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Systematic review

Effect of whole-body vibration on cardiac function and functionality in patients with chronic non-communicable disease: A systematic review and meta-analysis

Efeito da vibração de corpo inteiro sobre a função cardíaca e a funcionalidade de pacientes com doença crônica não-transmissível: revisão sistemática e metanálise

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ABSTRACT

Objective: To investigate evidence of the use of whole-body vibration training (WBV) on cardiac autonomic function and functionality in patients with chronic non-communicable diseases related to the cardiovascular, respiratory and metabolic systems. **Methods:** The search involved Medline/PubMed, Lilacs, PEDro and Scopus databases. Randomized or quasi-randomized controlled trials were eligible for this review when comparing a group of patients with cardiovascular, respiratory or metabolic conditions who trained with WBV with a control group without intervention or other training modalities. **Results:** A total of 12 studies were included. Subgroup analyzes were performed considering sample size and age of participants. WBV training improved sympathovagal balance and reduced systolic blood pressure in patients with obesity and hypertension. There was a trend towards an increase in the distance covered on the six-minute walk test (6MWT) in COPD patients and a decrease in heart rate (HR) in overweight or obese women and hypertension after WBV, but no difference was found between the groups. No repercussions were observed in kidney transplant patients. **Conclusion:** WBV can be an alternative training modality to improve cardiac autonomic function and systolic blood pressure in obese and hypertensive patients, with moderate quality of evidence. We suggested that larger studies be carried out to assess the effect of WBV on outcomes such as distance covered in the 6MWT, HR, VO_{2max}, diastolic blood pressure, gait speed and balance.

Keywords: Cardiovascular system; chronic disease; heart rate; exercise.

RESUMO

Objetivo: Investigar evidências do uso do treinamento de vibração de corpo inteiro (VCI) na função autonômica cardíaca e na funcionalidade em pacientes com doenças crônicas não transmissíveis relacionadas aos sistemas cardiovascular, respiratório e metabólico. **Métodos:** A busca envolveu as bases de dados Medline/PubMed, Lilacs, PEDro e Scopus. Ensaios clínicos randomizados ou quasi-randomizados foram elegíveis para esta revisão ao comparar grupo de pacientes com condições cardiovasculares, respiratórias ou metabólicas que treinaram com VCI com grupo controle sem intervenção ou outras modalidades de treinamento. **Resultados:** Doze estudos foram incluídos. Foram realizadas análises de subgrupo considerando o tamanho da amostra e a idade dos participantes. O treinamento VCI melhorou o equilíbrio simpatovagal e provocou redução da pressão arterial sistólica em pacientes com obesidade e hipertensão. Houve tendência ao aumento da distância percorrida no teste de caminhada de seis minutos (TC6M) em pacientes com DPOC e redução da frequência cardíaca (FC) em mulheres com sobrepeso ou obesidade e hipertensão após VCI, porém sem diferença entre os grupos. Não foi observada repercussão em pacientes transplantados renais. **Conclusão:** A VCI pode ser uma modalidade de treinamento alternativa para melhorar a função autonômica cardíaca e a pressão arterial sistólica de pacientes com obesidade e hipertensão, com moderada qualidade de evidência. Por outro lado, sugere-se que estudos maiores sejam realizados para avaliar o efeito da VCI sobre desfechos como distância percorrida no TC6M, FC, $VO_{2máx}$, pressão arterial diastólica, velocidade da marcha e equilíbrio.

Palavras-chave: sistema cardiovascular; doenças crônicas; frequência cardíaca; exercício.

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Introduction

The benefits of whole-body vibration (WBV) training on human performance have been described in the literature since the mid-1960s [1]. In addition to the effects on muscle strength and power, flexibility, balance and bone mineral density [2], neural stimulation triggered from spinal reflexes also seems to promote changes in cardiac autonomic function, being the object of study in both athletes and in people with renal [3], respiratory [4] and cardiovascular dysfunctions [5].

The vibration generated by a platform can be synchronous, alternating or triplane [6]. Oscillatory movements cause rapid and repetitive eccentric-concentric action in all types, which evokes muscle work and consequently increases the metabolic rate [7]. Reflex stimulation of the muscle spindle and alpha motoneurons located in the spinal cord favors the synchronization of motor units with a consequent increase in muscle contraction and tissue perfusion [5,7,8].

Frequency, peak-to-peak amplitude, direction and duration of vibration are factors, which can determine training intensity [9]. The frequency is measured in hertz (Hz) and represents the number of oscillations per second, while the amplitude, measured in millimeters (mm), reflects the displacement magnitude of the vibrating platform [10].

Heart rate variability (HRV) is the time variation between the RR intervals of an electrocardiogram and can be objectively and non-invasively evaluated, being able to reflect the cardiac autonomic function state through observing the heart rate [11]. Sympathetic and parasympathetic nervous system modulations on this parameter reflect the sympathovagal balance state [12], and low HRV represents lower parasympathetic activity and is associated with worse cardiovascular function performance. Thus, therapeutic strategies that positively influence this variable favor cardiovascular health [13].

Despite the diversity of protocols and application forms, associated or not with other therapeutic modalities, frequency, exposure time and populations with variable characteristics, the effects of WBV on the cardiovascular system are frequently reported in the literature [6,5,14]. These benefits can be partly explained by the greater sensitivity of the baroreflex, the increase in angiotensin II levels and the bioavailability of nitric oxide [6]. In addition, muscle contractions caused by vibration can more efficiently reduce endothelial dysfunction compared to training with conventional exercises and thus induce an increase in muscle mass between 10 and 30% [5,14].

However, considering that cardiac autonomic activity and functionality levels are often altered in the occurrence of non-communicable chronic conditions related to the cardiac, respiratory, vascular and metabolic systems, it is necessary to systematically analyze the effectiveness of WBV training in these populations. Therefore, the aim of this study was to perform a systematic review of randomized clinical trials to verify the effects of WBV training programs to promote sustained improvement in cardiac autonomic function and functionality in patients with chronic degenerative cardiac, respiratory, metabolic and vascular diseases.

Methods

This review followed a previous protocol according to PRISMA-P and was registered in PROSPERO: CRD42021277220.

Databases and research

Searches were performed in Medline/PubMed, Lilacs, PEDro and Scopus databases. Descriptors in Health Sciences (DeCS) and in Medical Subject Headings (MeSH) were used. The search strategy was defined through the use of the Boolean operators "AND" or "OR" to cross the descriptors as described in Chart I.

