ISSN:

Gratis

Journal of Bone Biology and Osteoporosis

Research Article

Bone Mineral Density in Female Professional Athletes Involved in Weight Bearing and Non-Weight Bearing Exercises

Amineh Amanilori[1,2], Farideh Shojaee[1], Patricia Khashayar[3,4], Hamid Reza Aghaei Meybodi[3], Eidi Alijani[1] and Ramin Heshmat[5,6*]

[1]Physical Education Department, Karaj Islamic Azad University, Karaj, Tehran, Iran

[2]Department of Biology, Faculty BioMedicine, University of Barcelona, Barcelona, Spain

[3]Osteoporosis Research Center, Endocrinology and Metabolism Clinical Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran,

[4]Center for Microsystems Technology, Imec and Ghent University, Gent-Zwijnaarde, Belgium

[5]Chronic Diseases Research Center, Endocrinology and Metabolism Population Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran

[6]Endocrinology and Metabolism Research Center, Endocrinology and Metabolism Clinical Sciences Institute, Tehran University of Medical Sciences, tehran, Iran

Received: June 05, 2015; Accepted: June 22, 2015; Published: June 25, 2015

Abstract

The present study was designed to assess the effect of different types of exercises on the BMD values in female professional atheletes. The case control study was conducted on 59 healthy female atheletes aged between 20 and 30 years who were a member of the country's national teams in the past three years. They were involved in weight-bearing (soccer and golf) and non-weight bearing (swimming and rowing) exercises. The BMD values of the L1–L4 anteroposterior lumbar spine and femoral subregions were recorded using a DXA bone densitometer and compared to that of a group of age and sex-matched non-athletes. Mean BMD values at all the studied sites were highest among the footballers and lowest among the golf players. Except for the spine, a significant difference between the BMD values at all the studied sites. As for spine, a significant difference was only seen in the BMD values of the footballers and that of golf players. There was no significant difference between the BMD values of the controls and those involved in either weight bearing or non-weight bearing exercises. The considerable difference noted in BMD values at different sites in footballers and golf players' points out the great influence of weight-bearing exercises on the bone structure. The bones' response to exercises is site-specific. High-impact weight bearing exercises stressing bones in a variety of directions are more effective in improving BMD values. Athletes involved in non-weight bearing exercises should do certain weight-bearing exercises to strengthen their bones.

Keywords: Bone mineral density; Osteoporosis; Physical activity; Female

---

***Correspondence:** Ramin Heshmat, Chronic Diseases Research Center, 19th st, Kargar ave, Tehran, Iran Tel: (98)2188354367; Fax:(98)2188637563 E-mail: rheshmat@razi.tums.ac.ir

Introduction

Osteoporosis, a common disorder in the female elderly population, has become one of the most significant public health concerns across the globe [1-4]. The condition results in the loss of bone strength which, in combination with an increased tendency to fall, accounts for the surging number of hip fractures during the past decade [5-7]. While certain studies have named reduced bone mineral density as one of the most common complications in adolescents and young women involved in strenuous sports activity, others consider exercising during youth as a non-pharmacological preventive strategy not only to increase muscle strength but also to regulate bone maintenance and stimulate bone formation, all of which would improve balance and subsequently would reduce the overall risk of falls and fractures during middle and later life [5,8-12].

These studies suggest that physical activity can improve the width and the mineral content of bones in girls and adolescent females, particularly if it is initiated before puberty, carried out in volumes and at intensities seen in athletes, and accompanied by adequate caloric and calcium intakes [9]. The majority of the researches conducted in this field have focused predominantly on post-menopausal women; studies on premenopausal women, though, remain sparse [4,12-18]. Taken as a whole, these studies have revealed that not all exercises are effective in this regard.

