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Original Article

Mild chronic whole body vibration does not affect bone mineral mass or density in young females

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ABSTRACT

Milanese C, Piscitelli F, Simoni C, Zancanaro C. Mild chronic whole body vibration does not affect bone mineral mass or density in young females. *J. Hum. Sport Exerc.* Vol. 6, No. 2, pp. 474-479, 2011. Whole body vibration (WBV) is increasingly being used in several physical therapy settings. In order to evaluate the ability of WBV to affect bone mineral component, thirty-six young (mean age 25.3 ± 5.26 yrs) healthy females underwent eight weeks of WBV exercise (nineteen minutes per session, two session a week; vibration amplitude 2.0-5.0 mm, vibration frequency 40-60 Hz). Bone mineral content (BMC) and density (BMD) were evaluated before and after the WBV trial using dual-energy X-ray absorptiometry in the whole body mode. Data were analyzed with repeated measures analysis of variance. Results show that neither BMC nor BMD were significantly affected by the WBV trial at the total body or regional skeletal level. It is concluded that, under the current experimental conditions, WBV exercise is not able to improve bone mineral parameters in young healthy females before the peak bone mass. Further investigation is required to recommend WBV for increasing bone quality parameters in premenopausal women. **Key words**: BONE, DXA, WOMAN, BODY COMPOSITION.

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INTRODUCTION

Bone is characterized by the ability to adapt to changes in the body physiological and mechanical environment. Low-amplitude, high frequency vibration has been shown to be anabolic to trabecular bone, indicating that bone, including osteoporotic bone, is able to adapt to changes in the mechanical loading environment (Rubin et al., 2001; Routh et al., 2005; Rumancik et al., 2005). It has been suggested in this regard that large strain levels are instrumental to the anabolic response. As such, in order to increase bone mass, many patients are also prescribed a vigorous aerobic and strength training regimen to complement the anti-resorptive medication (Verschueren et al., 2004).

It has been recently demonstrated by experimental studies in a number of animal models that whole body vibration (WBV), a way to delivering a low magnitude, dynamic stimulus to the bone, can be osteogenic without the need for large magnitude strain stimulus (Fritton et al., 1997; Flieger et al., 1998; Judex et al., 2002). This may be an advantage for subjects needing rehabilitation who are not willing or capable of carrying out a rigorous exercise regimen. These experiments have led to the implementation of studies in humans using a variety of loading parameters including frequency, amplitude, and duration (Verschueren et al., 2004; Torvinen et al., 2003). However, while sufficient evidence of a positive effect of WBV on muscle power and balance has been achieved at least in certain subpopulations, the outcome of WBV on bone quality is not clearly defined in healthy subjects; moreover, it is not known whether WBV has different effect on bone mineral component according to the main body regions (trunk, appendices).

In this work, the effect of an 8-week WBV exercise protocol on bone mineral mass and density was investigated in young women by means of dual-energy X-ray absorptiometry (DXA) in the whole body.

MATERIAL AND METHODS

Participants

The study protocol was in accordance with the Helsinki Declaration (as revised in 2008) and was approved by the Ethical Committee of the University of Verona. A total of 36 women (mean age 25.3 ± 5.26 yrs) participated in this study after matching for inclusion and exclusion criteria, and written informed consent. Inclusion criteria were age >18 yrs <30 yrs, BMI<25 kg/m^2, and a normal menstrual status; exclusion criteria were performing agonistic sport, acute or chronic illness, assumption of drugs affecting body composition.

All subjects underwent anthropometry and DXA at baseline and started WBV exercise within one week. The same measurements were taken within one week after completion of the WBV trial. Subjects were asked not to change their alimentary habits or level of physical exercise until completing the protocol. Body mass was taken at the nearest hg with an electronic scale (Tanita electronic scale BWB-800 MA [Wunder SA.BI. Srl], max 200 kg); height was measured with a Harpenden stadiometer (Holtain Ltd., Crymych, Pembs, UK) at the nearest mm.

DXA

Total body and regional bone parameters (bone mineral content, BMC; bone mineral density, BMD) were evaluated by means of DXA using a QDR Explorer W scanner (Hologic, MA, USA; fan-bean technology, software for Windows XP version 12.6.1) operated in the whole body mode according to the manufacturer's procedures. The scanner was calibrated daily against the standard supplied by the manufacturer to avoid possible baseline drift. Whole body scanning time was about seven minutes. All scanning and analyses were performed by the same operator (CM) to ensure consistency. For the standard regional BMC estimations, Hologic software readings divided the body into trunk, entire arm, entire leg; BMD was available for entire arm, entire leg and, in the trunk, left and right ribs, thoracic spine, lumbar spine, and pelvis.

WBV exercise protocol

All subjects exercised 2 times a week for eight weeks on a Bioplate-RF (BIOS-Italia, Milan, Italy) vibrating platform generating vertical sinusoidal vibrations. Subjects performed 20 sequential unloaded static leg and arm exercises (e.g., high squat, deep squat, wide stance squat, bent over pull, standing abdominals) according to a fitness programme (#E4) implemented in the equipment. The total duration of each session was 19 min (14 min vibration training, 5 min rest), each exercise during 30 to 60 s; the vibration amplitude ranged 2.0 to 5.0 mm, and the frequency 40 to 60 Hz according to the individual exercise implemented.

Statistical analysis

Data were analyzed by means of analysis of variance (ANOVA) for repeated measures using the SPSS statistical package (v. 15). Log transformation was applied before analysis to normalize data where needed. Significance was set at $P<0.05$. Data are presented as means±SD.

