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Systematic review

Effects of the vibratory platform on bone mineral density in women after menopause: a systematic review

Efeitos da plataforma vibratória na densidade mineral óssea em mulheres pós-menopausa: uma revisão sistemática

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ABSTRACT

Aim: To review studies that analyzed the effects of the vibrating platform on bone mineral density in postmenopausal women. **Methods:** Systematic review, PROSPERO (CRD42020173020), of articles published in the Pubmed, PEDro and Portal da VHL databases. Descriptors: "Vibration", "Bone Density", "Women", "Osteoporosis", "Postmenopausal" and "Clinical Trial". Included: 1) Randomized clinical trials; 2) who analyzed the effects of the vibrating platform on bone mineral density; 3) in postmenopausal women. 4) Available in full. Excluded: 1) Absence of frequency, exposure time and body position parameters, and 2) Master's/doctoral theses and dissertations. Methodological quality (risk of bias) was assessed with the Cochrane PEDro scale and risk of bias tool. **Results:** The searches identified 1,108 studies, however, 7 were included. They were randomized clinical trials, published between 2006 and 2020. The sample totaled 509 postmenopausal women. Of these, 292 used the vibrating platform, and 217 in the control group and/or other interventions. The time since menopause ranged between 1 and 12 years. The intervention protocol ranged between 12.5 and 90 Hz, with exposure time between 5 and 60 minutes, lasting from 4 to 12 months. The results suggest that the vibrating platform promoted improvements and/or maintenance in bone mineral density of the femur, lumbar spine and cervical in postmenopausal women. In the methodological analysis, most studies have a moderate risk of bias. **Conclusion:** The vibrating platform promotes an increase/maintenance in bone mineral density in postmenopausal women, which can lead to a reduction in falls and a reduction in the risk of hospitalization.

Keywords: vibration, bone density; postmenopause.

RESUMO

Objetivo: Revisar estudos que analisaram os efeitos da plataforma vibratória sobre a densidade mineral óssea em mulheres na pós-menopausa. **Métodos:** Revisão sistemática, PROSPERO (CRD42020173020), de artigos publicados nas bases Pubmed, PEDro e Portal da BVS. Descritores: "Vibration", "Bone Density", "Women", "Osteoporosis", "Postmenopausal" e "Clinical Trial". Incluídos: 1) Ensaios clínicos randomizados; 2) que analisaram os efeitos da plataforma vibratória na densidade mineral óssea; 3) em mulheres pós-menopausa; 4) disponíveis na íntegra. Excluídos: 1) ausência dos parâmetros frequência, tempo de exposição e posição corporal e, 2) teses e dissertações de mestrado/doutorado. A qualidade metodológica (risco de viés) foi avaliada com a escala PEDro e ferramenta de risco de viés da Cochrane. **Resultados:** As buscas identificaram 1.108 estudos, contudo, 7 foram incluídos. Eram ensaios clínicos randomizados, publicados entre 2006 e 2020. A amostra totalizou 509 mulheres pós-menopáusicas. Dessas, 292 utilizaram a plataforma vibratória, e 217 do grupo controle e/ou outras intervenções. O tempo desde a menopausa variou entre 1 e 12 anos. O protocolo de intervenção, variou entre 12,5 e 90 Hz, com tempo de exposição entre 5 e 60 minutos, com duração de 4 a 12 meses. Os resultados sugerem que a plataforma vibratória promoveu melhoras e/ou manutenção na densidade mineral óssea do fêmur, coluna lombar e cervical em mulheres pós-menopausa. Na análise metodológica, a maioria dos estudos possuem moderado risco de viés. **Conclusão:** A plataforma vibratória promove aumento/manutenção na densidade mineral óssea em mulheres pós-menopáusicas, podendo acarretar em redução das quedas e diminuição do risco de hospitalização.

Palavras-chave: vibração; densidade óssea; pós-menopausa.