Some of the existing studies have compared the effects of various types of exercises on different athletic populations, suggesting that athletes involved in high-impact sports such as hurdling, volleyball and squash have greater bone density than those involved in lower impact sports including orienteering or skiing [13,19-22]. These studies have also linked activities with a relatively high impact component such as jumping alone or in combination with aerobic step exercise to increased BMD values at the hip, adding that high-intensity resistance training can improve BMD values at both hip and spine [19,22,23]. In other words, they have suggested that the relative effects of varying modes of activity are site specific, depending on the age and the health condition of the individual [24,25].

The present study was therefore designed to assess the effect of weight-bearing and non-weight-bearing exercises on the BMD values of a group of female atheletes and to determine whether the exercise-related BMD change differed between different parts of the body.

Material and Methods

After being approved by the Ethical Board Committee of Endocrinology and Metabolism Research Institute (EMRI), this case control study was conducted on atheletes involved in weight-bearing (soccer and golf) and non-weight bearing (swimming and rowing) exercises. The participants were selected among healthy female atheletes aged between 20 and 30 years who were a member of the country's national teams in the past three years. Women complaining about irregular menses, expectant and lactating mothers, smokers and those taking medications that could modify bone metabolism were excluded from the study.

A control group was also recruited from healthy women, matched to the exercise group on age, from Tehranis who participated in the Iranian Multi – center Osteoporosis Study (IMOS) [26]. The same eligibility criteria for enrollment in the exercise program were applied to the controls.

After negotiating with the related federations, each woman was sent a letter explaining the purpose of the study and inviting her to make an appointment to attend an initial assessment. Women who declined this invitation were not contacted again; up to three mailings were sent to women who did not reply. Women were recruited in sufficient numbers aiming to achieve a 90% power and the ability to detect a 0.05 g/cm^2 (which increased to a 0.07 g/cm^2 while taking into account the drop-outs) difference in bone mineral density (BMD) values between exercise and control groups at the 5% level of significance. Subjects signed an informed written consent.

Anthropometric measurements

Measurement of height and weight was conducted with participants in light clothing and without shoes by trained technician following international guidelines [27]. Each anthropometric measurement was done by a similar instrument, and with the same technique. Quality control for all measurements was monitored regularly.

The standing height (to the nearest 0.1 cm) and the weight (to the nearest 0.1 kg) were measured using a wall-mounted stadiometer (Seca) and a mobile digital scale (Seca, Hamburg, Germany), respectively. The BMI was calculated as the body weight divided by the height squared (kg/m^2) [27].

Bone mineral density

Patients underwent both an L1–L4 anteroposterior lumbar spine and femoral subregions (trochanter and neck) DXA study with a Lunar DPXMD densitometer (Lunar 7164, GE, Madison, WI) by a trained operator out in accordance with the manufacturer's recommendations. Instrument validation was determined regularly by a weekly calibration procedure using a phantom supplied by the manufacturer. Precision error for BMD measurements was 1-1.5% in the lumbar and 2-3% in the femoral regions.

Statistical analysis

All statistical analyses were performed with SPSS 13.0 for Windows (SPSS, Chicago, IL), and P values lower than 0.05 were considered statistically significant. Descriptive data are presented as mean ± standard deviation. The differences between the demographic and BMD values of the two case and the control groups were determined using one-way analysis of variance (ANOVA) and post-hoc comparisons.

Results

Some 59 mature premenopausal women of average height, weight, body composition and bone health were enrolled in the exercise groups; 31 (52.5%) of them were involved in weight bearing exercises whereas the other 28 (47.5%) did non-weight bearing workouts. The demographic data of these two groups are outlined in Table 1. Except for age, there was no significant difference between the demographic data of the individuals involved in weight bearing and non-weight bearing exercises. While comparing the data between the controls and the athletes, there was a significant difference between the mean height, weight, and BMI values of these groups (Table 1). Subgroup analysis of the data revealed no significant differences between the mean height, BMI and menarche age in women involved in different sports. The mean age, however, was significantly higher in golf players (golf players: 27.36 ± 3.89, swimmers: 27.0 ± 6.87, rowers: 21.93 ± 2.31, and footballers: 24.86 ± 2.71, p-value: 0.05). A similar result was reported for the differences noted between the weight of the studied groups (swimmers: 62.1 ± 9.33, rowers: 60.06 ± 9.33, golf players: 55.07 ± 7.10, and footballers: 54.36 ± 6.78, p-value: 0.020).

