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Effects of a short-term whole body vibration intervention on bone mass and structure in elderly people

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ABSTRACT

Objectives: We aimed to clarify whether a short-term whole body vibration training has a beneficial effect on bone mass and structure in elderly men and women.
Design: Randomised controlled trial.
Methods: A total of 49 non-institutionalised elderly (20 men and 29 women) volunteered to participate in the study. Participants who met the inclusion criteria were randomly assigned to one of the study groups (whole body vibration or control). A total of 24 elderly trained squat positioned on a vibration platform 3 times per week for 11 weeks. Bone-related variables were assessed by dual-energy X-ray absorptiometry and peripheral quantitative computed tomography. Two-way repeated measures one-way analysis of variance (group by time) was used to determine the effects of the intervention on the bone-related variables and also to determinate the changes within group throughout the intervention period. Analysis of covariance was used to test the differences between groups for bone-related variables in pre- and post-training assessments and in the percentage of change between groups. All analysis were carried out including age, height, subtotal lean mass and daily calcium intake as covariates.
Results: 11 weeks of whole body vibration training led to no changes in none of the bone mineral content and bone mineral density parameters measured by dual-energy X-ray absorptiometry through the skeleton. At the tibia, total, trabecular and cortical volumetric bone mineral density decreased significantly in the whole body vibration group (all $P < 0.05$).
Conclusions: A short-term whole body vibration therapy is not enough to cause any changes on bone mineral content or bone mineral density and it only produces a slight variation on bone structure among elderly people.

1. Introduction

Osteoporosis is defined as a skeletal disease characterised by bone fragility and susceptibility to fracture as a result of low bone density and microarchitectural deterioration of bone tissue.[1] This pathology is a critical age-related disorder within the older population and constitutes a large and important problem worldwide due to osteoporotic fractures have a deep impact on quality of life[2] and mortality[3] of the individuals.

Although the participation in regular physical activity throughout lifetime has been proved to be beneficial for bone health in older adults and elderly people, it has been suggested that the best non-pharmacological way to improve all bone-related variables includes specific exercise training programmes. In fact, bone mass can be increased, or at least the common decline in bone mass during ageing attenuated, by following specific training programmes, especially in postmenopausal women.[4]

Whole body vibration (WBV) is a new type of exercise that uses high-frequency mechanical stimuli, which are generated by a vibrating platform and transmitted through the body where they load the bone and stimulate sensory receptors. Skeletal responses to WBV are reported to be similar to that of specific training activating mechanotransduction in bone and stimulating osteogenesis.[5,6] This type of training seems to be more effective than walking and similar to strength training for improving bone mass at different sites in postmenopausal women; nevertheless, there are no studies proving that this also occurs in men.

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In contrast to other forms of exercise, where the duration of the training programme seems to be of great importance in order to achieve the desired effects on bone mass, the impact of WBV on bone mineral density (BMD) among older adults may be reached more quickly.[7] However, the minimum training duration that may promote benefits on bone mass among elderly people has not been tested yet.

Even if there are a wide variety of techniques available to assess bone-related variables,[8] most of the studies that have evaluated the effect of WBV training have assessed bone mineral content (BMC) and BMD by dual-energy X-ray absorptiometry (DXA); nevertheless, it has been suggested that peripheral quantitative computed tomography (pQCT) could be the most relevant and precise technique in order to identify the real adaptations of the bone after exercise.[9]

Therefore, the aim of this research was to clarify whether a short-term WBV training has a beneficial effect on bone mass and structure in elderly men and women.

2. Methods

A total of 49 non-institutionalised elderly (20 men and 29 women) volunteered to participate in the study. The recruitment was carried out through the elderly EXERNET multi-centre study, whose participants were informed with the details of the study including purposes and procedures to use. Briefly, the elderly EXERNET multi-centre study was a cross-sectional study for the evaluation of physical fitness and body composition in elderly people that were carried out in 6 different regions from Spain. The general characteristics of this project have been described in detail elsewhere.[10,11]

Written informed consent was obtained from all the participants included. The study was performed according to the principles established with the Declaration of Helsinki (1964) as revised in 2000 in Edinburgh, and approved by the Clinical Research Ethics Committee of (18/2008).

The exclusion criteria were: (1) people under 65 years, (2) those suffering from cancer, (3) elderly who were living in nursing homes or were not able to take care of themselves, (4) non-postmenopausal women, (5) any persons with neuromuscular or neurodegenerative diseases or physical disabilities, including orthopaedic or arthritic problems, (6) those with serious heart problems as heart failure and arrhythmias, (7) diabetes, (8) epilepsy, (9) gallstones, (10) kidney stones, and (11) stroke.

