World Journal of Sport Sciences 3 (1): 11-16, 2010
ISSN 2078-4724

The Effect of Walking Exercise on Bone Mass Density in Young Thin Women with Osteopenia

N. Habibzadeh, F. Rahmani-Nia and H. Daneshmandi

Department of Sport Sciences, University of Guilan, Rasht, Iran

Abstract: Osteoporosis is a widespread disorder for women, that causing bone fractures after simple trauma in them. But exercise is long being known to reduce the risk of osteoporosis. Therefore this study aims to investigate the effect of walking program on bone mass density in order to reduce bone loss and osteoporosis in thin young women. Twenty thin (*BM I <20*) osteopenic women with age 22.00 ± 1.50 years volunteered to participate in this study. Then they were randomly assigned to exercise (n=10) and control (n=10) groups. Before and after the training program both groups had anthropometric measurements, blood analysis by routine laboratory test, BMD evaluation. Bone mass density was measured by using dual-energy X-ray absorptiometry (DXA) at hip and spin (L_2-L_4). Each walking session was 30 min. walking at 50-75% of maximal heart rate, 3 days per week, for 2 months. After 2 months, exercise group had no effect assignment on BMD at the spin (L_2-L_4) and hip ($p>0.05$).However they experienced slightly increased in BMD at both regions, while the control group did not. Also no change was observed in serums of calcium, phosphorous and estrogen ($p>0.05$). Percent body fat, fat mass and lean mass changes in response to training were significant in the exercise group (all $p=0.000$). This study concluded that short term walking program does not affect bone mass density in thin girls and it means that they are still at risk of osteoporosis and it seems that more studies for preventing this illness in thin osteopenic girls are needed.

Key words: Osteoporosis % Osteopenia % Bone Mass Density % Walking Exercise % Thin women

INTRODUCTION

Millions of Americans have osteoporosis, but while this common condition is both preventable and treatable, it often goes undetected because it has no symptoms. In medical textbooks osteoporosis is defined as "a disease characterized by low bone mass and microarchitectural deterioration of bone tissue, leading to enhanced bone fragility and a consequent increase in fracture risk". Fractures are known to occur typically in the hip, spine and wrist [1]. Although symptoms of osteoporosis do not generally occur until after menopause, recent evidence suggests that bone loss starts much earlier in life. That is why the world Health Organization (WHO) believes that we are heading for a major epidemic the years to come [2]. In spite of development in diagnosis of osteoporosis, still the preventive measure of osteoporosis is neglected and the already staggering medical, social and economic costs can be expected to increase unless effective prophylactic and therapeutic regimens are developed [3].

Osteoporosis is mostly found in women following menopause. However, young women have an equivalent degree of osteoporosis when their bone mineral density (BMD) falls within a certain range [4]. Certain people are more likely to develop osteoporosis than others. Various studies suggest that low BMI is related to decrease BMD. Low bone density is though to be the single most important risk factor in the development of osteoporosis and fragility fractures [5]. Researchers used a manufacturer-supplied reference dataset of healthy young adult female BMD values and identified a Z-score (a score expressed in standard deviation units from a given mean of age-matched controls) <-2.0 as an equivalent of osteoporosis. In this study 44 percent of constitutionally thin subjects presented with a Z-score <-2.0 [6].

Women with small bones and those who are thin are more liable to have osteoporosis [7]. Part of the reason is that body weight puts stress on bone, stimulating it to form more bone [8]. Also, thin women may have lower

Corresponding Author: Farhad Rahmani-Nia, Exercise Physiology Department of Exercise Physiology, University of Guilan, Rasht, Iran

estrogen levels than heavier women, because thin women usually have less body fat. Fat tissue produces some estrogen [9]. But that does not mean heavier or larger people can't get it. Underweight women have below normal levels of calcium, making them more likely to fracture bones and putting themselves at increased risk of osteoporosis [10].

The dramatic increase in osteoporosis over the last few decades may be explained by increasingly sedentary lifestyle. Bone is broken down in response to inactivity. People who are less physically active throughout life are more likely to develop osteoporosis [11, 12].