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Introduction

Osteoporosis is defined as a disease characterized by reduced bone mineral density (DMO) and consequently increased risk of fracture. Among the potential risk factors for this condition, postmenopausal conditions stand out, a condition related to decreased estrogen availability that promotes increased bone demineralization [1]. In addition, in Brazil, the annual expenditure on osteoporosis reaches R$ 1.2 bi, being mainly associated with loss of productivity, an increase in the number of falls, and a higher risk of hospitalization. In addition, with the increase in population aging rates, the number of cases as well as, the expenses for its treatment tend to increase, especially in decorence to the increase in the number of fractures [2]. Thus, it is essential to search for strategies aimed at the prevention and/or rehabilitation of this clinical outcome.

Thus, the exploration of existing methods that contribute to the treatment or prevention of the reduction of DMO in postmenopausal women is extremely important since this decrease contributes to the emergence of silent diseases, such as osteoporosis [3]. This condition compromises the individual quality of life and affects the health system since it increases the number of hospitalizations, resulting in a public health problem [4]. Thus, the form of treatment that has become popular in the fight against osteoporosis is the vibratory platform (PV), mainly due to its mechanical stimulus. This therapy is related to the response of muscle and bone tissues to the damping and absorption of energy generated by mechanical stimuli [5]. Thus, the modifications promoted are capable of generating an increase in bone synthesis through the stimulation of osteoblasts, thus producing more bone tissue [3,5].

Stimulating the regular practice of physical exercise is an important strategy when talking about promotion, prevention, and rehabilitation, so it is extremely important to study PV in postmenopausal women because in addition to being a low economic cost resource, it is more convenient for users who have other comorbidities. Thus, studies suggest that PV acts globally, from DMO reduction to other diseases such as obesity [5], hypertension [6], type 2 diabetes mellitus [7], and cardiovascular risk factors, also acting to reduce acute cardiopulmonary demand in patients with severe DPOC [8], and may also improve variables related to functional capacity [9]. Therefore, this evidence emphasizes the importance of the use of PV since it will act on other pathologies that affect postmenopausal women and this will decrease the risk of hospitalization and development of future complications that may increase the risk of morbidity and mortality.

Thus, knowing the effects of PV on DMO in the population mentioned will help in the implementation of health strategies aimed at increasing, as well as maintaining DMO, directly impacting the improvement of quality of life and health promotion. Thus, the present study aims to systematically review studies that analyzed the effects of PV on DMO in postmenopausal women.

Methods

Type of study

This is a systematic review, structured based on the criteria established by the guideline "Preferred Reporting Items for Systematic Reviews and Meta-Analyses" (PRISMA) [10], to answer the following clinical question: What are the effects of the vibratory platform on bone mineral density in postmenopausal women? Prospectively registered study in PROSPERO under opinion: CRD42020173020.

Eligibility criteria

The following were included: 1) Randomized clinical trials; 2) That analyzed the effects of the vibratory platform on bone mineral density; 3) In postmenopausal women; 4) Such studies should be available in full. No restrictions were made regarding the language and time of publication of the studies. On the other hand, 1) studies with no parameters related to frequency, exposure time and body position of the intervention and 2) theses and master/doctoral dissertations were excluded.

Outcome of interest

For the study bone mineral density was defined as the amount of bone mass or mineral content, expressed in g/cm^2.

Search strategy

The searches were carried out in the Pubmed databases, PEDro and BVS Portal, by two independent authors [N.J.S.S] and [V.A.G], between March and November 2020, through the descriptors selected through the "Medical Subject Headings" – (MESH) and "Decs in Health Sciences" – (DeCS): "Vibration", "Bone density", "Women", "Osteoporosis", "Postmenopausal" and "Clinical Trial", and their respective synonyms. Specific crosses were performed for each database, and boolean operators [AND], and [OR], as described in (Table I).

Table I - Search strategies used by database

Database	Search strategies
Pubmed	((((vibrations) AND (Bone Mineral Density)) AND (Woman)) AND (Bone loss, Postmenopausal)) AND (clinical trial)
PEDro	Vibrati* bone dens* osteoporos*
BVS	(tw:(Bone Mineral Densities)) OR (tw:(Density, Bone Mineral)) OR (tw:(Bone Mineral Content)) OR (tw:(Bone Mineral Contents)) AND (tw:(Woman)) OR (tw:(Women Groups)) OR (tw:(Women's Group)) AND (tw:(Bone Loss, Postmenopausal)) OR (tw:(Osteoporosis, Post-Menopausal)) OR (tw:(Post-Menopausal Osteoporoses)) OR (tw:(Postmenopausal Osteoporosis)) OR (tw:(Osteoporoses, Postmenopausal)) OR (tw:(Postmenopausal Bone Loss)) AND (tw:(Clinical Trial))