The BMD values of the studied groups at different sites are outlined in Table 2. There was no significant difference between the BMD values of the controls and those involved in either weight bearing or non-weight bearing exercises. Between groups, there was a significant difference in the values reported at different sites (Table 3). Mean BMD values at all the studied sites were highest among the footballers and lowest among the golf players. Except for the spine, post Hoc analysis revealed a significant difference between the BMD values at all the studied sites. As for spine, a significant difference was only seen in the BMD values of the footballers and that of golf players.

Discussion

Several lines of evidence, both cross-sectional and interventional, have pointed out the beneficial effects of regular exercising on BMD values in women [28,29]. Animal studies have considered loading exercises that are high in magnitude, rapidly applied, dynamic and novel as greater osteogenic stimuli, adding that the duration of the workout is less important once a certain threshold level has been reached [13,30,31]. Furthermore, it has been suggested that the distribution of strain may be more important than its magnitude, as unusual patterns of strain can stimulate an osteogenic response at a lower minimum effective strain (MES) [31-33]. Mechanical loading, therefore, is more osteogenic when short rest intervals are inserted between cycles in order to avoid the saturation of the bone's adaptive response to mechanical load [34,35].

In line with previous studies, our study demonstrated that bone responds to site-specific exercise [24,36]. In this regard, many studies have studied the influence of resistance or high-impact exercises on increas-

Table 1: The demographic data of the individuals of the three studied group.

	Weight Bearing exercise (n=28)	Non-weight Bearing exercise (n=31)	Control (n=236)	P-value*
Age (yrs)	26.11 ± 3.53	24.55 ± 5.72	24.61 ± 3.18	0.036
Height (cm)	161.46 ± 6.50	164.58 ± 6.44	160.51 ±5.79	0.002
Weight (kg)	54.71 ± 6.82	61.35 ± 8.56	62.05 ± 12.08	0.006
BMI (kg/m2)	20.96 ± 1.96	22.65 ± 2.94	24.06 ± 4.40	< 0.001
Menarch (yrs)	13.43 ± 1.69	13.52 ± 1.55	13.66 ± 1.49	0.685

* Analysis of Variances (ANOVA)

Table 2: BMD values of the individuals of the three studied group.

	Weight Bearing exercise (n=28)	Non-weight Bearing exercise (n=31)	Control (n=236)	P-value*
Femoral Neck	0.99 ± 0.14	0.97 ± 0.13	0.96 ± 0.13	0.447
Femoral Trochanter	0.81 ± 0.14	0.77 ± 0.10	0.78 ± 0.12	0.324
Total Hip	1.00 ± 0.14	0.97 ± 0.12	0.98 ± 0.14	0.624
Spine L1-4	1.19 ± 0.15	1.16 ± 0.13	1.17 ± 0.13	0.703

*Analysis of Variances (ANOVA)

Table 3: BMD values at different sites based on the exercises in which the athletes were involved.

BMD	Swimming (n=16)	Rowing (n=15)	Golf players (n=14)	Footballer (n=14)	P-value*
Femoral Neck	0.93 ± 0.13	1.01 ± 0.13	0.91 ± 0.12¥	1.06 ± 0.13¥	0.008
Femoral Trochanter	0.75 ± 0.71¥	0.80 ± 0.12	0.73 ± 0.13§	0.89 ± 0.09¥§	0.001
Total Hip	0.94 ± 0.09¥	1.00 ± 0.13	0.93 ± 0.14§	1.07 ± 0.10¥§	0.006
Spine L1-4	1.16 ± 0.13	1.16 ± 0.12	1.11 ± 0.11¥	1.26 ± 0.15¥	0.035

* Analysis of Variances (ANOVA)

¥, §: significant at p-values<0.05, Tukey Post Hoc Test

ing or maintaining BMD values in different population [19,25,29,37]. Similarly, differences in BMD values have been shown in athletes participating in different sports [20,38,39]. These studies had also revealed increased BMD of both the hip and spine in women who added upper body resistance exercise to a routine of lower body resistance plus jump training, stressing that lower body training only influences BMD values at the hip, not the spine [21,24,37,40].