The role of exercise in the prevention and treatment of osteoporosis is multi-faceted. Physical activity affects the risk of developing osteoporosis [13]. There is abundant evidence that mechanical loading of skeleton promotes bone formation. Estour *et al*., hypothesize that mechanisms related to insufficient load on key weight-bearing bone regions may be responsible for impaired bone quality in constitutionally thin young women. Moreover weight-bearing exercise is also recommended due to the positive stimulus of the mechanical pull of the muscles on the bone [14]. Sinaki *et al*., showed that nonloading muscle exercise was ineffective in bone loss [15]. The most easily accessible form of weight-bearing exercise is walking. It may not involve high loading but it is accessible to majority of all women [16]. Training based on weight-bearing activities such as walking has been shown to increase BMD although to a lesser extent. Bone is formed in response to weight-bearing activity such as walking because they put legs to work [17, 18]. The results of observational studies on exercising individuals show that they have higher BMD than non-exercise individuals. Evidence in the literature links physical inactivity to bone loss. Puntila *et al*., reported the annual loss of BMD to be 23% less in physically active peri-and postmenopausal women. This loss is 52% less for BMD in women reporting walking as their sole form of weight-bearing exercise [19]. Brooke-Wavell *et al*., reported that 20 min walking a day increased BMD [20].

Exercise has been demonstrated to either retard bone loss or to increase bone mass in postmenopausal women. However, most of these studies were done in postmenopausal women and very few studies have included women with low bone density which is 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 osteopenic women.

MATERIALS AND METHODS

Subjects: Subjects were recruited through various advertising strategies such as posters in physicians' offices daycare centers and drugstore. The women were eligible if they had a BMD T-score of<-1 in total hip or spine L_2-L_4 and were able and willing to participate in the training. Twenty osteopenic women between the ages of 20-25 years volunteered to participate in this study. Then they were randomly assigned to exercise (n=10) and control (n=10) groups. Written informed consent for all procedures was obtained from all participants prior to entering the study. The criteria for the invitation were being willing to participate, clinically healthy (no cardiovascular, musculoskeletal, respiratory, or other chronic diseases that might limit training or testing), no menstrual irregularities, not using medication that alert bone mass density and no beta-blockers or stories, sedentary life style (no regular sports activities for at least 2 years), nonsmoking and no apparent occupational or leisure time responsibilities that impede their participation.

Procedure: The following measurements were made at baseline prior to the start of the exercise program and at after completion of the 2-month training program.

Anthropometric Measurement: Body weight and height were recorded and body mass index (BMI) was calculated as weight (kg) divided by height (m) squared. DXA (Lunar DPX-L, software version 1.31, USA) was used to measure each subject's fat mass, percentage body fat and lean mass. The DXA scans were performed in the Orthopaedic Diagnostic Centre at the National University Hospital, Guilan. In addition, all subjects were weighed every week so that none of them gained or lost > 2.2 kg body weight over the entire study period.

BMD Assessment: The main endpoints of the study were the change in bone mass density of the hip and the lumbar spin (L_2-L_4).BMD (g/cm^2) was measured with the dual X-ray absorptiometry scans (DXA) (Norland XR-26, WI, USA).All the scanning and analyses were done by the same operator. The vivo day-to-day (coefficient of variation) of the BMD measurement in our laboratory range from 0.7 to 1.7%.The scanner was calibrated daily and its performance was followed with our quality assurance protocol. There was no significant machine drift during the study period.

Blood Analysis: Blood samples were collected after an overnight fast (>12 h) in a sitting position and centrifuged at 1500 rpm for 30 minutes at 4° C within 2 h. Serum samples from each participant were stored frozen at-20° C until analyzed. Serum estrogen level was assessed by radioimmunoassay (Amersham Biosciences, Piscataway, NJ, USA) in follicular stage in each subject's menstrual cycle and serum calcium, phosphorus levels were measured by standard automated laboratory techniques.

Dietary Intake: Caloric expenditure was calculated based on the weight of the subject. To minimize any affect that dietary composition might have on the measured metabolic variables, the initiation of the study all subjects were instructed on the American Health Association (AHA) diet by registered dietitian. The composition of this diet was 50-55% carbohydrate, 15-20% protein, <30% fat [21]. The subjects were asked to maintain this diet composition throughout the study's duration (2mo).Compliance was monitored by review of 7-day food records taken every week.