Source: Elaboration of the authors

Selection of studies and data extraction

The selection of studies was performed by two independent authors [N.J.S.S] and [V.A.G], and when possible disagreements occurred, a third reviewer was requested [R.M.B]. Thus, the titles and abstracts were carefully read so that those who met the above-mentioned eligibility criteria were for the final selection. As shown in Table II, the eligible studies were selected for reading the full text, a new evaluation of the selection and recovery criteria for data referring to: 1) Author and year of publication of the study; 2) Characteristics of the population; 3) Intervention protocols (frequency, exposure time and body position); 4) Methods (main methods for measuring outcomes); 5) Outcomes and main results obtained by the studies.

The references reviewed and included in this review were analyzed to verify the existence of potential unidentified studies in the searches for the selected electronic databases. The (Figure 1) summarizes the strategies for selecting studies that make up the scope of this systematic review.

Methodological quality (risk of bias)

The quality of the studies was evaluated using the PEDro (Physiotherapy Evidence Database) scale, based on the Delphi list. The PEDro scale consists of 10 items, and each item contributes 1 (one) point (except for item 1 which is not scored). The total score ranges from 0 (zero) to 10 (ten). This scale evaluates the methodological quality of randomized controlled clinical studies, observing two aspects of the study: whether it presents internal validity (credibility of observations and scientific results with the reality of what is studied) and whether it contains enough statistical information to make it interpretable. The scale does not evaluate the external validity, significance, or size of the treatment effect. The articles were independently qualified through the same instrument by two evaluators already familiar with the scale. The divergences regarding the PEDro classification were discussed by the evaluators and by consensus the study score was defined (Table III). The cutoff point established to separate the studies of high and low methodological quality was <6 (low quality) or ≥6 (high quality) on the PEDro scale [11].

In addition, the risk of bias in clinical trials was evaluated using the Cochrane collaboration tool. It consists of seven domains: 1) Generation of random sequence, 2) Concealment of allocation, 3) Blinding of participants and professionals, 4) Blinding of outcome evaluators, 5) Incomplete outcomes, 6) Report of the selective outcome, and 7) Other sources of bias. These domains are classified into three categories: low risk of bias, high risk of bias, or risk of uncertain bias [12].

Results

The search strategies developed and the references analyzed by manual search returned a total of 1,108 articles. However, after analysis by the reviewers [N.J.S.S and V.A.G], 8 were eliminated due to duplicity, leaving 1,100 studies. In another step, after screening based on eligibility criteria, 1,091 studies were excluded by analysis of titles and abstracts, leaving 9 articles for full reading. Subsequently, 2 studies were excluded as they were not pilot studies. Finally, 7 studies met the eligibility criteria, summarized in Figure 1.