Selection criteria

Types of studies

All experimental randomized or quasi-randomized clinical trial studies, with participants of both genders, without distinction of age, published in any language, in the period from 1950 to February 28, 2022, which investigated the efficacy of whole-body vibration training, of any modality, on cardiac function, including heart rate variability in patients with chronic degenerative diseases, excluding those of neurological origin, were included. Observational studies, narrative review or pre-print studies, or studies that did not describe the WBV training protocol were excluded.

Participants

Studies with participants of both genders, with chronic degenerative heart, respiratory, vascular or metabolic diseases, without distinction of age, published until 2022, who had undergone a WBV intervention protocol.

Intervention

Studies which performed WBV training comparing it with other physical training modalities and/or with a control group were included. Studies that evaluated the acute effects of exposure to WBV and that did not present a control group were excluded.

Outcome

The main outcomes considered were sympathovagal balance, expressed by the low frequency/high frequency ratio (LF/HF) and the distance covered in the six-minute walk test (6MWT).

The secondary cardiac outcomes considered were systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate (HR), maximal oxygen consumption

(VO_{2max}), as well as the frequency domain of HRV, considering the high-frequency components (HF) ranging from 0.15 to 0.40 Hz and low frequency (LF) ranging from 0.04 to 0.15 Hz. Normalized HF and LF (nHF and nLF) are defined as HF or LF/(HF+LF), expressing spectral power as the relative contribution (percentage) of sympathetic (nLF) and parasympathetic (nHF) activities in the sinoatrial node. The analysis of cardiac autonomic function was divided into improvement/worsening of sympathovagal balance and increase/decrease in sympathetic or parasympathetic activity. The secondary functionality outcomes were gait speed and balance.

Data extraction and analysis

Studies were initially selected through title and abstract analysis by two independent reviewers (NTSA and MJSTN). Then, in a second more detailed analysis, the reviewers read the full text of the articles to verify if they met the inclusion criteria of the systematic review. In case of disagreement between the reviewers on any aspect, a third reviewer (PEMM) was asked for their analysis. A separate form was used to independently extract the data.

Evaluation of evidence quality

Evidence quality assessment was performed using the GRADE [15] system. The outcomes "sympathovagal balance", "distance covered in the six-minute walk test", "heart rate" and "systolic blood pressure" were used in the evaluation. Five factors can decrease the quality of evidence in randomized trials: study limitation, inconsistency, indirect evidence, indirection, imprecision, and publication bias, according to the classification of evidence level as high, moderate, low, and very low. The reviewers scored the evidence analysis for each variable according to the following classification: none (no point reduction), serious (one-point reduction) and very serious (two-point reduction).

Risk of bias evaluation

The analysis of risk of bias criteria used in Cochrane clinical trials was used, which considers the risk from the assessment of items such as randomization, allocation secrecy, blinding, loss control, selective description of outcomes and early interruption of the study. According to the guidelines established to assess the risk of bias, they are divided into: high, low or unclear. Table II presents the evidence quality regarding the outcomes included in the meta-analysis: sympathovagal balance, distance covered in the six-minute walk test, systolic blood pressure and heart rate.

Data analysis strategy

Data were analyzed using Review Manager (RevMan) version 5.30 software program. Ultra-homogeneity of the studies was evaluated using the heterogeneity test, being considered homogeneous when p-values were >0.05. The heterogeneity of the studies was classified as low heterogeneity when the heterogeneity index (I^2) was up to 30%, moderate from 30 to 60%, and high when >60%. A fixed-effect meta-analysis was performed in the first statistical analysis. A random effects meta-analysis was performed when $I^2 > 60\%$. The difference of means was used for studies that used the same assessment instruments, while the difference of standardized means was used for different instruments. Data available in graphs were extracted using the web plot digitizer v 4.5 extension program. Considering the heterogeneity level observed in the studies included in this review in terms of sample size and age of participants, a subgroup analysis was performed for the "sympathovagal balance", "heart rate" and "systolic blood pressure" outcomes from the number of study participants (< 5 patients and > 5 patients) and age (< 50 years and > 50 years).

Results

A total of 121 relevant titles and abstracts were found in the initial search and 3 studies were found from a secondary search, totaling 124 studies. Of these, 20 were excluded because they were duplicates and 33 were excluded after screening the title and abstract reading, as they did not address the outcomes of interest in this study. Thus, 71 studies were selected for the next stage, in which 12 studies were included after careful reading, as they met the inclusion criteria. The flowchart according to the Preferred Reporting Items for Review and Meta-Analyses (PRISMA) [16] guidelines in this review is shown below (figure 1).

