Original Paper

Biomedical Human Kinetics, 2, 5 - 8, 2010

DOI: 10.2478/v10101-010-0002-1

Effects of two-month walking exercise on bone mass density in young, thin women

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Summary

Study aim: To examine the effects of a walking programme on the bone mass density (BMD) in sedentary, thin women aimed at preventing bone losses.
Material and methods: Twenty thin (BMI<20) women aged 22.0 ± 1.5 years volunteered to participate in the study. They were randomly assigned into the exercise (n = 10) or control (n = 10) groups, those from the experimental group being submitted to a training programme lasting two months. The programme consisted of 3 walking sessions per week, 30 min each, at 50 – 75% of maximal heart rate. Anthropometric measurements, bone mass density (by DXA) at the hip and lumbar spine ($L_2 - L_4$) and oestradiol concentration in serum (by radioimmunoassay kits) in the follicular phase were made before and after the training programme. The same diet was maintained throughout the study and was monitored by 7-day recalls.
Results: The walking programme induced significant increases in BMD (by 5.2% in the hip site, $p<0.001$, and by 7.3% in the spine, $p<0.05$). Significant decreases were found in calcium concentration in both groups (by about 5%) and in phosphorus concentration in the experimental group (by about 16%). In the experimental group also the relative body fat content significantly decreased (by 7.7%).
Conclusion: Walking exercise practiced for two months reduced the risk of bone loss by significantly increasing bone density.

Key words: Osteoporosis – Bone mass density – Walking exercise –Women

Introduction

Osteoporosis, when left untreated, may lead to bone fractures, the hip, spine and wrist being the most typical locations [30]. Although symptoms of osteoporosis do not generally occur until after menopause, recent evidence suggests that bone loss starts much earlier in life. The WHO considered osteoporosis a major epidemic in the years to come [31]. In spite of advances in the diagnosis of osteoporosis, the preventive measures are often neglected and the mounting medical, social and economic costs can be expected to increase unless effective prophylactic and therapeutic regimens are developed [1].

Osteoporosis is mostly found in postmenopausal women. Low bone density is though to be the most important single risk factor in the development of osteoporosis and fragility-induced fractures [29]. Young women, however, may also develop osteoporosis when their bone mass density (BMD) falls below the Z-score equal to -2 SD for given age [9]. Such a low Z-score was found in 44% of constitutionally thin subjects [13].

Women with small bones and those who are thin are more liable to osteoporosis [14], one of the reasons being their low body weight and, thus, insufficient load to stimulate bone accretion [7]. Moreover, thin women, having low body fat content, may have lower oestrogen levels than heavier women, fat tissue being known to increase oestrogen stores [8]. Underweight women may have abnormally low levels of calcium which puts them at increased risk of osteoporosis and bone fractures [20].

The dramatic increase in the incidence of osteoporosis over the last few decades may be explained by increasingly sedentary lifestyle. People who are less physically active throughout life are more likely to develop osteoporosis [15,21]. The role of exercise in the prevention and treatment of osteoporosis is widely known – physical activity reduces the risk of developing osteoporosis [33]. There is abundant evidence that mechanical loads

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on the skeleton enhance bone formation. Mosisio *et al*. [23] hypothesize that the mechanisms related to insufficient load on the sensitive bone regions may be responsible for impaired bone quality in constitutionally thin young women. Moreover, weight-bearing exercise is also recommended due to stimuli generated by the mechanical forces the muscles exert on the bone [27]. Sinaki *et al*. [32] showed that muscle exercise at no load was ineffective in preventing bone loss.

The most easily accessible form of weight-bearing exercise is walking. Even when not involving high loads, it is accessible to the majority of women [27]. Training, based on activities such as walking, was shown to increase BMD and bone formation [18,12] – walking 20 min daily increased BMD [3]. On the other hand, bone loss may be associated with physical inactivity; Puntila *et al*. [28] reported annual loss of BMD to be by half lower in physically active women than in their sedentary mates but might be ineffective in the prevention of femoral osteoporosis in peri- and postmenopausal women. However, postmenopausal women were the most often studied and very few studies included women with low bone density, who represent the most important population for osteoporosis intervention. The aim of this study was to investigate whether walking exercise can prevent the expected bone loss in young, thin women.