Certain studies have linked being involved in resistance exercises with a significant increase in BMD values at the lumbar spine; others, however, have maintained that high-impact exercises are associated with increased BMD values at the femoral neck and lumbar spine in premenopausal women when performed daily [13,29,41]. While high-impact sports are associated with a greater BMD, there is no difference between bone properties of swimmers, who do not experience any loading, compared to the sedentary controls [20,31]. Some studies have also shown the lower prevalence of osteopenia and osteoporosis among those involved in brisk walking compared to those involved in Taijiquan and swimming [5,42]. Aerobic or weight-bearing activities are associated with significant effects at lumbar spine and femoral neck in postmenopausal women [8,14,16,43]. Many have shown higher BMD values at the hip and spine of gymnasts compared to that of long distance runners, stressing on the beneficial effect of impact forces generated in gymnastics movements [35,44,45].

The present study similarly showed higher BMD values in individuals involved in football and rowing, stressing the effect of weight bearing exercises on BMD values at different sites. Such a difference can be explained by the fact that exercises producing ground reaction forces, such as running or walking, are more effective in increasing BMD values whereas exercises associated with joint reaction forces, such as resistance training, best improve lean body mass and strength in postmenopausal women [4,23,46]. In other words, the present study showed individuals involved in golf, which is a pure weight bearing exercise, to have the least BMD values at the studied sites. Footballers, on the other hand, had the highest BMD values; apart from the fact that ground reaction forces attenuate the influence of the weight bearing exercise on BMD values, footballers should perform body building and other fitness programs at the same time, all of which improve their BMD values.

The present study was not a randomized controlled trial, bringing out the suspicious that baseline differences between individuals involved in diverse sports may cause selection bias. In other words, studies on the effects of exercise on bone may be subject to confounding factors including differences noted between the endocrine status, calcium or other dietary intakes, genotype and even other lifestyle habits, including the fact that whether the subject has participated in the exercise program recently or since childhood, of the participants.

The similar trend in BMD values at the studied sites in the athletes and the control group of the present study failed to show the impact of exercising on BMD values. Considering the results of other studies conducted in this field, all of which revealed the influence of exercising on reducing the fracture risk, it is possible to say that exercise affects the quality of the bone more than in its BMD, indicating that BMD is not an accurate indicator in evaluating the effect of exercise on bones.

Moreover, the present study failed to compare the effect of exercising on the BMD values of the dominant and non-dominant side nor the upper and lower body, while previous studies had noted a significant difference in the effectiveness of training on BMD values of these sides [47,48]. It should also be mentioned that recent studies have failed to approve BMD as the most appropriate study endpoint in assessing the effects of exercise on bone strength and fracture risk.

Considering the concept of strain distribution, it could be concluded that sports such as football, squash, volleyball, gymnastics and rowing, which stress bone in a variety of directions, are associated with a higher BMD than sports consisting of only one direction of movement such as running and swimming [31,38]. As a result, individuals should be recommended to perform exercises that provide adequate skeletal loading so that they would benefit the most from their time and effort dedicated to physical activity.

References

1. Moayyeri A, Soltani A, Khaleghnejad Tabari N, Sadatsafavi M, Hossein-neghad A, et al. (2005) Discordance in diagnosis of osteoporosis using spine and hip bone densitometry. BMC Endocrine Disorders 5: 3.

2. (1993) Consensus development conference: Diagnosis, prophylaxis and treatment of osteoporosis. Am J Med 94: 646-650.