RESULTS

The number of WBV sessions per week, the modalities of WBV exercise, and the total duration of the intervention revealed quite acceptable to the participants, all of which completed the trial. In the study group at baseline, body mass and height were 59.04±6.30 kg and 1.65±0.06 m, respectively, and body mass index (BMI) was 21.71±2.43 kg/m^2. DXA analysis revealed normal bone mineral status in all participants. After eight weeks of WBV, body mass did not change (59.14±6.23 kg, P=NS vs. baseline) as well as BMI (21.73±2.38; P=NS vs. baseline). At the total body level, BMC was 2225±337,1 g (95% CI 2111-2339) at baseline and 2221±321,0 g (95% CI 2112-2329) after trial; the difference was not significant (F=0.363, P=0.551). BMD was 1,105±0.0943 g/cm^2 at baseline (95% CI 1.073-1.137) and 1.104±0.0906 after trial (95% CI 1.073-1.135); the difference was not significant (F=0.079, P=0.780). Values for regional BMC and BMD at different body skeletal regions are presented in Table 1 and Table 2; all differences were not significant.

Table 1. *Bone mineral content (BMC) and density (BMD) at the regional level in young women (n=36) before and after eight weeks of whole body vibration exercise. Means±SD. Differences were not significant by repeated measures ANOVA.*

Bone parameter	Left arm (g)		RightArm (g)		Trunk (g)		Left leg (g)		Right leg (g)	
	BE	AE	BE	AE	BE	AE	BE	AE	BE	AE
BMC	121.3±18.32	122.7±19.06	137.1±21.78	139.3±21.42	615.7±122.58	604.3±113.91	372.4±60.26	371.9±60.48	388.2±67.06	386.6±65.66
BMD	0.67±0.044	0.66±0.047	0.71±0.061	0.70±0.066	NC	NC	1.07±0.096	1.07±0.099	1.09±0.109	1.09±0.105

BE, before exercise; AE, after exercise; NC, not calculated

***Table 2.** Bone mineral density at several trunk sites in young women (n=36) before and after eight weeks of whole body vibration exercise. Means±SD. Differences were not significant by repeated measures ANOVA.*

Left ribs (g/cm^2)		Right ribs (g/cm^2)		Thoracic spine (g/cm^2)		Lumbar spine (g/cm^2)		Pelvis (g/cm^2)	
BE	AE	BE	AE	BE	AE	BE	AE	BE	AE
0.63±0.075	0.63±0.077	0.63±0.074	0.62±0.073	0.88±0.129	0.87±0.113	1.19±0.205	1.17±0.174	1.12±0.149	1.12±0.154

BE, before exercise; AE, after exercise

DISCUSSION AND CONCLUSIONS

Exercise can increase bone mass in adults and even in the elderly (Guadalupe-Grau et al., 2009). The most effective exercise modalities are those requiring intense forces and/or high impacts (e.g., a combination of weight lifting and jumping) (Morel et al., 2001; Vicente-Rodriguez, 2006; Egan et al., 2006). In principle, WBV exercise is well suited to elicit increased bone mass because during vibration accelerations are transmitted from the plantar surface of the foot through the weight-bearing muscles and bones (Kiiski et al., 2008); however, in spite of the promising results found in experimental animals and research efforts over the last several years, the effect of WBV on the human skeleton is not yet defined. Inconsistent results are at least partly attributable to vibration training protocols, which have differed markedly in terms of vibration amplitudes, frequencies, durations, type and repetition rate of vibration, target group, and the total duration of the intervention. According to a recent meta-analysis (Slatkowska et al., 2010), WBV seems to consistently induce small but significant increment in BMD at some body sites in postmenopausal women (Verschueren et al., 2004; Iwamoto et al., 2005), and certain children and adolescents (Gislanz et al., 2006). Surprisingly enough, in young healthy adults only one randomized controlled study was performed (Torvinen et al., 2003), showing no significant changes in the BMC of 56 volunteers (21 males and 35 females) at the lumbar spine, femoral neck, and tibia after an 8-month WBV trial (1 to 4 min/day, 3-5 times per week/25 to 45 Hz). In the present study we investigated the effect of WBV exercise on bone mineral component of young women before the peak bone mass; in order to avoid confounding factors, subjects with overweight/obesity (Reid, 2002) and overtly altered menstrual status (Nichols et al., 2007) were not recruited. Weekly frequency and intensity of WBV exercise in the current trial were such to meet current practice for fitness, and the trial was completed by all of the participant young females reporting no side effects; accordingly, we consider the present protocol as “mild” WBV exercise.

Results presented here show that chronic, “mild” WBV exercise (eight weeks, two 19-min sessions per week) according to a fitness programme, does not affect the mineral content or density of the skeleton at the regional or total body level in young women before the peak bone mass is achieved. This finding is supported by the data obtained with an incremental WBV protocol (Torvinen et al., 2003) in subjects of both sexes after a much longer (8-mo) intervention. Quite recently (Humphries et al., 2009) a significant 2.7% increase in femoral neck BMD was found in a relatively small (n=15) group of healthy active women between the ages of 18 and 30 yrs, following a graded WBV intervention consisting of twice-weekly sessions in the squat position for 16 wk; such a discrepancy was explained alleging the multidirectional vibration exposure postures used by Torvinen et al. (2003) as well as variation in subject cohorts.

In conclusion, while WBV is promising for improving bone quality in certain populations, further research is required involving larger groups and dedicated vibration administration before WBV can be recommended for clinical practice in young healthy women.

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