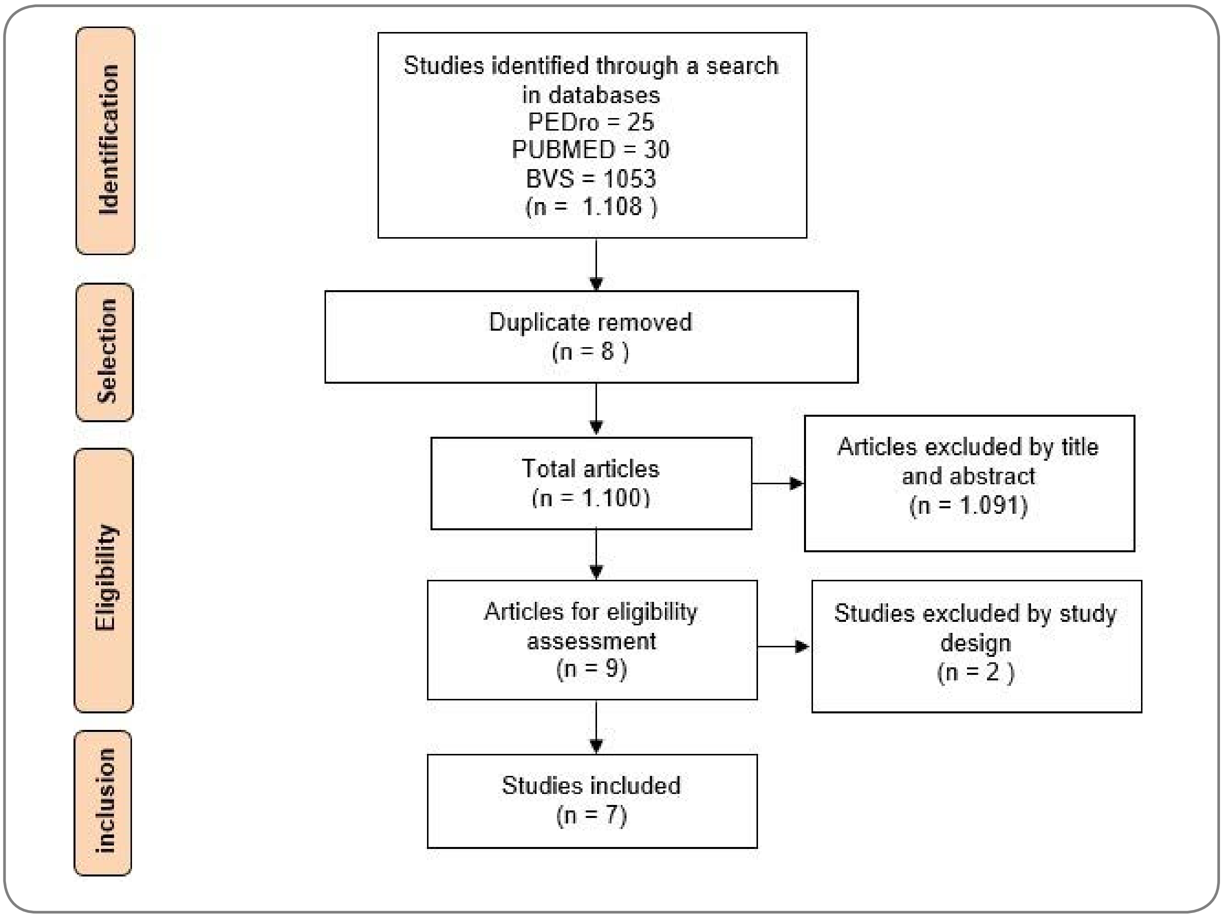

Figure 1 - Study selection flowchart

According to the data presented (Table II), it can be observed that the studies included in this review were published between 2006 and 2020, and 100% of the studies were controlled clinical trials. Regarding the characteristics of the population, the sample ranged from 28 to 202 individuals, totaling 509 postmenopausal women. Of these, 292 were part of the groups that used the vibratory platform, and 217 of the control group and/or other interventions (High impact exercises and multiple components). In addition, the time since menopause ranged from 1 to 12 years. Regarding the intervention protocol, it varied between 12.5 and 90 Hz, with PV exposure time between 5 and 60 minutes, lasting from 4 to 12 months, where body positions and/or movements such as orthostasis, static and/or dynamic squats, and knee flexion were prescribed. Moreover, when analyzing the comparison methods, the most used were: control without any intervention and groups focused on jumping exercises. Where the outcome of interest, bone mineral density, was evaluated by clearly described methods such as double energy x-ray absorptiometry and bone ultrasound. Regarding the main results, the studies analyzed by the present review suggest that PV promoted improvements and/or maintenance in the DMO of the femur, lumbar spine, and cervical in postmenopausal women. In addition, the different PV intervention methods promoted increased/maintained DMO.