Exercise Program: The program included warming-up phase for 5 minutes of stretching exercises, 30 minutes walking at 50-75% of maximum heart rat and cooling-down phase for 5 minutes of stretching, three times a week for 2 months. Stretching exercises were performed for the arms, leg, back and stomach. A target heart rate range between 50-75% of age adjusted maximum heart rate intensity was calculated by each walker from her age and walking supine resting heart rate [22]. Heart rate was measured with an electronic heart rate meter (Sport Tester PE, Polar Electro, Oy, Finland). The exercise program was accompanied by music. All sessions were supervised by a professional exercise physiologist leader.

Statistical Analysis: The data were analyzed using the SPSS statistical package (SPSS 13 for Windows; SPSS, Chicago, USA).Mean and standard deviation (SD) was used as descriptive statistic. Student's t-test was used for normally distributed variables. Paired t-test was used to assess the change in BMI, body weight, serum calcium, phosphorus and estrogen before and after the exercise intervention. One-way analysis of variance (ANOVA) was used to detect significant change and differences in response over time between groups. The results are given in 95% confidence interval (CI). 95% CI was estimated by Confidence Interval Analysis Software 13.

The final level of significance was accepted as $p<0.05$ for all comparisons.

RESULTS

Twenty subjects (100%) completed the training program. No major change in menstrual status was observed during the study. Table 1 shows the physical characteristics of the study subjects (pre, post study). There were no significant differences in mean age, height, BMI between the two groups at the first. Percent body fat, fat mass and lean mass changes in response to training

Table 1: Changes in Anthropometric variables in pre and post test exercise (X ±SD)

	Thin(Exe)		Thin(Con)		
variable	pre	post	pre	post	P value
Age (year)	21.10± 1.73	-	21.90±1.29	-	
Height (cm)	159.90± 7.56	-	162.70±6.65	-	
Weight (kg)	45.88 ± 5.33	46.43±5.18	46.49±5.70	46.31±5.21	0.000*
BMI (kg/m^2)	17.73± 1.05	17.89±1.49	17.51±1.05	17.24±0.98	0.000*
Lean mass (kg)	33.54± 3.72	34.53±3.97	34.93±4.31	33.67±4.57	0.000*
Fat mass (kg)	9.86±1.85	9.21± 2.14	10.38±1.92	10.51±1.90	0.000*
% Body fat	21.82±3.13	20.13±3.60	22.35±2.86	22.43±4.20	0.000*

* Significantly different from the 'Pre' value:* p < 0.05.
*Exe=Experimental *Con=Control

Table 2: Change in BMD and blood variables in pre and post test exercise (X ±SD)

	Thin(Exe)		Thin(Con)		
variable	pre	post	pre	post	P value
Hip BMD (g/cm^2)	.843± 0.059	0.863±0.063	0.834±0.115	0.831±0.106	0.868
Spine (L_2-L_4) BMD (g/cm^2)	1.051±0.147	1.128±0.216	1.057±0.120	1.056±0.134	0.562
Estrogen (pg/ml)	25.55±8.93	42.15±18.80	38.00±10.57	30.42±15.60	0.967
Calcium (ml/dl)	9.78±0.42	9.25±050	9.67±0.30	9.28±0.315	0.410
Phosphorous (ml/dl)	3.81±0.39	3.55±036	3.96±0.53	3.80±0.38	0.939

were significant in the two groups. The lean mass in both groups were significantly increased but the present body fat, fat mass were significantly decreased (p = 0.000). Body mass index (BMI) and the mean body weigh in the exercise group significantly differ from before the intervention compared with the control group ($p<0.05$).

All subjects showed normal ranges of serum calcium, phosphorus, or estrogen levels at the baseline and analysis of data showed that the post-test differences between the groups were not significant ($p>0.05$). This lack of change in serum calcium, phosphorus and estrogen indicates that they are not important factors for normal bone metabolism and did not influence our results. Moreover, no change was observed on BMD of the spin (L_2-L_4) and hip in exercise group ($p<0.05$) (Table 2).

