughout all stages of disease. Other limitations of functional testing are its lack of sensitivity to detect a subtle improvement or decline in muscle strength, and the difficulty of applying standard statistical methods to analyze disease progression or therapeutic efficacy. However, the advantages of functional testing outweigh the limitations.

A meta-analysis performed by Osawa et al. (47) gathered data 7 studies with a total of 249 participants in countermovement jump height using random-effect models. The use of WBVE would lead to greater improvements in countermovement jump than under identical conditions without WBVE. Corroborating, our study showed that the performance of jumping with countermovement increased significantly and that jumping ability improved in two WBVE groups, but without statistical significance (35). However, among the selected articles, one study showed that jumping power did not decrease in the WBVE group (35), on the other hand, peak jumping power significantly decreased in the WBVE and control groups (41). WBVE produced significant differences in the main effect of time and agility, for both genders, acutely. Women performed better in balance compared to man and poorer in vertical jump, but males performed better in agility and power (48).

Fall risk and fracture rates

WBVE could prevent fall risk, which could lead to reduced fracture rates (38). It is in agree with Bemben et al. (45) that reported the WBVE as an effective modality of exercise for counteracting the loss of muscle strength associated with sarcopenia in elderly individuals. In addition, balance and leg and plantar flexor strength improvements due to WBVE indicate benefit to reduce risk and incidence of falls, frailty, and fracture risks. In concordance with the results from the Cochrane review (49) that suggest a relatively small, statistically significant, but possibly important effect of exercise on bone density in postmenopausal women compared with control groups. Although the meta-analysis (50) suggests that WBVE may prevent fractures by reducing falls but seems to have no overall effect on bone mineral density (BMD).

WBVE may positively influence balance and muscle performance and thus also indirectly impacts fracture risk (42).

Public health implications

WBVE is a safe intervention capable to bring some benefits for postmenopausal women, as an increase of the functionality, preventing fractures and reducing falls risk. As a perspective, the WBVE would add reduce, the signs, and symptoms from the menopause to a better functionality and consequentially, would promote a bigger quality of life in postmenopausal women.

Limitations

This systematic review has some limitations. Although eight well-known databases were used, only studies in English were included. Moreover, for the search terms that, could have provided different results if a broader search strategy was used. The variety in the selected studies made clear that large methodological differences exist between the reviewed studies. In addition, the risk of bias and methodological quality assessment showed that limitations are present in terms of study design, cohorts, and variety of WBVE protocols and control groups, which was not able to provide a consistent methodology to avoid discrepancies, as possible biases risks. This heterogeneity forms the comparison between studies and interpretation of WBVE effects very difficult.

Conclusion

WBVE potentially suggested as intervention in the treatment of issues related with ageing such as the decline of functionality, is a safe, feasible and effective intervention for postmenopausal women. It can be observed improvements muscle strength, functionality, and balance. Finally, multiple factors must be considered when designing a treatment, and that methodological gaps and differences among research protocols suggest the need of more research in this area with additional RCT studies.

Journalism Ethics considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

Acknowledgements

The authors gratefully acknowledge the support of the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), the Universidade do Estado do Rio de Janeiro (UERJ), and the Fundação de Amparo à Pesquisa do Estado do Rio de Janeiro (FAPERJ).

Conflict of interest

The authors declare that there is no conflict of interests.