Table II - Síntese do processo de avaliação, intervenção, desfechos e principais resultados dos estudos sobre a PV em mulheres pós-menopáusicas

Author/ Year	Population characteristics	Intervention protocols		Methods	Outcomes	Main results
		GE	GC			
Gusi *et al.*, 2006 [13]	28 women, physically untrained, ± 12 years after menopause. Age: 66.	GVCI = 14 women, mean age 66 ± 6 years. PR= 3x per week, for 8 months. Hz: 12.6, TE: 6X1 min, PC: 60° Knee flexion.	CG + AL = 14 women, mean age 66 ± 4 years. PR = 3x per week for 8 months. 55 min of walking and 5 of stretching.	Dual-energy x-ray absorptiometry	DMO	After 8 months, the DMO in the femoral neck in the GVCI was increased by 4.3% (P = 0.011) compared to the GC+AL.
Beck *et al.*, 2010 [14]	47 women, 5 years after menopause. Age: 71.5 ± 9 years. *	GVCIBI= 13 women, mean age 68.5 ± 8. PR= 2x per week for 8 months. HZ: 30 (0.106 m/s), TE: 15 min, PC: Total knee extension. / GVCIAI = 15 women, mean age 68.9±7. PR = 2x per week for 8 months. Hz: 12.5 (0.5 m/s), TE: 2 x 3 min, PC: Flexed knee.	GC = 14 women, mean age 74.2 ± 8. PR = Continue AVDs and abstain from VCI for a period of 8 months prior to accompaniment.	Calcaneus ultrasound	DMO	Maintenance of DMO of the femur and spine bones. GC there was no maintenance.
Slatkovska *et al.*, 2011 [15]	202 women, more than 1 year after menopause. Age: 59 - 60 years.	GVCI-90 Hz = 67 women, mean age 60.5 ± 7. PR = 7 days a week for 12 months. Hz = 90 (0.3g), TE = 20 min per day, CP = Upright, with neutral posture in the neck, lumbar spine and knees / GVCI-30 Hz = 68 women, mean age 59.6 ± 6. PR = 7 days a week for 12 months. Hz = 30 (0.3g), TE = 20 min per day, CP = Upright, with neutral posture in neck, lumbar spine and knees.	GC = 67 women, mean age 60.8 ± 5. PR = 12 months of follow-up. Did not use a VCI.	Dual-energy x-ray absorptiometry;	DMO	12 months of low-magnitude VCI (0.3 g) at 90 or 30 Hz had no effect on DMO or bone structure in healthy postmenopausal women.
Stengel *et al.*, 2011 [15]	108 women. Average age 65.8 ± 3 years.	GVCIR = 36 women, mean age 67.9 ± 3 years. PR = 3x week for 12 months. HZ = 12.5 (12mm), TE = 15 min, PC= 1) static squat, 2) dynamic squat; 3) leg abduction; 4) single leg squat; 5) single leg squat including hip flexion on the contralateral side, 6) repetition of exercise 1 and 7) repetition of exercise 2. / GVCIV = 36 women, mean age 68.1 ± 4 years. PR = 3x week for 12 months. Hz = 35 (1.7mm), TE = 15 min, PC = (equal to GVCIR).	GC = 36 women, mean age 67.6 ± 4. PR = Blocks of 10 sessions of low intensity gymnastics.	Dual-energy x-ray absorptiometry	DMO	Both GI showed gains in cervical and lumbar spine DMO when compared to the GC.

Table II - Continuation

Author/ Year	Population characteristics	Intervention protocols		Methods	Outcomes	Main results
		GE	GC			
Lai *et al.*, 2013 [17]	28 women, ± 9.8 years after menopause. Average age: 60.1 ± 7.1 years	GVCI = 14 women, mean age 60.1 ± 7.1. PR = 3x per week for 6 months. Hz = 30 (3.2g) TE = 5 min, PC = Orthostasis.	GC = 14 women, mean age 62.4 ± 7.1. PR = Maintain daily life habits and do not use any medication for osteoporosis, including calcium and vitamin D.	Dual-energy x-ray absorptiometry	DMO	6 months of high frequency and high magnitude VCI increased lumbar spine DMO when compared to GC.
Cascales *et al.*, 2019 [18]	38 women. Average age: 59.8 ± 6 years.	GVCI = 14 women, mean age 60.1 ± 5 years. PR = 3x per week for 12 weeks. Hz = 35 (4mm); TE = 5 - 8x of 45 - 60s (5-8 min), PC = half squat (knee and hip angle 120º) and ankle plantar and dorsal flexion / GMC = 14 women, mean age 57.7 ± 7 years. PR = Progressive vertical jumps; walk 35-45 min at 50-60% FCR.	GC = 10 women, mean age 59.8 ± 6 years. PR = No intervention.	Dual-energy x-ray absorptiometry	DMO	Maintenance of the DMO.
Sen *et al.*, 2020 [19]	58 women. Age 40-60 years.*	GVCI = 15 women, mean age 55 ± 4 years. PR= 3 days a week for 24 weeks. Hz = 30-40 (2-4mm), TE = 20-60 min, PC = squat, deep squat, step squat, lunge and front lunge with hands. / GEAI = 16 women, mean age 53.1 ± 4. PR = 10-60 jumps per session for 12 weeks.	GC = 18 women, 54.5 ± 6 years. PR = No intervention.	Dual-energy x-ray absorptiometry	DMO	Increased DMO in the femoral neck and lumbar regions in the GVCI compared to the GC. In GEAI there was no significant effect.