Material and methods

Subjects: A group of 20 untrained women aged 20 – 25 years volunteered to participate in this study and were randomly assigned into exercise (n = 10) or control (n = 10) groups. None of them had menstrual irregularities, cardiovascular, musculoskeletal and respiratory or other chronic diseases, they were under no medication. All of them were sedentary (no regular sports activities for at least 2 years), non-smokers. All of them submitted their written consents to participate. The study was approved by the local Committee of Ethics.

Methodology: Women from the experimental group were subjected to a 2-month training programme consisting of warm-up (stretching exercises for 5 min), 30 min walking at 50 – 75% of HR_{max} and cooling-down (5 min), 3 days a week. Stretching exercises involved arms, legs, back and abdomen. The recommended heart rate was set individually considering subject's age and resting HR [19]. Heart rate was monitored using Sport-Tester PE devices (Polar Electro, Finland). The exercise was accompanied by music and supervised by a professional exercise physiologist. Women from the control group remained sedentary throughout the study.

The measurements were conducted in all women twice: at the start and end of the programme. The following anthropometric measurements were recorded: body mass (recorded weekly) and height, BMI, body fat content by DXA method (Lunar DPX-L, software version 1.31, USA) and lean body mass. The DXA scans were performed in the Orthopaedic Diagnostic Centre, National University Hospital, Guilan. Body mass was kept within ± 2.2 kg throughout the study period.

Bone mass density (BMD; g/cm^2) was measured at the hip and lumbar spine ($L_2 - L_4$) using dual X-ray absorptiometry (DXA; Norland XR-26, WI, USA). All the scans and analyses were done by the same operator. The relative day-to-day error of BMD measurements ranged 0.7 – 1.7%. The scanner was calibrated daily and its performance was monitored with our quality assurance protocol. No significant machine drift during the study period was noted.

Blood samples were collected from the antecubital vein after an overnight fast and centrifuged at 1500 rpm for 30 minutes at 4^o C within 2 h. Serum was collected and stored frozen at -20^o C until assayed. Oestrogen was determined by radioimmunoassay kits (Amersham Biosciences, Piscataway, NJ, USA) at subject's follicular stage; calcium and phosphorus concentrations were measured by standard automated laboratory techniques.

The subjects were instructed as to their diet by a licensed dietician according to the American Health Association (AHA) rules. The diet contained 50 – 55% carbohydrate, 15 – 20% protein and <30% fat [26]. The subjects were requested to stay on that diet throughout the study and were monitored by applying 7-day recalls every week. Subjects from the experimental group received additionally two glasses of milk (1.5% fat) 6 days a week.

The data were subjected to two-way ANOVA (SPSS 13 for Windows); since in all variables, except calcium, the periods × groups interaction was significant, Student's *t*-test for dependent or independent data was used, the level of $p \leq 0.05$ being considered significant.

Results

The anthropometric data of both groups of subjects are shown in Table 1. No significant between-group differences were noted in any variable. In the experimental group a significant decrease in the relative body fat content (by 7.7%; $p<0.05$) and an increase (by about 16%; $p<0.001$) in lean body mass were noted at the end of the study ('Post') compared with the initial ('Pre') values. No major change in menstrual status was observed during the study.

Table 1. Mean values (±SD) of anthropometric variables before (Pre) and after (Post) training programme

Group	Experimental (n = 10)		Control (n = 10)	
Variable	Pre	Post	Pre	Post
Age (years)	21.1 ± 1.7		21.9 ± 1.3	
Body height (cm)	159.9 ± 7.6		162.7 ± 6.7	
Body mass (kg)	45.9 ± 5.3	46.4 ± 5.2	46.5 ± 5.7	46.3 ± 5.2
BMI	17.8 ± 1.1	17.8 ± 1.5	17.5 ± 1.1	17.6 ± 1.0
Lean body mass (kg)	33.5 ± 3.7	34.5 ± 4.0***	33.9 ± 4.3	33.7 ± 4.6
% Body fat content	21.8 ± 3.1	20.1 ± 3.6*	22.4 ± 2.9	22.4 ± 3.2