References

1. Greendale GA, Lee NP, Arriola ER (1999). The menopause. *The Lancet,* 353:571–580.
2. Harlow SD, Gass M, Hall JE, et al (2012). Executive Summary of the Stages of Reproductive Aging Workshop + 10: Addressing the Unfinished Agenda of Staging Reproductive Aging. *J Clin Endocrinol Metab*,97:1159–68.
3. Johnstone RA, Cant MA (2019). Evolution of menopause. *Curr Biol*, 29:R112–R115.
4. Angelou K, Grigoriadis T, Diakosavvas M, et al (2020). The Genitourinary Syndrome of Menopause: An Overview of the Recent Data. *Cureus*, *12*(4)-7586.
5. Khoudary SR El, Greendale G, Crawford SL, et al (2019). The menopause transition and women's health at midlife: A progress report from the Study of Women's Health across the Nation (SWAN). *Menopause*, 26(10):1213-1227.
6. Kaur J, Sahni RK, Singh A GS (2020). Effect of Menopause on Cognition in Post-menopausal Women. *Biomedical Journals,*9-257.
7. Santoro N, Epperson CN, Mathews SB (2015). Menopausal Symptoms and Their Management. *Endocrinol Metab Clin North Am*, 44(3):497–515.
8. Dashti S, Bahri N, Fathi Najafi T, et al (2021). Influencing factors on women's attitudes toward menopause: a systematic review. *Menopause*, 28:1192–1200.
9. Asghari M, Mirghafourvand M, Mohammad-Alizadeh-Charandabi S, et al (2017). Effect of aerobic exercise and nutrition educationon quality of life and early menopause symptoms: A randomized controlled trial. *Women & Health*, 57(2):173–188.
10. Benjamin EJ, Muntner P, Alonso A, et al (2019). Heart Disease and Stroke Statistics—2019 Update: A Report From the American Heart Association. *Circulation,*139: e56–e528.
11. Ko S-H, Kim H-S (2020). Menopause-Associated Lipid Metabolic Disorders and Foods Beneficial for Postmenopausal Women. *Nutrients,*12(1):202.
12. Schweizer-Schubert S, Gordon JL, Eisenlohr-Moul TA, et al (2021). Steroid Hormone Sensitivity in Reproductive Mood Disorders: On the Role of the GABAA Receptor Complex and Stress During Hormonal Transitions. *Front Med (Lausanne)*, 7:479646.
13. Kling JM, Dowling NM, Bimonte-Nelson HA, et al (2019). Impact of menopausal hormone formulations on pituitary-ovarian regulatory feedback. *Am J Physiol Regul Integr Comp Physiol,* 317(6): R912–R920.

14. Collins BC, Arpke RW, Larson AA, et al (2019). Estrogen Regulates the Satellite Cell Compartment in Females. *Cell Rep*, 28:368-381.e6.
15. Chidi-Ogbolu N, Baar K (2019). Effect of Estrogen on Musculoskeletal Performance and Injury Risk. *Front Physiol,* 9:1834.
16. Wischmeyer PE, Puthucheary Z, San Millán I, et al (2017). Muscle mass and physical recovery in ICU. *Curr Opin Crit Care,* 23:269–278.
17. Otero M, Esain I, González-Suarez ÁM, et al (2017). The effectiveness of a basic exercise intervention to improve strength and balance in women with osteoporosis. *Clin Interv Aging*, 12:505–513.
18. Filipović TN, Lazović MP, Backović AN, et al (2021). A 12-week exercise program improves functional status in postmenopausal osteoporotic women: randomized controlled study. *Eur J Phys Rehabil Med,* 57(1):120–130.
19. Koevska V, Nikolikj-Dimitrova E, Mitrevska B, et al (2019). Effect of Exercises on Quality of Life in Patients with Postmenopausal Osteoporosis â€“ Randomized Trial. *Open Access Maced J Med Sci,*7(7):1160–1165.
20. Howe TE, Shea B, Dawson LJ, et al (2011). Exercise for preventing and treating osteoporosis in postmenopausal women. *Cochrane Database Syst Rev,* (7):CD000333.
21. Gerdhem P (2013). Osteoporosis and fragility fractures: Vertebral fractures. *Best Pract Res Clin Rheumatol.* 27:743–755.
22. van Heuvelen MJG, Rittweger J, Judex S, et al (2021). Reporting Guidelines for Whole-Body Vibration Studies in Humans, Animals and Cell Cultures: A Consensus Statement from an International Group of Experts. *Biology (Basel),*10(10): 965.
23. Rauch F, Sievanen H, Boonen S, et al (2010). Reporting whole-body vibration intervention studies: Recommendations of the International Society of Musculoskeletal and Neuronal Interactions. *J Musculoskelet Neuronal Interact,* 10(3):193-8.
24. Dionello CF, Sá-Caputo D, Pereira HVFS, et al (2016). Effects of whole body vibration exercises on bone mineral density of women with postmenopausal osteoporosis without medications: novel findings and literature review. *J Musculoskelet Neuronal Interact,* 16(3):193–203.
25. Chen H, Ma J, Lu B, et al (2017). The effect of whole-body vibration training on lean mass: A PRISMA-compliant meta-analysis. *Medicine (Baltimore),* 96(45):e8390.
26. Fratini A, Bonci T, Bull AMJ (2016). Whole Body Vibration Treatments in Postmenopausal Women Can Improve Bone Mineral Density: Results of a Stimulus Focussed Meta-Analysis. *PLoS One*, 11(12):e0166774.
27. Liberati A, Altman DG, Tetzlaff J, et al (2009). The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration. *BMJ,* 339:b2700.
28. Pacheco RL, Latorraca C de OC, Martimbianco ALC, et al (2018). PROSPERO: base de registro de protocolos de revisões sistemáticas. Estudo descritivo. *Diagn Tratamento,*23(3):101–104.
29. Cardinale M, Wakeling J (2005). Whole body vibration exercise: Are vibrations good for you? *Br J Sports Med,*39(9):585-9.
30. Rittweger J (2010). Vibration as an exercise modality: How it may work, and what its potential might be. *Eur J Appl Physiol,* 108(5):877–904.
31. Merlin T, Weston A, Tooher R, et al (2009). NHMRC additional levels of evidence and grades for recommendations for developers of guidelines. *BMC Med Res Methodol,* 9:1–23.
32. Maher CG, Sherrington C, Herbert RD, et al (2003). Reliability of the PEDro Scale for Rating Quality of Randomized Controlled Trials. *Phys Ther,*83(8):713–21.
33. de Morton NA (2009). The PEDro scale is a valid measure of the methodological quality of clinical trials: a demographic study. *Aust J Physiother,*55(2):129–33.
34. Higgins JPT, Altman DG, Gotzsche PC, et al (2011). The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. *BMJ,*343:d5928.
35. Roelants M, Delecluse C, Verschueren SM (2004). Whole-Body-Vibration Training Increases Knee-Extension Strength and Speed of Movement in Older Women. *J Am Geriatr Soc,*5296):901–8.
36. Klarner A, Stengel Sv, Kemmler W, et al (2011). (Effects of two different types of whole body vibration on neuromuscular performance and body composition in postmenopausal women). *Dtsch Med Wochenschr,* 136(42):2133-9.