DISCUSSION

The aim of this study was to investigate the effects of walking exercise on BMD in young thin woman. In our patient a simple 30 minutes of walking exercise at the range of 50-75% maximum heart rate was not enough to significant change the BMD in thin exercise group. A short duration study cannot adequately the benefits related to bone quality, because bone is a slowly responding organ. However women in the control group reported had lower BMD than women in the exercise group. Several well-controlled studies similarly supported a positive effect of exercise on BMD, indicating either less reduction or more gain in BMD for the training group compared with the control group [23]. Several studies also have shown that exercise of relatively short duration did not enhance BMD, but decline in BMD were reported in non-exercise groups [24, 25]. Result of the blood parameters also showed that neither estrogen nor calcium and phosphorous levels were significantly altered as a result of two-month training regimen, suggesting that estrogen, calcium and phosphorous did not mediate the observed skeletal changes in the both groups.

Body weight and weight changes are strongly linked to BMD changes in women regardless of body site. In this study, change in weight during the follow-up period was the main determinant of the BMD, indicating that maintaining or even gaining weight seems to retard excessive bone loss in thin women [26]. The increase in body weight in exercise group accounts for the responses of body weight to walking exercise compare with the control group. In our patient a simple 30 minutes of walking exercise at the range of 50-75% maximum heart rate was enough to decreasing the fat mass and increasing in lean body weight. Mechanical factors that affect bone remodeling include muscular contraction and gravity. Lanyon found that bone responds in proportion o the amount of stress place on it [27]. Abramson and Dwlagi showed that weight bearing and muscle contractions generate stress on bone necessary to prevent bone loss [28]. Although overall fat mass does improve bone density, so does overall lean mass. “Lean mass” means muscle."Lean mass," the researchers conclude, "is the major determinant of bone size, providing further evidence that bone size is adapted to the dynamic load imposed by muscle force rather than passive loading" by fat [29].

However exercise will only play a part in preventative strategy to decrease the incidence of osteoporosis if the amount and type of exercise needed to be effective is perceived as attainable by the majority of young-aged and older women. Though it may be desirable to design a regimen likely to be maximally effective at a number of different skeletal sites, such a program may be difficult to implement. Walking is the most common exercise and is a suitable activity for lowering bone loss [30]. Comparisons among studies evaluating the effect of walking on bone density at various skeletal sites are limited by differences in methods to measure walking activity of the study population. Among postmenopausal women, Yamazaki *et al*., demonstrated that the positive effect of 1 year of moderate walking exercise on the BMD was caused by a decrease in bone turnover in osteopenic postmenopausal women [31]. Bergstrom concluded that 30 minutes of walking a small but positive effect on hip BMD in postmenopausal women with low BMD [32]. Gina Bravo also observed that intensity of back pain was lowered by walking exercise in osteopenic woman [33]. These finding confirm that exercise decreased bone turnover, which was elevated by estrogen deficiency and resulted in positive effect the skeleton. Chow *et al*., 24-week program of walking exercise at 80% of the maximum heart rate, 2-3 times per week was beneficial for enhancing physical fitness and bone mineral density (BMD) in osteopenic postmenopausal women [34]. Researchers found that women who walk a mile a day have greater bone in reserve than women who do not. A recent study by Mulhim *et al*., have shown that 30 minutes of walking at 1.5 km/hour was increased lumbar spin and femoral BMD and decreased total body weight in sedentary woman [35]. These finding confirm that bone maintenance effect of exercise during the premenopausal and postmenopausal period may be an essential

factor, making a favorable difference as compared with sedentary women. Furthermore young people, especially young girls and women, can improve their bone health throughout life.

The degree and the extent of any exercise should be adapted to the age, the physical ability, the skeletal condition of the individual. Cavnaugh and Cann also reported that aerobic exercise such as walking program did not prevent bone loss in postmenopausal [36]. Korpelainen similarly observed that 30-monthes walking exercise had no effect on BMD in elderly women with low BMD [37]. Hotori *et al*., showed that walking for 30 minutes above the anaerobic threshold (AT) was effective in increasing BMD, whereas exercise below the AT was not [38]. Iwamato *et al*., fond that walking exercise led to a significant increase in lumbar BMD in postmenopausal women with osteoporosis compared with the control, but that the BMD reverted toward a level that was not significantly different from the control with detraining. However continued exercise is required to maintain any gain [39].