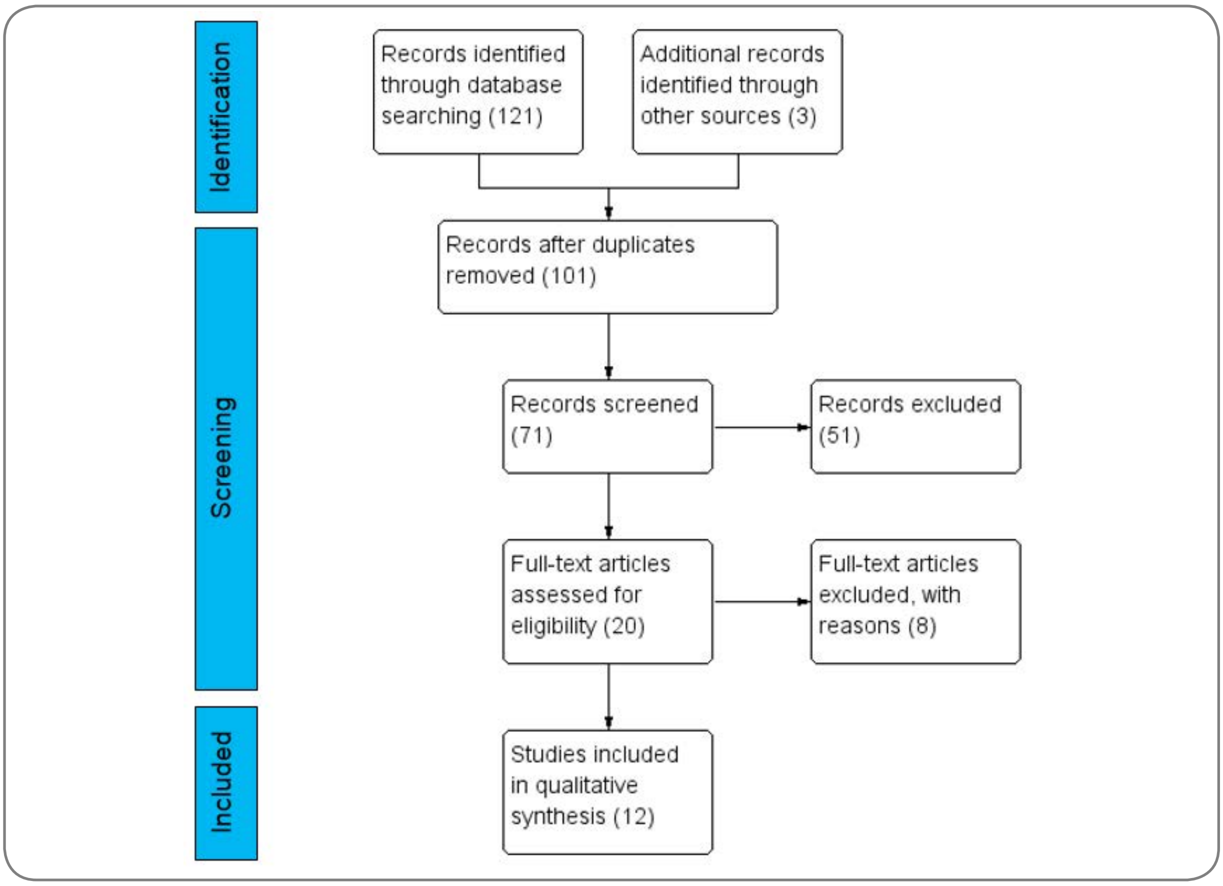

Figure 1 - Preferred Reporting Items for Review and Meta-Analyses (PRISMA) flow chart illustrating the different phases of study inclusion

The risk of bias analysis of the studies included in this review is shown in Figure 2.

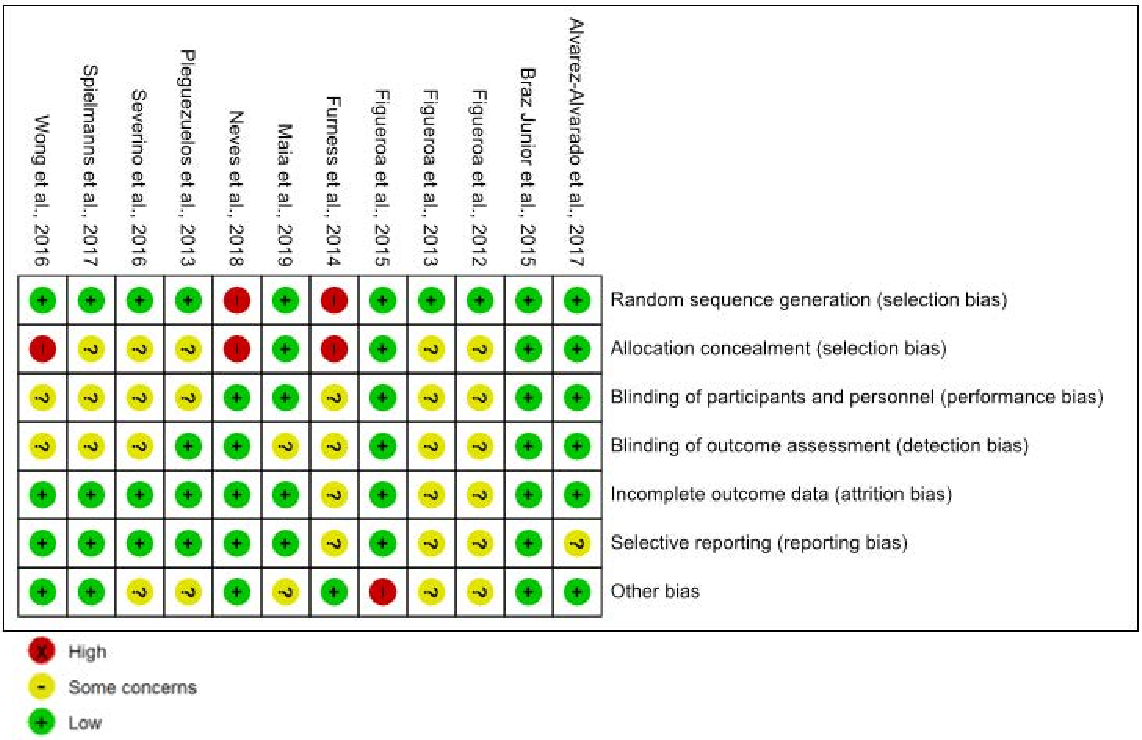

Figure 2 - Risk of bias summary according to Cochrane Collaboration criteria

The final sample consisted of 312 individuals, aged between 18 and 80 years. Five studies [18-20,23,24] included only women, one [21] only men, and another six recruited individuals of both genders [3,4,22,25-27].

The vibration frequency used in the protocols ranged from 25 to 40 Hz, the duration of the sessions from 10 to 60 minutes, and the total training duration ranged from 6 to 12 weeks. Regarding health status, three studies [18,20,23] evaluated the effects of WBV in overweight or obese women and pre-hypertension or stage one, two hypertension [19,24] in overweight or obese women, five studies [4,21,22,26,27] observed the effects of WBV in Chronic obstructive pulmonary disease (COPD) patients, and one in kidney transplant patients [3]. Three studies [4,19,22] were randomized clinical trials with a crossover design. One study [3] was not included in the meta-analysis of the “sympathovagal balance”, “heart rate” or “systolic blood pressure” outcomes, as it presented its results only in median, differing from the presentation of the results of the other included studies, which presented mean and standard deviation. Although the lead author was contacted by e-mail, she responded that she did not have the data of interest for this review. Table I presents the main characteristics of the studies included in this review.

Sympathovagal balance

Three studies [18,19,24] observed improvement in sympathovagal balance after training with WBV in a population of young or postmenopausal, overweight or obese, pre-hypertensive or stage one hypertension women, when compared to no intervention in analyzes by sample size (Figure 3) and by age (Figure 4), based on moderate evidence quality (Table II). One study [3] showed no improvement in sympathovagal balance in kidney transplant patients comparing WBV with Sham.

Distance covered in the 6MWT

Five studies [4,21,22,26,27] evaluated the distance covered in the 6-minute walk test. In all, the sample consisted of subjects with COPD, varying the severity level between mild [26], moderate [22,26,27] and severe [4,21,26]. There was no statistically significant difference in the distance covered for the WBV intervention groups compared to no intervention [4,21,26] and calisthenics training [26] in the control groups (Figure 5).

Heart rate

Eight studies [3,18-20,22-25] evaluated the effects of WBV on HR, with the total duration of the intervention varying between 6 weeks [19,20,22,24,25], 8 weeks [18] and 12 weeks [3,23]. Six studies [18-20,22,23,25] were included in the meta-analysis because they presented similar results (Figure 3). There was no reduction in heart rate in overweight or obese women and in COPD patients after WBV training, with moderate evidence quality (Table II).