GE = Experimental group; GC = Control Group; GVCI = Full Body Vibration Group; GC+AL = Control Group plus Stretching; PR = Intervention Protocol; Hz = hertz TE = Exposure Time; PC = Body Position; DMO = Bone Mineral Density; * = Sample loss; GVCIBI = Low Intensity Whole Body Vibration Group; GVCIAI = High Intensity Full Body Vibration Group; GVCI-90 Hz = Full Body Vibration Group at 90 Hz; GVCI-30 Hz = Full Body Vibration Group at 30 Hz; GVCIR = Rotational Whole Body Vibration Group; GVCIV = Vertical Full Body Vibration Group; GMC = Multi Component Group; GEAI = High Impact Exercises Group

With regard to methodological quality, Table III, it can be seen that more than 50% of the studies [14-16,18] can be classified as high quality by the evaluation of the PEDro scale.

Table III - Evaluation of methodological quality - PEDro Scale

Author	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Criterion 5	Criterion 6	Criterion 7	Criterion 8	Criterion 9	Criterion 10	Criterion 11	Total Score
Gusi *et al.*, 2006 [13]	YES	YES	NO	YES	NO	NO	NO	NO	YES	YES	YES	5
Beck *et al.*, 2010 [14]	YES	YES	YES	NO	NO	NO	NO	YES	YES	YES	YES	6
Slatkovska *et al.*,2011 [15]	YES	YES	YES	YES	YES	NO	YES	NO	YES	YES	YES	8
Stengel *et al.*, 2011[16]	YES	YES	YES	YES	YES	NO	YES	NÃO	YES	YES	YES	8
Lai *et al.*, 2013 [17]	YES	YES	NO	YES	NO	NO	NÃO	YES	NO	YES	YES	5
Cascales *et al.*, 2019 [18]	NO	YES	YES	YES	NO	NO	YES	NO	NO	YES	YES	6
Sen *et al.*, 2020 [19]	YES	YES	NO	YES	NO	NO	NO	NO	YES	YES	YES	5

Critérios de 1 a 11 = 1. Eligibility criteria were specified. 2. Subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated an order in which treatments were received). 3. Allocation was concealed. 4. The groups were similar at baseline regarding the most important prognostic indicators. 5. There was blinding of all subjects. 6. There was blinding of all therapists who administered the therapy. 7. There was blinding of all assessors who measured at least one key outcome. 8. Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups. 9. All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analysed by "intention to treat".10. The results of between-group statistical comparisons are reported for at least one key outcome.11. The study provides both point measures and measures of variability for at least one key outcome

Regarding the risk of bias assessed using the Cochrane tool, it is perceived that one study presented "high risk of bias" for random sequence, three studies presented "high risk of bias" for concealment of allocation, five studies presented "high risk of bias" and "risk of uncertain bias" for blinding outcome evaluators, reports of selective outcomes and other sources of bias. Figures 2 and 3 represent the complete analysis of the risk of bias.