In conclusion, our data suggest that short term walking program does not affect bone mass density in thin girls and it means that they are still at risk of osteoporosis. The duration of our study may be too short to evaluate the effects of moderate intensity exercise. However further studies are needed to evaluate the efficacy of walking exercise on bone quality and the risk of bone loss as an exercise-related effect in thin osteopenic groups. Also educating and rising awareness of osteoporosis among young women is very important and needed.

ACKNOWLEDGEMENT

The work was supported by grants from the University of Guilan. The authors gratefully acknowledge the all subjects whom cooperated in this investigation.

REFERENCES

1. Renfro, J. and J.B. Brown, 1998. Understanding and Preventing Osteoporosis. AAOHN J., 46: 181-191.
2. Sambrook, P. and C. Cooper, 2006. Osteoporosis. Lancet, 367: 2010-18.
3. Abdy, S.E., 1998. A Strategy to Prevent Osteoporosis. Prac Nurse, 16: 614-619.
4. Cummings, S.R. and L.J. Melton, 2002. Epidemiology and Outcomes of Osteoporotic Fractures. Lancet, 359: 1761-17670.
5. Ravn, P., G. Cizza, N.H. Bjarnason, *et al.*, 1999. Low body mass index is an important risk factor for low bone mass and increased bone loss in early postmenopausal women. Early Postmenopausal Intervention Cohort (EPIC) study group. J. Bone. Miner Res., 14: 1622-7.
6. Galusca, B., M. Zouch, N. Germain, C. Bossu, D. Frere, F. Lang, *et al.*, 2008. Constitutional thinness: unusual human phenotype of low bone quality. J. Clin. Endocrinol. Metab., 93(1): 110-7.
7. krahe, C., R. Friedman and J.L. Gross, 1997. Risk fractor for decreased bone density in premenopausal women. Brazalian J. Med. Biol. Res., 30: 1061-1066.
8. Coin, A., G. Sergi, P. Beninca, L. Lupoli and G. Cinti, 2000. Bone mineral density and body composition in underweight and normal elderly subjects. Osteoporos Int., 11(2): 1043-50.
9. Compston, J.E., 2001. Sex steroids and bone, 81: 419-447.
10. Korpelaien, R., J. Korpelaien, J. Heikkinen, K. Vaananen and S. Kiuaanniemi, 2003. Lifestyle factor are associated with osteoporosis in lean women but not in normal and overweight women. Osteoporos Int., 4: 34-43.
11. Hata, M., M. Miyom and Y. Mizuno, 2003. Osteoporosis as a lifestyle related disease. Nippon Rinsho, 61: 305-313.
12. Korpelaine, R., J. Korpelaine, J. Hekkinen, *et al.*, 2003. Life long factor for osteoporosis and fractures in elderly women with low body mass index. Bone, 39: 385-391.
13. Turnerc, H., 1998. Exercise as a therapy for osteoporosis. Bone, 23: 83-85.
14. Galusca, B., N. Germain and B. Estour, 2009. Bone abnormalities in constitutional thinness., Br J. Nutr., 22: 1-2.
15. Sinaki, M.H.W., Wahner, K.P. Offord and S.F. Hodgson, 1989. Efficacy of nonloading exercise in preventing vertebral bone loss in postmenopausal women: a controlled trail. Mayo., 64: 762-9.
16. Palombaro, K.M., 2005. Effect of walking-only interventions on bone mineral density at various skeletal sites: a meta-analysis. J. Geritr. Phys. Ther., 28(3): 102-107.
17. Kato, Y., K.I. Takata, K. Yasaku and N. Koitaya, 2005. Walking during and habitual exercise related to bone mineral density using computer-assisted X-ray densitometry in Japanese women. Geriatric and Gerontol. Int., 5: 176-181.