Systolic blood pressure

The results of five studies [18-20,23,25] showed a reduction in SBP values after training with WBV in young or postmenopausal, overweight or obese, pre-hypertensive or stage 1 hypertension women (Figure 3), presenting moderate evidence quality (Table II). One study [3] did not observe a difference in the SBP of kidney transplant patients after WBV training.

Diastolic blood pressure

A reduction in DBP values was observed in three studies; the measurement was obtained by brachial measurement in two studies [18,20], and one study [25] reported a reduction only in the aortic DBP measurement in the intervention group, with no difference in the brachial DBP measurement. Two other studies [3,19] evaluated this outcome, but did not report any difference in relation to the control group.

Maximum oxygen consumption (VO_{2max})

Two studies [3,27] evaluated the maximum capacity for uptake and utilization of oxygen expressed by VO_{2max}. Only one study [27] observed an improvement in the values of this outcome in a population of patients with severe COPD when compared to baseline.

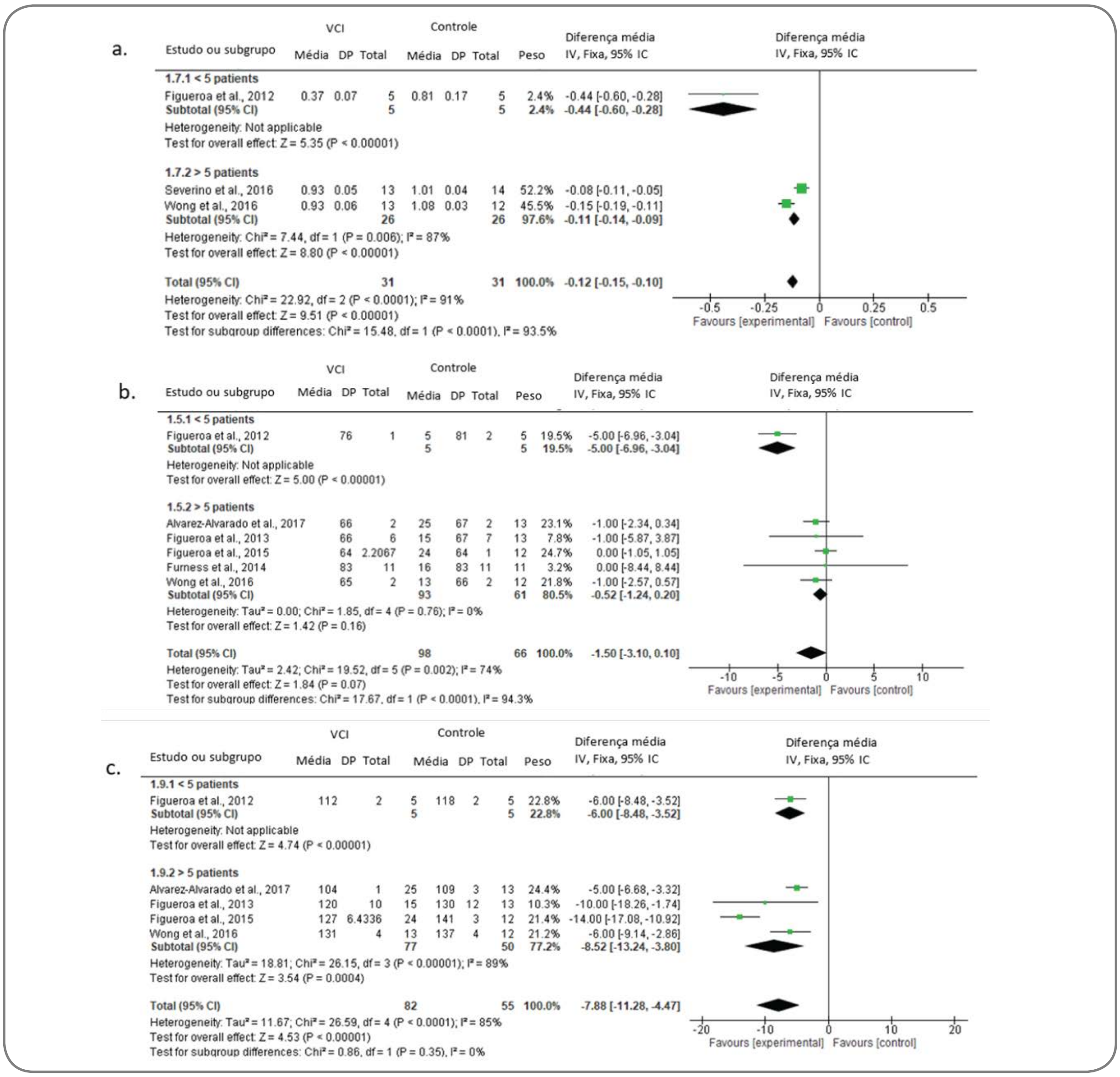

Figure 3 - (a) sympathovagal balance; (b) heart rate; (c) systolic blood pressure from whole-body vibration versus no intervention in subgroup analysis by sample size

Sympathetic tone (LF)

A decrease in sympathetic tone was observed in three studies [18,19,24] after intervention with WBV in overweight or obese patients, whether or not associated with prehypertension and stage 1 hypertension. One study [3] reported an increase in delta sympathetic tone in the Sham group in kidney transplant patients.

Parasympathetic tone (HF)

One study [24] found an increase in parasympathetic tone in the intervention group when compared to the control group, while another study [18] found an increase in nHF values in relation to baseline values in the intervention group, but with no difference in relation to the control group. Two other studies [3,19] evaluated the parasympathetic tone after WBV, but no difference was observed between the groups.