Significantly different from the 'Pre' value: * $p<0.05$; *** $p<0.001$

Table 2. Mean values (±SD) of bone mass density (BMD) and biochemical variables before (Pre) and after (Post) training programme

Group	Experimental (n = 10)		Control (n = 10)	
Variable	Pre	Post	Pre	Post
BMD (g/cm^2) Hip	0.843 ± 0.060	0.863 ± 0.064***	0.834 ± 0.115	0.831 ± 0.107
Spine (L_2-L_4)	1.051 ± 0.147	1.128 ± 0.216*	1.057 ± 0.120	1.056 ± 0.134
Oestrogens (pg/ml)	25.5 ± 8.4	60.2 ± 18.8***	33.0 ± 14.3	38.0 ± 10.6 ^{oo}
Calcium (mg/dl)	9.8 ± 0.4	9.3 ± 0.5**	9.8 ± 0.3	9.3 ± 0.3**
Phosphorus (mg/dl)	4.2 ± 0.4	3.5 ± 0.4**	4.0 ± 0.5	3.8 ± 0.4

Significantly different from the 'Pre' value: * $p<0.05$; ** $p<0.01$; *** $p<0.001$; ^{oo} Significantly ($p<0.01$) different from the respective value in the experimental group

Upon entering the study, all subjects were within normal ranges of serum calcium, phosphorus, or oestrogen levels. Calcium concentrations significantly ($p<0.01$) decreased post-training in both groups, otherwise no significant changes were noted in the control group. On the other hand, significant training-induced changes were noted in the experimental group in all variables presented in Table 2, the most important being those in bone mass density which increased by 5.2% in the hip site ($p<0.001$) and by 7.3% in the spine ($p<0.05$).

Discussion

Despite a relatively short duration of the exercise programme consisting of walking for 30 min at 50 – 75% of HR_{max} 3 days a week, it resulted in individually significant ($p<0.05 – 0.001$) increases in BMD indices; due to the relatively high between-subject variability, the between-group differences were non-significant. This finding is consistent with those of other authors who reported either training-induced increases in BMD (cf. [2]) or no change, but accompanied by a decline in the control group [11,17]. Individually significant increase in oestrogen concentrations was noted in the experimental group only, the post-training level being significantly higher than that in the control group. Interestingly, significant decreases were found in calcium and phosphorus concentrations, that latter in the experimental group only. This means that the prescribed diet might have been deficient in those minerals. A significant decrease in body fat percentage in the experimental group was another finding which confirmed the efficacy of the applied training.

Physical exercise is one of the factors in the prevention of osteoporosis, provided the amount and type of exercise are acceptable by the majority of women of given age. Walking is the most common and suitable activity for preventing or reducing bone losses [4]. The walking-induced effects on bone density at various skeletal sites may be difficult to compare due to differences in the approaches to measuring walking activity. Nelson [25] demonstrated beneficial effects of walking at 75 – 80% of HR_{max} for 50 min, 3 – 4 times a week, on BMD and body mass in postmenopausal women wearing a leaded belt. Chow *et al.* [6] reported an increase in BMD following treadmill exercise at 80% of HR_{max} and Dalsky *et al.* [10] reported an increase in BMD in postmenopausal women following a short-term walking exercise. It was shown in a recent study [24] that 20 min daily of walking (3 km/h) increased BMD in lumbar spine and femoral sites and decreased total body mass of

sedentary women. These findings confirm that the bone-maintenance effect of exercise in the pre- and posmenopausal periods may be an essential factor in preventing osteoporosis compared with sedentary women.

The degree and extent of any exercise should be adjusted to age, physical fitness and the condition of the skeletal system. Aerobic walking was reported ineffective in preventing bone losses in postmenopausal women [5] but Hotori *et al*. [16] showed that walking for 30 min at intensity above the anaerobic threshold (AT) was effective in increasing BMD, whereas exercise below the AT was not. It was also reported [22] that walking speeds of less than 6.4 km did not increase BMD.

In conclusion, our data suggest that 2-month walking exercise might be effective in reducing the risk of bone loss by increasing bone density. However, educating and rising awareness of osteoporosis among young women is very important and needed.

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Received 17.01.2010
Accepted 4.02.2010

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