18. Elizabeth, K. And H. Bess, 1994. Walking is related to bone density and rates of bone loss. The American J. Medicine, 96: 20-26.
19. Puntila, E., H. Kroger, T. Lakka, M. Tuppurainen, J. Jurvelin and R. Honkanen, 2001. Leisure-time physical activity and rate of bone loss among peri-and postmenopausal women: A longitudinal study. Bone, 29: 442-446.
20. Brooke Wavell, K., P.M. Jones, A.E. Hardman, I. Tsuritani and Y. Yamada, 2001. Commencing, continuing and stopping brisk walking: effects on bone mineral density, quantitative ultrasound of bone and markers of bone metabolism in postmenopausal women. Osteoporos Int., 12: 581-587.
21. New, S.A., C. Smith, D.A. Grubb and D.M. Reid, 1997. Nutritional influence on bone mineral density: a cross sectional study in premenopausal women. AM. J. Clin. Nutr., 65(6): 1831-9.
22. Karvaonen, M.J. and T. Vuorimaa, 1988. Heart rate and exercise intensity during sport activities: Practical application. Sport Medicine, 5: 303-312.
23. Berard, A., G. B ravo and P. Gauthier, 1997. Meta-analysis of the effectiveness of physical activity for prevention of bone loss in postmenopausal women. Osteoporos Int., 7: 331-337.
24. Wolff, I., J.V. Croonenborg, C.G. Kemper, P.J. Kostense and W.R. Twisk, 1999. The effect of exercise training program on bone mss: a meta-analysis of published controlled trails in pre-and postmenopausal women. Osteoporos Int., pp: 1-12.
25. Ehrlich, P.J. and L. Lanyonl, 2002. Mechanical strain and bone cell function: a review. Osteoporois Int., 13: 688-694.
26. Douchi, T., T. Oki, S. Nakamura, H. Ijuin, S. Yamamoto and Y. Nagata, 1997. The effect of body composition on bone density in pre-and postmenopausal women. Maturitas, 27(1): 55-60.
27. Mosley, J.R. and L.E. Lanyon, 1998. Strain rate as a controlling influence on adaptive modeling in response to dynamic loading of the ulna in growing male rats. Bone, 23: 313-318.
28. Abramson, A.S. and E.F. Delagi, 1961. Influence weight bearing and muscle contraction on disuse osteoporosis. Arch. Phys. Med. Reabil., 42: 147-51.
29. Kaufman, J.M., 2009. Muscle mass, not fat, makes for stronger bones. J. Clin. Endocrinol. Metabolism, www.canada.com/health.
30. Caplan, C.A., J.A. Ward and S.R. Lord, 1999. The benefits of exercise in postmenopausal women. Aust J. Public Health, 17: 23-26.
31. Yamazaki, S., S. Ichimura, J. Iwamato, T. Takeda and Y. Totama, 2004. Effect of walking exercise on bone metabolism in postmenopausal women with osteopenia/osteoporosis. J. Bone Miner Metab, 22: 500-508.
32. Bergstrom, I., B.M. Landgren, J. Brink and B. Freyschuss, 2007. Physical training preserves bone mineral density in postmenopusal women with forerm fractures and low bone mineral density. Osteoporos, Int., 6: 1-7.
33. Bravo, G., P. Gauthier, M. Roy Pierre, P. Gaulin, M. Harvey, L. Peloquin and M.F. Dubois, 1996. Impact of 12-month exercise program on the physical and psychological health of osteopenic women. J. Am. Geriatr Sos., 44(7): 756-62.
34. Chow, R., J.E. Harrison and C. Notarius, 1987. Effect of two randomized exercise programs on bone mass of healthy postmenopausal women. British Med. J, 259: 1441-44.
35. Mulhim, A.A., S. AL Gazzar, A. AL Bahnassy, *et al.*, 2004. Effect of exercise program on bone mineral density in sedentary females. Bahrain Medical Bulletin, 26(2): 1-5.
36. Cavanaugh, D.J. and C.E. Cann, 1988. Brisk walking did not stop bone loss in postmenopausal women. Bone, 9: 201-204.
37. Korpelaninen, R., S. Keinanen, J. Heikkinen, K. Vaananen and J. Korpelainen, 2006. Effect of impact exercise on bone mineral density in elderly women with low BMD: a population-based randomized controlled 30-month intervention. Osteoporosis Intl., 17(1): 109-118.
38. Hatori, M., A. Hasegawa, H. Adachi, A. Shynozaki, R. Hayashi and H. Okano, 1993. The effects of walking at the anaerobic threshold level on vertebral bone loss in postmenopausal women. Calcif Tissue Int., 52: 411-414.
39. Iwamoto, J., T. Takeda and S. Ichimura, 2001. Effect of exercise training and detraining on bone mineral density in postmenopausal women with osteoporosis. J. Orthop Scin, 6: 128-132.