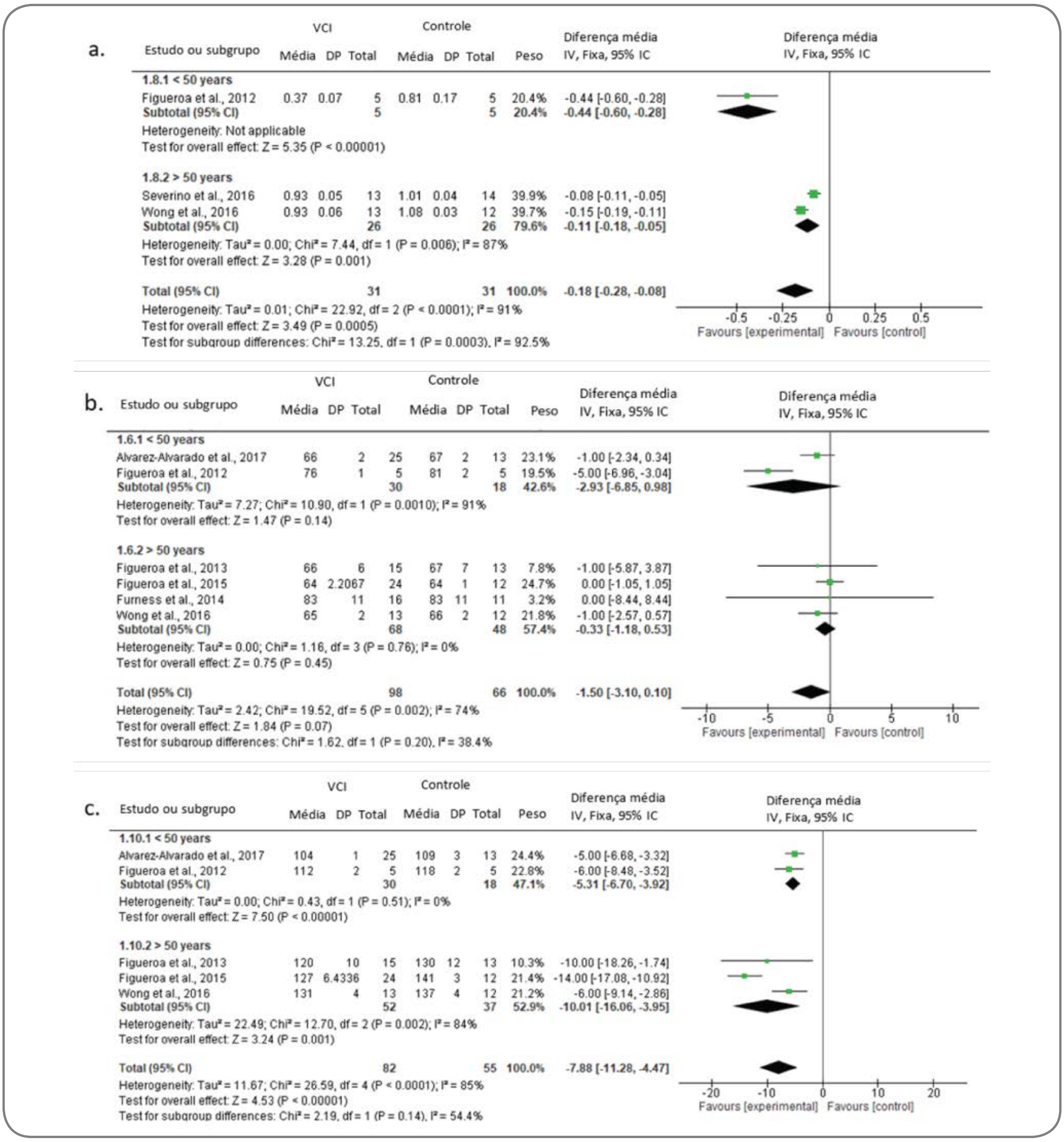

Figure 4 - (a) sympathovagal balance; (b) heart rate; (c) whole-body vibration systolic blood pressure versus no intervention in age subgroup analysis

Gait speed

A study by Furness *et al.* [22] observed an increase in gait speed in COPD patients undergoing WBV training. Another study [4] which evaluated this outcome found no difference between the groups.

Balance

Only one study [26] evaluated the effect of WBV on the balance of patients with stable COPD stage I to III according to the GOLD [28] classification compared to calisthenics. The authors did not observe significant differences between the groups for the unipedal stance test. Only the intervention group showed an increase of 1.5 points (0.00 - 4.00 points) in the multidimensional evaluation carried out using the Berg balance scale.

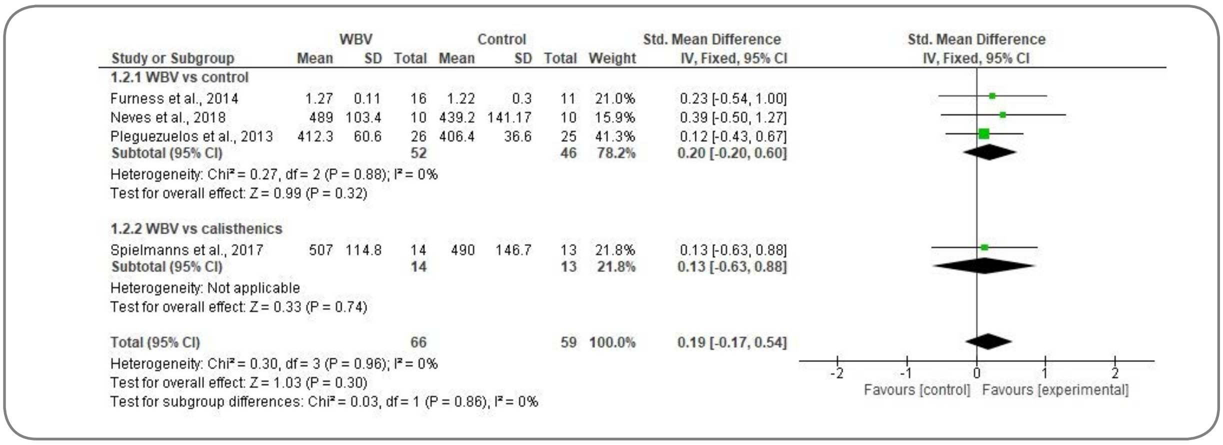

Figure 5 - Whole-body vibration versus no intervention and calisthenics on walking distance

Consumo máximo de oxigênio ($VO_{2máx}$)

Dois estudos [3,27] avaliaram a capacidade máxima de captação e utilização de oxigênio expressa pelo $VO_{2máx}$. Apenas um [27] observou melhora nos valores desse desfecho em população de pacientes com DPOC severa quando comparados à linha de base.

Tônus simpático (LF)

Foi observado em três estudos [18,19,24] diminuição do tônus simpático após a intervenção com VCI em pacientes com sobrepeso ou obesidade, associadas ou não a pré-hipertensão e hipertensão estágio 1. Um estudo [3] relatou aumento no delta do tônus simpático no grupo Sham, em pacientes transplantados renais.

Tônus parassimpático (HF)

Um estudo [24] verificou aumento do tônus parassimpático no grupo intervenção quando comparado ao controle, enquanto outro estudo [18] encontrou aumento dos valores de nHF em relação aos valores basais no grupo intervenção, porém sem diferença em relação ao grupo controle. Outros dois estudos [3,19] avaliaram o tônus parassimpático após VCI, porém não foi observada diferença entre os grupos.

Velocidade de marcha

O estudo de Furness *et al.* [22] observou aumento na velocidade da marcha de pacientes com DPOC submetidos a treinamento com VCI. Um outro estudo [4] que avaliou este desfecho não encontrou diferença entre os grupos.