Those who met the inclusion criteria were randomly assigned to one of the study groups. A total of 24 elderly trained on a vibration platform (WBV group). A group of 25 age-matched elderly served as a control group (CON group) and did not participate in any training. Participants of both groups were asked not to change their lifestyle during the course of the project. The baseline characteristics of both groups are shown in Table 1.

The trainings were performed 3 times per week for 11 weeks. Each session was supervised and included 10 repetitions of 45 s with a rest period of 60 s between each repetition. During the training intervention, the participants were asked to stand vertically with the knees slightly flexed on the vibration platform, lightly holding the handrails of the machine (Pro5 Power Plate, Power Plate International Ltd., London, UK) with both hands. To ensure that the vibration stimuli were correctly and evenly conducted, the body was kept upright and the distance between foots was similar to the width of the shoulders for each participant. The frequency of vibration was 40 Hz and the amplitude was 2 mm (peak to peak).

A DXA scanner (QDR-Explorer, Hologic Corp., Software version 12.4, Waltham, MA, USA) was used to evaluate bone area (cm^2), BMC (g) and BMD (g/cm^2) at the whole body [subtotal (whole body less head)], lumbar spine (mean L_1–L_4), hip and femoral neck as previously described.[12] Additionally, whole body lean mass (LM, g) and fat mass (FM, g) were also analysed. All DXA scans, which were completed with the same device and software, were performed by the same technician who had been fully trained in the operation of the scanner, the positioning of participants, and the analysis of results, according to the manufacturer's guidelines. Quality assurance and spine phantom calibration procedures were performed daily prior to each scanning session to ensure no machine drift occurred during the intervention period. We have previously examined the test–retest (with repositioning) precision error for regional analysis of the complete body scan, using coefficients of variation (CV). The CV were: 2.3% for BMC, 1.3% for BMD and 2.6% for bone area.[13]

The pQCT measurements were taken at 2 sites of the radius (4% – distal radius – and 66% – diaphyseal radius – of the forearm length) and 3 sites of the tibia (4% – distal tibia –, 38% – diaphyseal tibia and 66% of the tibia length) using a Stratec XCT-2000 L pQCT scanner (Stratec Medizintechnik, Pforzheim, Germany). The main features of this equipment and the description of its operation have been previously published elsewhere.[14] To ensure machine stability, the pQCT device was assessed daily based on a quality control phantom, which includes soft tissue equivalent material. The CV between measurements is lower than 1% for that phantom.[14] Similar CV have been found for the same devices both in young

Table 1
Descriptive characteristics of the participants.

	CON ($n=25$)		WBV ($n=24$)	
	Pre-training Mean ± SD	Post-training Mean ± SD	Pre-training Mean ± SD	Post-training Mean ± SD
Age (y)	74.8 ± 4.9	75.2 ± 4.9	75.2 ± 4.7	75.5 ± 4.8
Body mass (kg)	68.4 ± 11.3	68.3 ± 11.4	67.9 ± 11.3	67.6 ± 10.7
Height (cm)	157.1 ± 9.6	157.2 ± 9.7	159.5 ± 9.4	159.4 ± 9.2
BMI (kg/m^2)	27.7 ± 3.9	27.7 ± 3.8	26.6 ± 3.2	26.5 ± 3.3
Total fat mass (g)	23,676.7 ± 5487.1	23,332.4 ± 5333.5	22,495.5 ± 6404.5	22,326.9 ± 6254.1
Total lean mass (g)	36,734.2 ± 8029.2	37,144.5 ± 8069.7	38,727.2 ± 7888.7	38,541.8 ± 7199.8
Fat mass (%)	37.8 ± 7.2	37.3 ± 7.0	36.1 ± 7.4	35.9 ± 7.1
Subtotal BMC (g)	1504.6 ± 426.1	1516.2 ± 438.3	1600.9 ± 542.5	1609.1 ± 549.0
Subtotal BMD (g/cm^2)	0.9 ± 0.1	0.9 ± 0.1	0.9 ± 0.2	0.9 ± 0.2
Calcium intake (mg/day)	645.0 ± 349.7		649.5 ± 349.7	
Calcium (n)	6		9	
Vitamin D (n)	5		7	
Biphosphonates (n)	8		9	

CON: control group; WBV: whole body vibration group; BMI: body mass index; BMC: bone mineral content; BMD: bone mineral density.