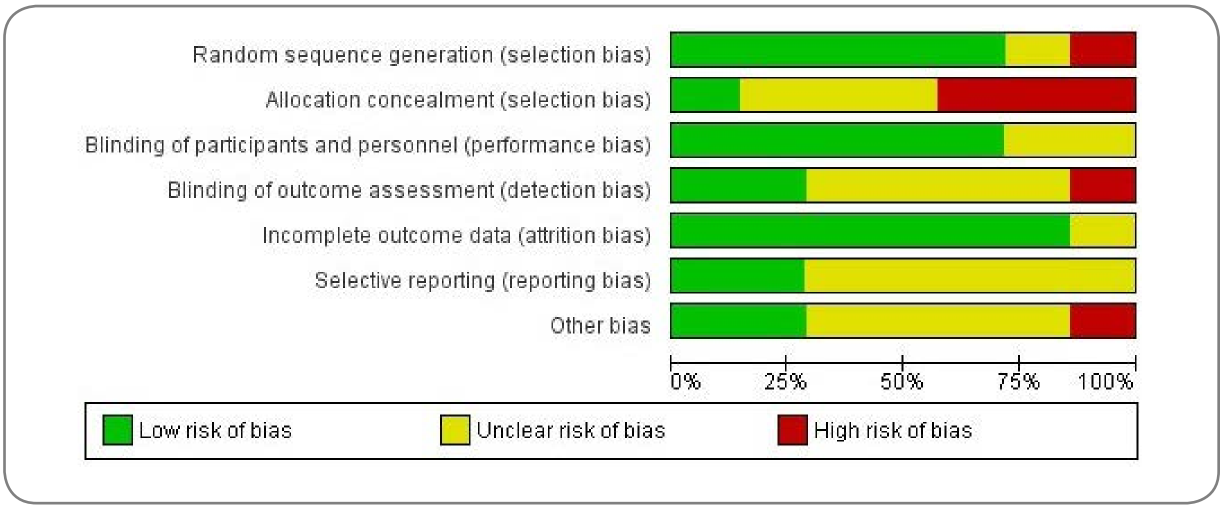

Figure 2 – Risk of bias

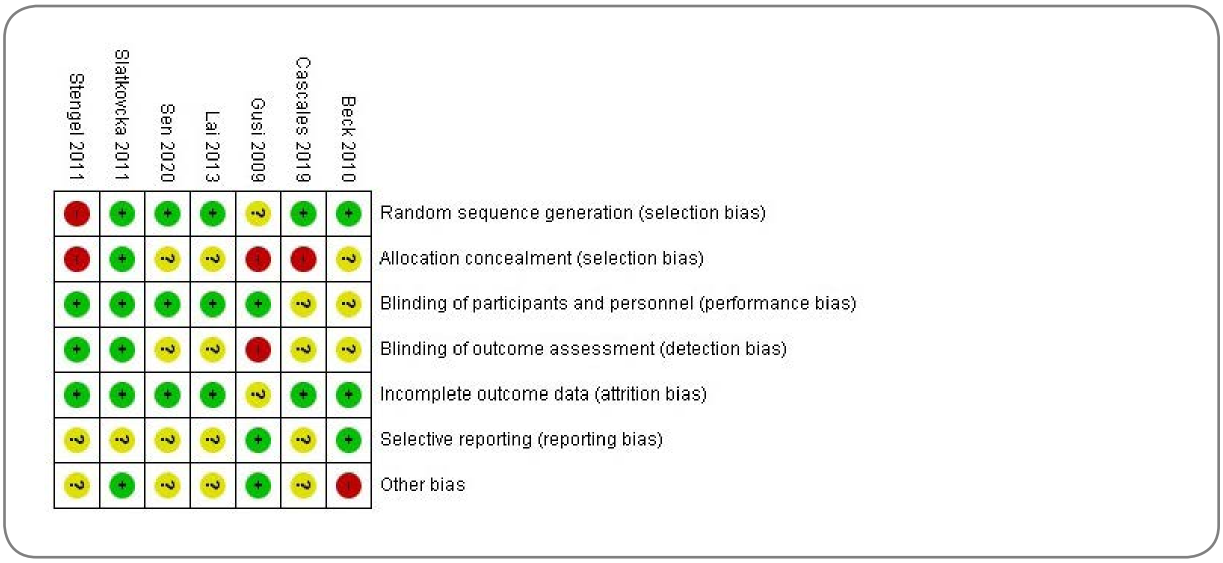

Figure 3 – Risk of bias

Discussion

The primary objective of this study was to evaluate randomized clinical trials investigating the effects of PV on DMO in postmenopausal women. In response to this objective, we identified that interventions of three to eight months in PV promoted an increase and/or maintenance in DMO in the femur, lumbar and cervical spine in postmenopausal women. It is also noteworthy that when comparing the types of intervention in PV and their effects on DMO, there was no difference between them.