Equilíbrio

Apenas um estudo [26] avaliou o efeito da VCI sobre o equilíbrio de pacientes com DPOC estável com estadiamento I a III de acordo com a classificação GOLD [28] comparado à calistenia. Os autores não observaram diferenças significativas entre os grupos para o teste de apoio unipodal. Na avaliação multidimensional, realizada por meio da escala de equilíbrio de Berg apenas o grupo intervenção apresentou aumento de 1,5 pontos (0,00 – 4,00 pontos).

Discussion

The results of this systematic review show that WBV training improved sympathovagal balance in overweight or obese women [18,19,24], as well as prehypertensive or those with stage one hypertension [18], however, it did not improve this outcome in kidney transplant patients for at least one year [3], in which the highest HRV response occurred in the Sham group. One study [24] showed a positive correlation between the improvement in sympathovagal balance and loss of body fat, indicating that a reduction in fat percentage can contribute to improve the autonomic function of obese women. Other authors [30-32] corroborate this finding, pointing out that endurance training improved sympathovagal balance, as well as the LF and HF parameters of HRV, with a reduction in sympathetic tone and an increase in parasympathetic tone in a population of healthy and obese people in a similar form to the result obtained with WBV [18,19,24].

Although WBV training did not promote an increase in the distance covered in the 6MWT in patients with COPD, there is a tendency for an increase in the intervention group in all studies [4,21,22,26,27] that evaluated this outcome, considering that the 35-meter increase in the distance covered in the 6MWT for COPD patients represents the smallest clinically relevant difference [29]. In addition, two studies [4,22] included in this review had a crossover design, with the same population exposed to training with whole-body vibration, with a variation in the washout period from two [4] to 12 weeks [22]. Studies [33,34] that performed a pulmonary rehabilitation program twice a week for 8 weeks with aerobic and resistance exercises in the same population also observed an increase of more than 35 meters in the distance covered in the 6MWT.

The results included in this review showed a trend towards a reduction in resting HR after completion of WBV training protocols in obese women [19,24,25] and in patients with moderate COPD [2]. These studies also showed that WBV was effective in reducing SBP values [18-20,23,25] in the trained group. Bradycardia and exercise-induced hypotension are chronic desired effects, widely reported in the literature and often not only associated with improved cardiovascular health in healthy individuals, but also in patients with chronic cardiovascular and metabolic conditions, reflecting increased parasympathetic autonomic control and baroreceptor reflex sensitivity [30-32,35-37].

Only two studies investigated the effect of WBV on VO_{2max} in patients with COPD [27] and in kidney transplant recipients [3]. COPD patients exposed to WBV increased VO_{2max} compared to baseline, however with no difference in the control group. One study [38] evaluated the cardiopulmonary response of patients with severe COPD during WBV training and observed an increase in oxygen consumption rates after the third minute; however, so far it cannot be said that WBV training promotes a sustained increase in VO_{2max} values in this population. The increase in VO_{2max} as a chronic effect of physical training was described in a study [39] that investigated the effects of endurance exercises performed with workload above 80% of baseline in a pulmonary rehabilitation program for patients with moderate and severe COPD. Corroborating these findings, another study [40] observed that 6 weeks of moderate and high-intensity resistance training in COPD patients promoted improvement in VO_{2max} values in this population.

Balance and gait speed were also assessed outcomes and showed a positive response to WBV training in COPD patients in two studies [22,26], in contrast to a study [4] in which no improvement in gait speed was observed after training.

The present review took into account the variation in sample size and the low number of studies that investigated these outcomes in patients with non-transmissible cardiovascular, respiratory or chronic metabolic conditions exposed to WBV, and this limits understanding of the training effect on these outcomes, with it being necessary that other studies are developed to establish the evidence of WBV on the outcomes investigated herein.

Conclusion

WBV proved to be an alternative training modality for patients with obesity, hypertension and COPD, who may have low tolerance to other therapeutic exercise modalities. WBV promoted an improvement in cardiac autonomic activity expressed by greater sympathovagal balance, in addition to being effective in reducing SBP baseline values in patients with chronic non-communicable diseases. There was also a trend towards a reduction in resting HR and greater distance covered in the 6MWT after training with WBV, however, given the heterogeneity present in the studies included in this meta-analysis, we suggest that these outcomes should be evaluated in larger studies with greater methodological rigor.

Potential conflict of interest
No conflicts of interests have been reported for this article.

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Authors' contributions
Research conception and design: Amorim NTS, Marinho PEM; **Data collection:** Amorim NTS, Nunes MJST; **Data analysis and interpretation:** Amorim NTS, Nunes MJST; **Manuscript writing:** Amorim NTS; **Critical review of the manuscript for important intellectual content:** Marinho PEM

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ANNEXES

Chart I - Search strategies in Medline/PubMed, Lilacs PEDro and Scopus databases

Base	Strategy
Pubmed/Medline	#1: (“Whole-body vibration” OR “Passive vibration” OR “Vibration training” OR “Sonic wave vibration”) AND (“Heart rate variability OR “Autonomic function” OR “Cardiac autonomic function” OR “autonomic dysfunction” OR “autonomic disorder”) AND (“Cardiovascular disease” OR “respiratory disease” OR “metabolic disease” OR “chronic disease” OR “obesity”)
Lilacs	#1 (“Whole-body vibration” OR Whole vibration body OR “passive vibration”) AND (“Heart rate variability” OR “autonomic function” OR “autonomic dysfunction”) AND (“Cardiovascular disease” OR ‘chronic disease” OR “respiratory disease”)
PEDro	#1 (“Whole-body vibration”) AND (“heart rate variability” OR “ autonomic *function”) AND (“Cardiovascular” OR “chronic disease” OR “obesity”).
Scopus	#1 (“Whole-body vibration” OR “Whole vibration body” OR “Passive vibration” OR “Vibration training” OR “Sonic wave vibration”) AND #2 (“Heart rate variability OR “Autonomic function” OR “Cardiac autonomic function” OR “autonomic dysfunction” “autonomic disorder”) AND (“randomized controlled trial” OR “clinical trial”) AND (“chronic disease” OR “obesity” OR “cardiovascular”)

