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REVIEW PAPER

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Use of whole-body vibration as osteoporosis treatment in postmenopausal women: a systematic review

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ABSTRACT

Introduction. The use of whole-body vibration (WBV) has increased in the therapeutic field for patients with osteoporosis, however, there is still some controversy about its real effects.

Aim. to perform a systematic review on the use of WBV for improving bone mineral density and effects of osteoporosis in postmenopausal women.

Material and methods. the search was conducted by two researchers in the MEDLINE/PubMED and SciELO databases. It was included in the study clinical trials that dealt with the influence of vibration platform treatment on osteoporosis in the Portuguese and English languages published since 2006.

Results. Ten selected clinical trials were found in a total of 405 articles. There are heterogeneous results owing to the divergences of the study. Six articles presented benefits of treatment with WBV in bone parameters, one article with changes in balance and muscle strength and three with no effects after treatment.

Conclusion. It is concluded that the use of WBV was presented as an option in the treatment of osteoporosis, however, studies using homogeneous methodologies are needed to compare the actual benefits of using them.

Keywords. bone and bones, exercise, osteoporosis

Introduction

Osteoporosis results from an imbalance between bone formation and resorption, affecting patients at different ages and altering normal bone architecture.[1,2] Aging increases the incidence of fractures associated with this disease, particularly in postmenopausal women, and the term postmenopausal osteoporosis is used when estrogen deficiency exacerbates demineralization of the bone architecture.[3–6]

This process occurs due to estrogen acting as a bone protector, decreasing bone resorption by increasing the

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expression of osteoprotegerin, secreted by osteoblasts and decreasing, among others, the expression of the nuclear transcription factor kappa B ligand (RANKL) in osteoclasts. Although maintenance of bone tissue with altered concentrations is maintained, this estrogen deficiency increases the levels of proinflammatory cytokines and tumor necrosis factor, stimulating osteoclastogenesis with increased expression of the activating receptor of RANKL.[7–9]

Fractures that occur due to bone fragility are a serious public health problem worldwide, since they have large proportions on mortality, morbidity and quality of life.[10] Regular exercise may be in charge of increasing and maintaining bone mineral density (BMD), improving balance, and reducing the risk of fractures and falls.[3,11,12] However, although physical exercise is beneficial, physical exercises may be contraindicated or difficult to perform in elderly individuals, thus increasing the likelihood of developing chronic diseases and their comorbidities.[1,3] For this reason, new methods of intervention for the increase in BMD have been increasing recently and among them, training in vibratory platform or whole-body vibration (WBV) is cited as a way to increase BMD, treat osteoarthritis and improve physical fitness, both in human and animal studies, although there are still several controversies about its effects.[12–19]

On these platforms, individuals receive mechanical stimuli that causes vibration of the entire body.[14,20,21] Its benefits in the bone tissue can be explained by the piezoelectric effect, because after a mechanical tension there is the generation of electric potential along the tissue, with negative charges generated on the bone surface and consequently the flow of positive ions to the extracellular medium after activation of ionic channels, stimulating the mechanotransduction, that is, osteocytes to generate biochemical responses and induce the formation of bone mass and suppress their resorption.[22,23] WBV is also capable of promoting muscle strength gains by potentiation muscle contraction after proprioceptive activation. It is also important to emphasize that the strengthening of periarticular muscles control the weight loss in the involved joints, reducing shock and overloads, which would also affect the skeletal system beneficially.[24,25]CINAHL, Embase, Scopus, PEDro, and Science citation index for research articles published prior to March 2015 using the keywords whole body vibration, vibration training, strength and vibratory exercise in combination with the Medical Subject Heading 'Osteoarthritis knee'. Study selection: This meta-analysis was limited to randomized controlled trials published in the English language. Data extraction: The quality of the selected studies was assessed by two independent evaluators using the PEDro scale and criteria given by the International Society of Musculoskeletal and Neuronal Interactions (ISMNI).

However, there are contraindications to its use, such as in diabetic individuals with neuromuscular diseases, severe heart disease, stroke, implant, bypass, stent; furthermore there is disagreement about the real effects of the use of WBV in the bone architecture and improvement of osteoporosis in postmenopausal women, as well as with respect to the parameters used, and the tissue responses are dependent on these factors, with the literature pointing out that its use is more effective when not used for strenuous periods and with frequencies between 30-60Hz.[3,13,26,27]Grupo Aula Medica S.A. All rightsreserved. Objective: The aim of this study was to examine the effect of 8 months of whole-body vibration training on bone mass in octogenarian women. Method: Thirty-seven women (aged 82.4 [SD=5.7] years).