3. Baheiraei A, Ritchie J, Eisman J, Nguyen T (2006) Exploring factors influencing osteoporosis prevention and control: A qualitative study of Iranian men and women in Australia. Maturitas 54:127-134.

4. Martyn-St James M, Carroll S (2010) Effects of different impact exercise modalities on bone mineral density in premenopausal women: a meta-analysis. J Bone Miner Metab 28: 251-267.

5. Ebrahim S, Thompson P, Baskaran V, Evans K (1997) Randomized placebo-controlled trial of brisk walking in the prevention of postmenopausal osteoporosis. Age Ageing 26: 253-260.

6. van Staa T, Dennison E, Leufkens H, Cooper C (2001) Epidemiology of fractures in England and Wales. Bone 29: 517-522.

7. Moayyeri A, Soltani A, Larijani B, Naghavi M, Alaeddini F, et al. (2006) Epidemiology of hip fracture in Iran: results from the Iranian Multicenter Study on Accidental Injuries. Osteoporos Int 17: 1252-1257.

8. Kohrt W, Bloomfield S, Little K, Nelson M, Yingling V (2004) Physical activity and bone health. Med Sci Sports Exerc 36: 1985-1996.

9. Borer K (2005) Physical activity in the prevention and amelioration of osteoporosis in women: interaction of mechanical, hormonal and dietary factors. Sports Med 35: 779-830.

10. Kohrt W, Bloomfield S, Little K, Nelson M, Yingling V (2004) American College of Sports Medicine position stand onphysical activity and bone health. Med Sci Sports Exerc 36: 1985-1996.

11. Hurvitz M, Weiss R (2009) The young female athlete. Pediatr Endocrinol Rev 7: 123-129.

12. Walker M, Klentrou P, Chow R, Plyley M (2000) Longitudinal evaluation of supervised versus unsupervised exercise programs for the treatment of osteoporosis. Eur J Appl Physiol 83: 349-355.

13. Bailey C, Brooke-Wavell K (2010) Optimum frequency of exercise for bone health: Randomised controlled trial of a high-impact unilateral intervention. Bone 46: 1043-1049.

14. Martyn-St James M, Carroll S (2008) Meta-analysis of walking for preservation of bone mineral density in postmenopausal women. Bone 43: 521-531.

15. Iwamoto J, Takeda T, Ichimura S (2001) Effect of exercise training and detraining on bone mineral density in postmenopausal women with osteoporosis. J Orthop Sci 6: 128-132.

16. Martyn-St James M, Carroll S (2009) A meta-analysis of impact exercise on postmenopausal bone loss: the case for mixed loading exercise programmes. Br J Sports Med 43: 898-908.

17. Asikainen TM, Kukkonen-Harjula K, Miilunpalo S (2004) Exercise for health for early postmenopausal women. Sports Med 34: 753-758.

18. Ala M, Aghaei Meybodi HR, Peymani M, Larijani B (2010) Osteoporosis and exercise in postmenopausal women. Iranian Journal of Endocrinology and Metabolism 11: 209-217.

19. Lohman T, Going S, Pamenter R, Hall M, Boyden T, et al. (1995) Effects of resistance training on regional and total bone mineral density in premenopausal women. J Bone Miner Res 10: 1015-1024.

20. Nikander R, Sievanen H, Heinonen A, Kannus P (2005) Femoral neck structure in adult female athletes subjected to different loading modalities. J Bone Miner Res 20: 520-528.

21. Kato T, Terashima T, Yamashita T, Hatanaka Y, Honda A, et al. (2006) Effect of low repetition jump training on bone mineral density in young women. J Appl Physiol 100: 839-843.

22. Bassey E, Ramsdale S (1994) Increase in femoral bone density in young women following high-impact exercise. Osteoporos Int 4: 72-75.

23. Bassey E, Rothwell M, Littlewood J, Pye D (1998) Pre and postmenopausal women have different bone mineral density responses to the same high-impact exercise. J Bone Miner Res 13: 1805-1813.