Table I - Characteristics of the experimental studies included in this review

Author/year (Country)	Sample	Participants	Intervention protocol
Figueroa *et al.* 2012 [19] (United States)	IG: 5 CG: 5	Women Age: 18 - 35 years Health condition: overweight and obese (BMI > 25 kg/m² < 40 kg/m²)	IG: Training on a vibrating platform with a frequency of 25 -30 Hz, 1-2 mm in amplitude, 3x/week, for 6 weeks. Series duration: 30 - 60 s. Rest periods: 60-30 s. Subjects wore a weight vest at 5% and 10% of their body weight during weeks 5 and 6, respectively. Dynamic exercises: 3 sec eccentric / 2 sec concentric for each repetition, considering 180º as total knee extension. Exercise 1: semi-squat with knees at 120° Exercise 2: semi-squat with 120° knees and wide base Exercise 3: Calf raise with maximum plantar flexion Static exercises: Exercise 1: Isometric squat with knees at 120° Exercise 2: Isometric squat with 120° knees and wide base Exercise 3: Calf raise with maximum plantar flexion 4 weeks washout period CG: instructed not to perform any type of physical exercise during the 6 weeks of duration

Table I - Continuation

Author/year (Country)	Sample	Participants	Intervention protocol
Figueroa *et al.* 2013 [20] (United States)	IG: 15 CG: 13	Women Age: 53 - 59 years Health condition: prehypertension or stage 1 hypertension, overweight or obesity (BMI >25 kg/m²), postmenopausal	IG: Training on a vibrating platform, 3x/week, for 6 weeks. The vibration frequency ranged from 25-35 Hz, amplitude of 1mm. The number of sets and duration of each exercise varied progressively, respectively, from 1-2 and from 30 to 45 seconds. The duration of the recovery periods between sets was kept at 60 seconds. Dynamic exercises: 3 sec eccentric / 2 sec concentric for each repetition, considering 180º as total knee extension. Exercise 1: Squat with knees at 90° with feet in line Exercise 2: Squat with knees at 120º with feet in line Exercise 3: Calf raise with maximum plantar flexion Static exercises: Exercise 1: Isometric squat with knees at 90° with feet in line Exercise 2: Isometric squat with knees at 120° with feet in line Exercise 3: Isometric calf contraction with maximum plantar flexion CG: instructed not to perform any type of physical exercise during the study period
Pleguezuelos *et al.* 2013 [21] (Spain)	IG: 26 CG: 25	Men Age: 59 - 80 years Health condition: severe COPD	IG: Warm-up (10 minutes): exercises for upper and lower limbs and spine, Training with WBV with a frequency of 35 Hz and 2 mm of amplitude + static squat with 30° of hip flexion and 55° of knee flexion, with the upper limbs holding the platform bars, 6 sets of 4 repetitions of 30 seconds, with 60 s of rest between each set. Cool-down: Stretches (10 minutes) 18 sessions, 3x/week, for 6 weeks. CG: general recommendations on physical activity and lifestyle (Mediterranean Diet + at least 30 min of moderate-intensity walking daily)
Furness *et al.* 2014 [22] (Australia)	IG: 16 CG: 11	Both genders Age: 65 - 79 years Health condition: moderate COPD	IG: Training on a vibrating platform, with a frequency of 25 Hz, 2 mm of amplitude, 2x/week, for 6 weeks. Static semi-squat posture (knees bent at ~55°) 2-week washout period CG: Sham training on a vibrating platform, with characteristic noise, without vibration, 0 mm amplitude, 2x/week, for 6 weeks. Static semi-squat posture (knees bent at ~44°)
Braz Júnior *et al.* 2015 [4] (Brazil)	IG: 11 CG: 11	Both genders Age: 54 - 72 years Health condition: COPD	IG: 10 minutes of stretching for upper and lower limbs Vibration platform training: 3x/week for 12 weeks. Static semi-squat posture (120-130°), with feet 20 cm apart, upper limbs slightly flexed in support. Weeks 1-4: 30 s of WBV at 2 mm, 60 s of standing rest, total duration 10 minutes Weeks 5-8: 60 s of 4 mm WBV, 60 s of standing rest for 20 minutes Weeks 9-12: 60s of 4mm WBV, 60s of standing rest for 20 minutes All subjects participated in the intervention group and the control group, with a 3-month washout period. CG: no intervention

Table I - Continuation

Author/year (Country)	Sample	Participants	Intervention protocol
Figueroa *et al.* 2015 [23] (United States)	IG: 24 (12 with high ankle SBP, 12 with normal ankle SBP) CG:12	Post-menopausal women Age: 55 - 59 years old Health condition: prehypertension or stage 1 hypertension, overweight or obese (BMI >25 kg/m²)	IG: Training on a vibrating platform, 3x/week, for 12 weeks. The vibration frequency ranged from 25-40 Hz, with low to high amplitude, duration of the exercise series from 30 to 60 seconds, number of series from 1 to 6 for each exercise, total duration of the training session: from 11 to 60 minutes and duration of recovery periods between sets of 60–30 seconds. Dynamic exercises, performed with socks on the feet: 3 sec eccentric/2 sec concentric for each repetition, considering 180º as total knee extension. Exercise 1: Squat with knees at 90° with feet in line Exercise 2: Squat with knees at 120º with feet in line Exercise 3: Squat with knees at 120° with feet apart Exercise 4: Calf raise with maximum plantar flexion Static exercises: Exercise 1: Isometric squat with knees at 90° with feet in line Exercise 2: Isometric squat with knees at 120° with feet in line Exercise 3: Isometric squat with knees at 120 degrees with feet apart Exercise 4: Isometric calf contraction with maximum plantar flexion CG: no exposure
Severino *et al.* 2016 [24] (United States)	IG: 13 CG: 14	Sedentary Hispanic women Age: 50 - 65 years Health condition: Obese (BMI > 30 and < 40 kg/m²) post-menopausal for at least 1 year	IG: Training on a vibrating platform, with a frequency of 25 Hz and 3 sets of 30s on/60s off (week 1), 30 Hz and 4 sets of 30s on/60s off (week 2), 35 Hz and 5 sets of 45s on/45s off (week 3), 35 Hz and 6 sets of 45s on/45s off (week 4), 40 Hz and 7 sets of 60s on/30s off (week 5), 40 Hz and 7 sets of 60s on/30s off (week 6), amplitude of 1 mm (weeks 1-3) and 2 mm (weeks 4-6), 3x/week for 6 weeks, associated with 4 dynamic exercises and 4 static exercises for the legs. Dynamic exercises: 3 sec eccentric/2 sec concentric for each repetition, considering 180º as total knee extension. Exercise 1: Squat with knees at 90° and normal posture Exercise 2: Squat with knees at 120° and normal posture Exercise 3: Squat with 120° knees and wide base Exercise 4: Calf raise with maximum plantar flexion Static exercises: Exercise 1: Isometric squat with knees at 90° Exercise 2: Isometric squat with knees at 120° Exercise 3: Isometric squat with 120° knees and wide base Exercise 4: Calf raise with maximum plantar flexion CG: no exposure