Aim

In this way, this study aimed to carry out a systematic review of the literature on the effects of WBV on bone mineral density and whether it is possible to attenuate the effects of osteoporosis in postmenopausal women.

Description of the subject literature

This systematic review was carried out according to the criteria and recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) methodology. We used the National Library of Medicine (MEDLINE / PubMED) and the Scientific Electronic Library Online (SciELO) electronic databases, investigating articles related to the proposed topic, searched in the period of May and June of 2018. The searches were performed with the terms "osteoporosis", "vibratory platform", "whole-body vibration", "bone", articulating also the words with "and", thus forming combinations.

We included in the study randomized clinical trials that had as an object of study the influence of the treatment of WBV on osteoporosis, published since 2006, with articles available in full online in Portuguese and English. Studies that did not fit these criteria and did not have menopausal women as participants were not included in the study. The analysis of the selected articles was done by two authors, if there was disagreement, a third author would be responsible for inserting the article or not in the review. The sequence of steps to select the articles was first made by the identification and selection of articles, followed by the eligibility in which the inclusion and exclusion criteria were implemented, and finally the inclusion of the articles chosen. For the included articles, the Physiotherapy Evidence Database (PEDro) scale was used to measure the methodological quality of the studies, also applied by two evaluators.

After searching the databases, a total of 405 scientific articles were found, 360 of which were found in MEDLINE / PubMED and 45 in SciELO. However, some