37. Leung KS, Li CY, Tse YK, et al (2014). Effects of 18-month low-magnitude high-frequency vibration on fall rate and fracture risks in 710 community elderly - A cluster-randomized controlled trial. *Osteoporos Int,* 25(6):1785-95.
38. Sen EI, Esmaeilzadeh S, Eskiyurt N (2020). Effects of whole-body vibration and high impact exercises on the bone metabolism and functional mobility in postmenopausal women. *J Bone Miner Metab,* 38(3):392–404.
39. Beck BR, Norling TL (2009). Effects of 8 months of twice-weekly high versus low intensity whole body vibration on risk factors for hip fracture in postmenopausal women: A randomized controlled trial. *Bone*, 44:S70–S71.
40. Sañudo B, Hoyo M de, Carrasco L, et al (2010). The effect of 6-week exercise programme and whole body vibration on strength and quality of life in women with fibromyalgia: a randomised study. *Clin Exp Rheumatol,* 28(6 Suppl 63):S40-5.
41. Stolzenberg N, Belavý D, Rawer R, et al (2013). Vibration or Balance Training on Neuromuscular Performance in Osteopenic Women. *Int J Sports Med.* 34(11):956–62.
42. Liphardt AM, Schipilow J, Hanley DA, et al (2015). Bone quality in osteopenic postmenopausal women is not improved after 12 months of whole-body vibration training. *Osteoporos Int,* 26(3):911-20.
43. Rehn B, Lidström J, Skoglund J, et al (2007). Effects on leg muscular performance from whole-body vibration exercise: A systematic review. *Scand J Med Sci Sports*, 17(1):2–11.
44. Dutra MC, Oliveira ML de, Marin RV, et al (2016). Whole-body vibration improves neuromuscular parameters and functional capacity in osteopenic postmenopausal women. *Menopause,* 23(8):870-5.
45. Bemben D, Stark C, Taiar R, et al (2018). Relevance of Whole-Body Vibration Exercises on Muscle Strength/Power and Bone of Elderly Individuals. *Dose-Response*,16(4): 1559325818813066.
46. Moxley RT (1990). Functional testing. *Muscle Nerve.* 13:S26–S29.
47. Osawa Y, Oguma Y, Ishii N (2013). The effects of whole-body vibration on muscle strength and power: a meta-analysis. *J Musculoskelet Neuronal Interact.* 13(3):380–90.
48. Wallmann HW, Bell DL, Evans BL, et al (2019). The effects of whole body vibration on vertical jump, power, balance, and agility in untrained adults. *Int J Sports Phys Ther*,14(1):55–64.
49. Savović J, Turner RM, Mawdsley D, et al (2018). Association Between Risk-of-Bias Assessments and Results of Randomized Trials in Cochrane Reviews: The ROBES Meta-Epidemiologic Study. *Am J Epidemiol.* 187(5):1113–1122.
50. Jepsen DB, Thomsen K, Hansen S, et al (2017). Effect of whole-body vibration exercise in preventing falls and fractures: A systematic review and meta-analysis. *BMJ Open,* 7(12):e018342.