Table I - Continuation

Author/year (Country)	Sample	Participants	Intervention protocol
Wong *et al.* 2016 [18] (United States)	IG: 13 6 with BMI > 30 < 35 kg/m² 7 with BMI > 35 <40 kg/m² = 7 CG: 12 7 with BMI > 30 < 35 kg/m² 5 with BMI > 35 <40 kg/m² = 7	Women Age: 50 - 65 years Health condition: Obese (BMI > 30 kg/m² and < 40 kg/m²) postmenopausal for at least 1 year, pre-hypertensive or hypertensive stage 1	IG: Training on a vibrating platform, 3x/week with 48-hour intervals between sessions, for 8 weeks. The vibration frequency ranged from 25-40 Hz, with low to high amplitude, resulting in peak acceleration between 4.3 and 21.3 g, duration of the exercise series from 30 to 60 seconds, number of series from 1 to 5 for each exercise, total duration of training session: 11–60 minutes and duration of rest periods 60–30 seconds. Dynamic exercises, performed with socks on the feet: 3 sec eccentric/2 sec concentric for each repetition, considering 180º as total knee extension. Exercise 1: Squat with knees at 90° and normal posture Exercise 2: Squat with knees at 120° and normal posture Exercise 3: Calf raise with maximum plantar flexion Static exercises: Exercise 1: Isometric squat with knees at 90° Exercise 2: Isometric squat with knees at 120° Exercise 3: Calf raise with maximum plantar flexion CG: no exposure
Alvarez-Alvarado *et al.* 2017 [25] (United States)	IG: 25 CG: 13	Women Age: 18 - 25 years Health condition: overweight and obese (BMI > 27 kg/m² < 40 kg/m²)	IG: Training on a vibrating platform, 3x/week, for 6 weeks. Vibration frequency ranged from 30-35 Hz, with low to high amplitude. Duration of exercise series from 30 to 60 seconds, number of series from 1 to 8 for each exercise, total duration of training session: from 11 to 30 minutes and duration of rest periods of 60–45 seconds. Dynamic exercises, performed barefoot: 3s eccentric phase/3s concentric phase for each repetition, considering 180º as total knee extension. Exercise 1: Squat with knees at 90° and normal posture Exercise 2: Squat with knees at 120° and normal posture Exercise 3: Squat with 90° knees and wide base Exercise 4: Calf raise with maximum plantar flexion CG: no exposure
Spielmanns *et al.* 2017 [26] (Germany)	IG: 14 CG:13	Both genders Age: > 65 years Health condition: Stable COPD Stages I to III	IG: Warm-up (10 minutes): low-intensity walking on a treadmill or bicycle, stretching. Whole body vibration training (15 minutes): - Weeks 1 - 4: Frequency 6 to 10 Hz, amplitude 4 to 6 mm, 3 sets of 2 minutes with a 2-minute break between sets. - Weeks 5 - 8: Frequency from 12 to 18 Hz, amplitude from 4 to 6 mm, 3-minute sets with a 2-minute break between sets. - Weeks 9 - 12: Frequency 21 to 24 Hz, amplitude 4 to 6 mm, 3-minute sets with a 2-minute break between sets. Participants trained in a static semi-squat position in all weeks, with bare feet and knees at 150º, considering 180º as full extension, arms at the sides or supported on the support bar of the device. Cool-down: (5 minutes) Total duration of each workout: 30 minutes, 2 x/weeks, for 3 months CG: Supervised group calisthenics training: relaxation and breathing training associated with calisthenics, total duration of each training session: 30 minutes, 2x/week, for 3 months.

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Table I - Continuation

Author/year (Country)	Sample	Participants	Intervention protocol
Neves *et al*. 2018 [27] (Brazil)	IG: 10 (COPD) CG: 10 (healthy)	Both genders Age: 45 to 80 years Health condition: moderate COPD	IG: Training with WBV + static squat with 30º of knee flexion, with feet 28 cm apart, with upper limbs holding the platform bars, performing 6 sets of 30 s with 60 s of rest between each set, 3x/week, for 12 weeks. - Weeks 1-4: Frequency 30 Hz, amplitude 2 mm. - Weeks 5 - 8: Frequency of 35 Hz, amplitude of 2 mm - Weeks 9 - 12: Frequency of 40 Hz, amplitude of 2 mm CG: no exposure
Maia *et al*. 2019 [3] (Brazil)	IG: 6 CG: 6	Participants of both genders Age: 18 - 59 years Health condition: kidney transplant recipients with at least 1 year of transplant	IG: Training on a vibrating platform, with F=35 Hz, 2x/week for 12 weeks, amplitude of 2 mm in the first 2 weeks and 4 mm in the other weeks. Exposure time 10 minutes (weeks 1-4), 15 minutes (weeks 5-8), 20 minutes (weeks 9-12) CG: Training on a vibrating platform, with an attached plate promoting light vibration at 8 Hz of frequency and similar noise. Both groups performed the training in an upright position, with knees semi-flexed and feet 20 cm apart.

IG = Intervention group; CG = Control group; BMI = Body mass index; WBV = Whole body vibration; Hz = Hertz; UL = Upper limbs; SAH = Systolic arterial hypertension; COPD = chronic obstructive pulmonary disease

Table II - Evidence quality evaluation using GRADE for the "'sympathovagal balance", "distance covered in the six-minute walk test", "systolic blood pressure" and "heart rate" outcomes of patients with chronic non-communicable diseases using full body vibration protocols

Certainty assessment							Summary of findings				
Participants (studies) Follow-up	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Publication bias**	**Overall certaint of evidence**	**Study event rates (%)**		**Relative effect (95% CI)**	**Anticipated absolute effects**	
							With non-exercise	**With Whole vibration body**		**Risk with non-exercise**	**Risk difference with Whole vibration body**
Sympathovagal balance											
52 (4 RCTs)	serious	not serious	not serious	not serious	none	⊕⊕⊕◯ Moderate	26	26	-	-	SMD **0.19 SD higher** (0.17 lower to 0.54 higher)
Six minute walk test											
164 (5 RCTs)	serious	not serious	not serious	not serious	none	⊕⊕⊕◯ Moderate	66	98	-	The mean six minute walk test was **0**	MD **1.5 lower** (3.1 lower to 0.1 higher)
Systolic Blood Pressure											
137 (5 RCTs)	serious	not serious	not serious	not serious	none	⊕⊕⊕◯ Moderate	55	82	-	The mean systolic Blood Pressure was **0**	MD **6.74 lower** (7.9 lower to 5.57 lower)
Heart rate											
164 (6 RCTs)	serious	not serious	not serious	not serious	none	⊕⊕⊕◯ Moderate	66	98	-	The mean heart rate was 0	MD 1.5 lower (3.1 lower to 0.1 higher)