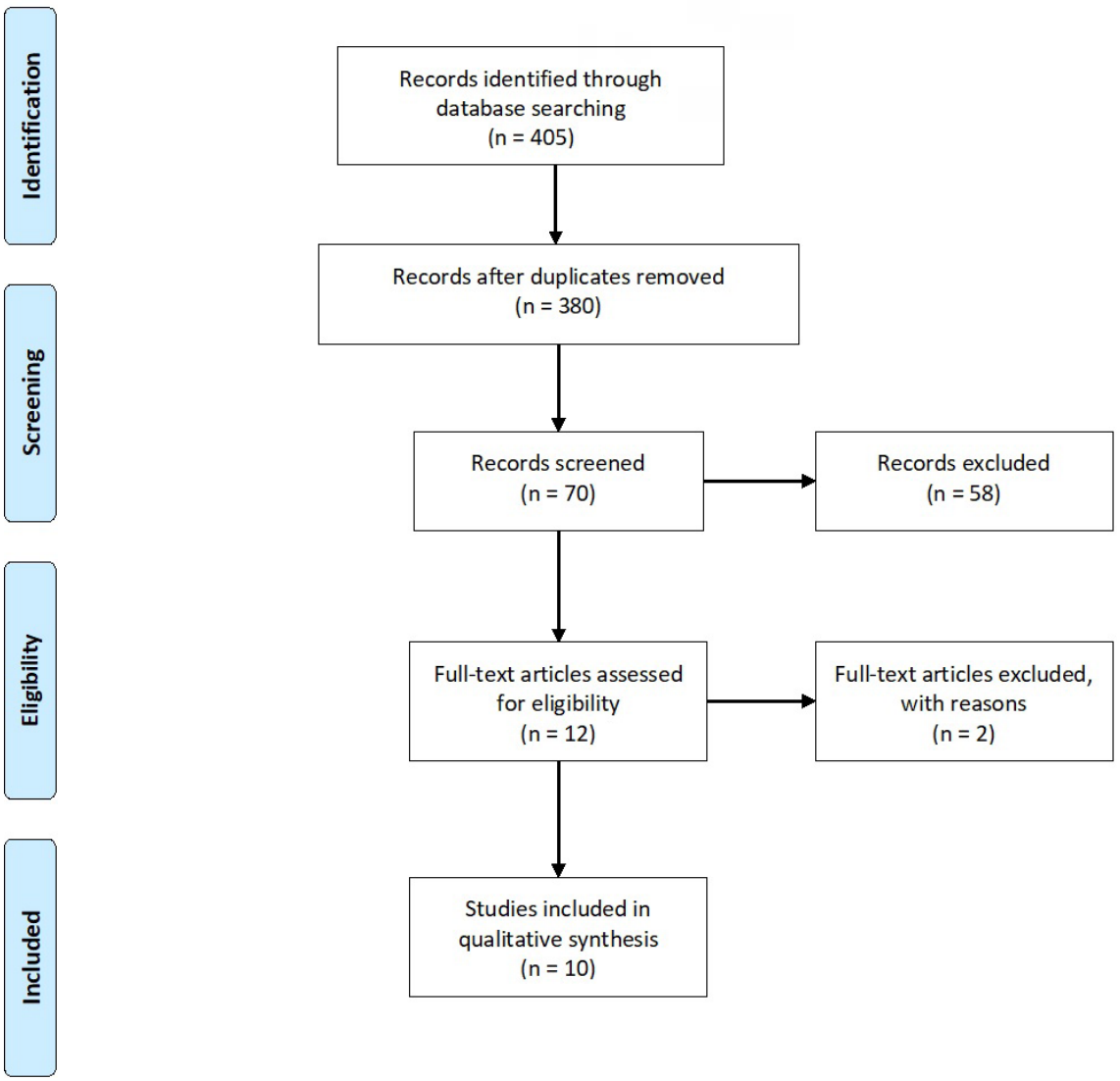

Fig. 1. Flowchart (based on PRISMA 2009) to identify the articles included in the study

articles were duplicated in the databases, thus totaling 380 articles initially. Following this step, a careful analysis of the articles occurred, by means of title and abstract readings, and later for pre-selected articles with full text reading, reaching an end of 10 articles selected for this systematic review. A flowchart was elaborated (Figure 1), to visualize the selection stages of the articles.

The methodological quality assessed by the PEDro scale resulted in an average of 8.2 ± 1.7. Higher scores do not necessarily imply clinical evidence, but they assure that the treatment used was adequate, with studies varying from 6 to 10 points on the scale.

The results showed that the periods can vary from 6 to 12 months of treatment, and the use of WBV may be involved in exercise, as well as vitamin D and calcium supplementation. In the articles studied, 6 suggest beneficial effects of intervention on bone, muscle and balance parameters.[28–31] One study had no effect on BMD, however, it decreased the frequency of falls.[32]the multi-purpose exercise training was effective to increase lumbar BMD but added WBV did not enhance this effect. However, falls were lowest in the exercise program combined with WBV. Introduction: WBV is a new approach to reduce the risk of osteoporotic fractures. In the \"Erlangen Longitudinal Vibration Study\" (ELVIS). Three other studies did not present significant consequences for the parameters evaluated (Table 1).[33–37]

Analysis of the literature

With the mechanical load it is possible to stimulate bone formation and maintenance of muscle mass, and body vibration is a proposal that is growing among the modalities of physical exercise.[38,39]selective effects of different frequency and acceleration magnitude modalities on musculoskeletal responses need to be better defined. Our aim was to investigate the bone effects of different

Table 1. Description of the articles included and analyzed, with presentation of the authors, participants, main interventions and evaluation forms, results found and a note attributed by the PEDro scale