Regarding the increase/maintenance of DMO, one of the possible justifications for these results lie in the fact that the PV produces mechanical stimuli of high frequency directed to sensory receptors throughout the body. Thus, promoting oscillatory waves, which require a greater response from bone and muscle tissue to absorb and dampen the energy dissipated by oscillatory waves [20]. Thus, PV is able to promote micro traumas in the bone tissue, being then repaired by osteoblasts, thus increasing DMO after physical stress. Added to this, studies suggest that the PV triggers osteogenic effects, being able to neutralize the possible alterations of bone mass related to the aging process [21-23].

Also according to the literature, another possible explanation for this increase in DMO lies in the mechanistic hypothesis, which defends the idea that, after exposure to a sufficient mechanical stimulus, bone tissue is altered due to exposure of muscle tissue, as a strategy to prevent deformation caused by the load imposed during the mechanical stimulus, thus acting on the increase and/or maintenance of DMO [24].

Added to the data already presented, our results indicate that when comparing the types of intervention in PV, they promoted increase and/or maintenance in DMO [13,14,16-19]. This data can be justified by the fact that the positive results in the PV seem to be associated with the combination of some variables such as frequency, intensity of stimulus and exposure time. Thus, low frequencies of vibration produce smaller stimuli compared to high frequencies. Moreover, when the exposure time is analyzed, studies suggest that the longer the exposure time, that is, the cumulative dose of the intervention, the better the gains associated with BMD [25]. Another point is also with respect to intensity, where more intense vibratory stimuli are associated with better results, since they are able to overcome the damping effect of soft tissues, and thus reach the bone tissue with adequate energy to promote the necessary adaptations [17].

Furthermore, another interesting finding is concerning body position and/or exercises performed during PV. Although the included studies [13-19] suggest that specific exercises/body positions performed during interventions promoted increases in DMO, the literature suggests that it is unclear whether the type of exercise, as well as the specific body position affects bone mass differently [26]. Thus, further research is needed to analyze which position/exercise would best promote improved bone health in this population.

Therefore, supported by these data presented, the PV presents itself as an effective intervention method that produces positive effects for the increase of BMD in postmenopausal women. Thus, it promotes an improvement in the quality of life in postmenopausal women and favors an increase in life expectancy since post-trauma hospitalizations will be avoided and consequent appearance of comorbidities and complications arising from this, besides keeping these women longer in the labor market and thus contributing actively to the economic sector of the country.

In addition to the aspects already discussed, this study has some limitations that need to be discussed. First, the low number of reviewed controlled trials that have focused on the effects of PV on BMD in postmenopausal women. Second the wide age range for defining menopausal women, including older women. Finally, according to the assessment of methodological quality (risk of bias), the studies showed weaknesses, especially with regard to the blinding of volunteers and outcome evaluators, sample losses during the reproduction of the study and reports of selective outcomes. However, these limitations do not invalidate the data presented since they are in line with others presented in the literature.

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Conclusion

It is concluded that the vibrating platform promotes increase/maintenance in bone mineral density in postmenopausal women, which may lead to a reduction in falls and a decrease in the risk of hospitalization. However, new studies with adequate methodological rigor are necessary to confirm the results found.

Academic link
This article represents the End of Course Work of Naiala de Jesus Silva Santos, oriented by Professor Vinícius Afonso Gomes at the Centro Universitário Uniruy.

Conflict of interest
The authors have declared that there are no competing interests.

Authors' contributions
Conception and design of the research: Santos NJS, Gomes VA; **Acquisition of data:** Santos NJS, Gomes VA; **Analysis and interpretation of data:** Santos NJS, Batista RM, Santos EC; **Writing of the manuscript:** Santos NJS, Santos EC; **Critical revision of the manuscript for intellectual content:** Batista RM, Gomes VA.

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