Author / year	Participants	Intervention	Evaluation	Outcome	PEDro Scale
Gusi et al., 2006	Groups Walk Exercise (n=14) and WBV (n=14)	8 months, 3x/week. Performed walking exercise (60min) or WBV (1-30min, 12.6Hz)	BMD femur and lumbar spine and balance	WBV group improved femur BMD and balance	7
Beck et al., 2010	Groups Control (n=15), low (n=15) and high intensity WBV (n=17)	8 months. Control group without intervention, WBV 2x/week with low (15 min, 30Hz, 0.3G) and high (2x3 min, 12.5Hz, 1G) intensity	Bone mineral content, lumbar spine BMD, femur, forearm, muscle strength and balance tests	WBV improved the parameters, without differences between high and low frequency	6
Slatkovska et al., 2011	Groups Control (n=67), low (n=68) and high WBV (n=67) frequency	12 months. Control group without intervention. Daily use of WBV (20min, 0.3G) of low (30Hz) and high (90Hz) frequency + supplementation of vitamin D and calcium for the three groups	Bone volume and thickness of the tibia and radius, femur BMD and lumbar spine	No difference between groups	10
Verschueren et al., 2011	Control Groups: Vitamin D supplementation with low (n=28) and high (n=29) dose; PV: Vitamin D low (n=28) and high (n=26) dose	6 months. Control groups without intervention and WBV groups (1-12 min, 30-40Hz, 1.6-22G), frequency 3x/week, associating static and dynamic exercises in the platform	Hip BMD and isometric and dynamic strength, muscle mass of knee extensors	Vibratory platform did not increase the parameters in comparison to the use of vitamin D, also not having difference between the doses	7
Von Stengel et al., 2011	Groups Low-intensity exercise (n=33), Training Rotational Vibration (n=29) and Vertical (n=34)	12 months, 3x/week. Exercise Group with 2x10 repetitions of low intensity exercises, rotational WBV of 12.5Hz, 0.8G, vertical PV of 35Hz, 0.8G, both associated with dynamic exercises during 15min	BMD lumbar spine and femur, muscle strength	Improves BMD and strength for both groups platform	10
Von Stengel et al., 2011	Groups Low intensity control (n=48), Training (n=47) and Training + WBV (n=46)	18 months, 2x/week Control group with light exercises, Group Training with conventional aerobic exercises, balance and muscle strength during 60min and when associated with WBV, used 25-35Hz for 6min	BMD hip and lumbar and frequency of falls	The use of WBV does not improve the effects that the training already promotes, but improves the frequency of falls	10
Lai et al., 2013	Control groups (n=14) and WBV (n=14)	6 months. Control group without intervention and WBV (30Hz, 3.2G), 3x/week, 5min	Lumbar spine BMD	Significant improvement for the WBV group	9
Stolzenberg et al., 2013	Groups Balance training (n=31) and WBV (n=26)	9 months, 2x/week. 15min progressive balance exercises and 4min PV (22-24Hz, 2-4mm, 3.9G-10.3G) with different postures	Peripheral CT of the tibia, fibula, radius and ulna	Improvement in both groups	7
Liphardt et al., 2015	Control groups (n=20) and WBV (n=22)	12 months. Control group without intervention, WBV (20Hz, 3-4mm) 2-3x/week, 10min	BMD, balance, jump performance and maximum voluntary contraction of flexors and knee extensors	There was no difference between the groups for the parameters evaluated	6
Shanb et al., 2016	Pharmacological treatement (PT) (n=25); Magnetic therapy+PT (n=30) and WBV+PT (n=30)	4 months. WBV (20-24Hz) 2/week, 55min	BMD, venous blood (calcium and vitamin D)	PV and magnetic therapy were superior to the medication only group, yet with no differences between them	10

Legend: n - number of participants, x - times, min - minutes, Hz - hertz, G - acceleration of gravity, mm - millimeters (displacement), WBV – whole-body vibration platform, BMD - bone mineral density, CT - computadorized tomography.

vibration frequencies at constant g level. Vertical WBV was delivered at 0.7. g (Peak acceleration In this review, five clinical trials with positive effects for the treatment of osteoporosis were found. In the study by Lai et al. a WBV group (30Hz frequency, magnitude 3.2G) and a control group were assessed. After treatment, the WBV group increased lumbar spine BMD.[28] The authors suggest that this occurred because of the training using high frequency and high magnitude and for assessing the lumbar spine, the neutral orthostatic position on the platform favors the direct transmission of the vibration to the spine, in addition to the duration of each session being five minutes, without provoking deleterious effects, and being an exercise of easy adhesion.

Stolzenberg et al. compared the WBV Group (24-26Hz frequency progression and 2-4mm amplitude) with a Balance Training (BT) group after performing resistance exercises, finding an increase in BMD in the tibia in both groups, with no significant difference between them. The authors point out that a significant improvement between the groups could be perceived through more modern measurements, such as Dual Emission X-ray, and suggested that these results appear in shorter treatment periods with vibration training with frequencies and longer durations for a better stimulus. In addition, there was a difference for the BT Group in the parameters that evaluated the radius and the ulna, which is justified by the fact that this group also performed exercises for upper limbs, which the WBV Group did not do so it is necessary to perform new studies that analyze the effect of body vibration also on upper limbs.[29]

In the work of Von Stengel et al. two types of vibration were evaluated: vertical (35 Hz, 1.7 mm amplitude) and rotation (12.5 Hz, 12 mm amplitude), those associated with muscle strengthening exercises, compared to Control group with low intensity exercises.[30] Two groups of vibration improved BMD of the lumbar spine, but did not affect BMD of the femur. However, the vertical group presented results in the non-significant borderline, different from the rotation group, possibly explained by the given stimulus (rotation plate frequency) being twice as strong in the spine as in the femur region. In addition, individuals positioned themselves on the platform with slight flexion of the lower limb joints and the vibration transmission is dependent on this flexion, being greater in the vertical position, with the semi-squat position reducing acceleration up to ten times in the hip, explaining this possible result and corroborating that found in the article by Lai et al..[28] In addition, the gain of muscle strength in both groups of vibration can be explained by the concomitant use of exercise and the position of semi-flexion, different from other studies that do not associate the exercise.

In another study, with a population with the same characteristics as the previous one, Von Stengel et al. sought to evaluate whether VF (frequency 25-35 Hz and 1.7 mm amplitude) would enhance the effects of physical training on BMD and the frequency of falls in women. Physical training addressed aerobic, functional and balance exercises. The results suggest that both training and training groups associated had an increase in BMD in the lumbar spine when compared to low intensity control. However, the number of falls decreased significantly only in the group that associated with the training of the WBV. Thus, it is evident the benefit that physical exercises can promote in bone tissue due to mechanical loading and weight loss, but, although it does not directly contribute in this study to these alterations, possibly due to the time and period used, WBV reduced the number of falls, being this important factor for the risk of fractures.[32]the multi-purpose exercise training was effective to increase lumbar BMD but added WBV did not enhance this effect. However, falls were lowest in the exercise program combined with WBV. Introduction: WBV is a new approach to reduce the risk of osteoporotic fractures. In the \"Erlangen Longitudinal Vibration Study\" (ELVIS).

In the study by Gusi et al. a 55-minute walk exercise group per session (3x week) and another exercise group with WBV of 12.6 Hz and 3mm amplitude were compared for 8 months. The WBV Group was more effective in improving balance and BMD, only in the femoral neck and not in the lumbar spine, probably also explained by the position of the subjects on the apparatus, with a knee flexion of 60º, which affects the vibration to the spine. The authors suggest that the platform stimulus is different from the day-to-day walking stimulus, causing adaptations in the bone tissue, in addition to the low magnitude and high frequency used. Another possible result could be found with resistance exercises, which were not used in the study.[33]increasing the lateral accelerations. A few studies have shown recently the effectiveness of the up-and-down plate for increasing Bone Mineral Density (BMD).

Beck and Norling aimed to determine the effects of high (12.5 Hz, 1G) and low intensity (30Hz, 0.3G) WBV twice weekly during a period of eight months on the risk of hip fracture in women post menopause. They observed that the use of low intensity WBV helped in the slight but not significant mass gain in the femoral neck region and in both intensities the use of the platform assisted in the maintenance of the bone mass in the regions of the neck of the femur and spine, when compared to the control group.[34]

In the study by Liphardt et al., the group that associated with WBV had no improvement in BMD, area and mineral resistance, in addition to parameters of muscle strength and balance. They suggest that to potentiate a bone change, it would be a necessary concomitant to the training of vibration, the resistance training, which was

not associated with the study. There was only difference in the parameters of muscular strength in the first four months, being justified by the action of the WBV in promoting stimuli to the sensory system, provoking a period of adaptation, however, this stimulus is not able to cause physiological changes measurable since after this period the values were the same as those found in the control.[35] According to Lai et al., these adverse effects can be justified due to exposure of great intensity, magnitude or long duration, which also affects blood vessels and peripheral nerves.[28]

In the study by Slatvoska et al., the therapy of high (90Hz, 0.3g magnitude) and low (30Hz, 0.3G) frequency was unable to change the BMD and bone structure of postmenopausal women who received calcium and vitamin D. The authors justify these results because they obtained median adherence ranging from 65-79% and because the treatment was administered at home and without supervision, which makes it impossible to know if the participants performed the activities correctly and following recommended posture and instructions.[36] Verschueren et al. associated WBV with vitamin D supplementation in institutionalized elderly women. There were no differences between the groups analyzed. This situation can be explained by the lack of a control group without vitamin D supplementation associated with physical exercise, and a control group without PV activities and supplementation, which makes it impossible to verify the real influence of the use of PV in the elderly in an isolated way.[37] Shanb et al. compared the PV associated with drug therapy with magnetic therapy, and after 4 weeks of therapy, they observed that both groups were superior to the BMD results compared to the only medication group, but with no differences between them.[31] The use of WBV in the treatment of osteoporosis can be used to minimize or prevent the changes caused by this disease in the body, however, there are no standards defined in the literature regarding the frequency, duration of the intervention and the period to be used. Clinical trials present heterogeneous results due to the divergences used in the methodology, however, in short, the platform has positive effects in the treatment of osteoporosis when used at high frequency and associated with physical exercises, but the low frequency can also help positively the parathyroid response and thus, targeting positive results in bone tissue.[40]

Conclusion

We concluded that the use of WBV is presented as an option in the treatment of osteoporosis, however, studies using homogeneous methodologies are needed to compare the actual benefits of using them.

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