24. Winters-Stone KM, Snow CM (2006) Site-specific response of bone to exercise in premenopausal women. Bone 39: 1203-1209.

25. Beck B, Snow C (2003) Bone health across the lifespan - exercising our options. Exerc Sport Sci Rev 31: 117-122.

26. Aghaei Meybodi H, Heshmat R, Maasoumi Z, Soltani A, Hossein-Nezhad A, et al. (2008) Iranian

Osteoporosis Research Network: Background, Mission and Its Role in Osteoporosis Management. Iranian J Publ Health 37: 1-6.

27. Lohman T, Roche A, Martorell R (1988) Anthropometrical standardization reference manual. Champaign: Human Kinetics Books.
28. Layne JE, Nelson ME (1999) The effects of progressive resistance training on bone density: a review. Med Sci Sports Exerc 31: 25-30.
29. Martyn-St James M, Carroll S (2006) High-intensity resistance training and postmenopausal bone loss: a meta-analysis. Osteoporos Int 17: 1225-1240.
30. Srinivasan S, Weimer D, Agans S, Bain S, Gross T (2006) Low-magnitude mechanical loading becomes osteogenic when rest is inserted between each load cycle. J Bone Miner Res 17: 1613-1620.
31. Bailey C, Brooke-Wavell K (2008) Exercise for optimising peak bone mass in women. Proc Nutr Soc 67: 9-18.
32. Turner C, Robling A (2005) Mechanisms by which exercise improves bone strength. J Bone Miner Metab 23: 16-22.
33. McClanahan B, Harmon-Clayton K, Ward K, Klesges R, Vukadinovich C, et al. (2002) Side-to-side comparisons of bone mineral density in upper and lower limbs of collegiate athletes. J Strength Cond Res 16: 586-590.
34. LaMothe JM, Zernicke RF (2004) Rest insertion combined with high-frequency loading enhances osteogenesis. J Appl Physiol 96: 1788-1793.
35. Snow CM (1996) Exercise and bone mass in young and premenopausal women. Bone 18: S51-S55.
36. McBride J, Blaak J, Triplett-McBride T (2003) Effect of resistance exercise volume and complexity on EMG, strength, and regional body composition. Eur J Appl Physiol 90: 626-632.
37. Wallace B, Cumming R (2000) Systematic review of randomized trials of the effect of exercise on bone mass in pre- and postmenopausal women. Calcif Tissue Int 67: 10-18.
38. Heinonen A, Kannus P, Sievanen H, Haapasalo H, Manttari A, et al. (1995) Bone mineral density in female athletes representing sports with different loading characteristics of the skeleton. Bone 17: 197-203.
39. Pettersson U, Nordstrom P, Alfredson H, Henriksson-Larsen K, Lorentzon R (2000) Effect of high impact activity on bone mass and size in adolescent females: a comparative study between two different types of sports. Calcif Tissue Int 67: 207-214.
40. Vainionpaa A, Korpelainen R, Leppaluoto J, Jamsa T (2005) Effects of high-impact exercise on bone mineral density: a randomized controlled trial in premenopausal women. Osteoporos Int 16: 191-197.
41. Nelson M, Fiatarone M, Morganti C, Trice I, Greenberg R, et al. (1994) Effects of high-intensity strength training on multiple risk factors for osteoporotic fractures. A randomized controlled trial. JAMA 272: 1909-1914.
42. Wang C, Yang Z, Chen Y (2009) Effects of different exercises on the bone metabolism level of middle-aged and old women. Sheng Wu Yi Xue Gong Cheng Xue Za Zhi 26: 1306-1310.
43. Bonaiuti D, Shea B, Iovine R, Negrini S, Robinson V, et al. (2002) Exercise for preventing and treating osteoporosis in postmenopausal women (Cochrane Review). Cochrane Database Syst Rev CD000333.
44. Robinson T, Snow-Harter C, Taaffe D, Gillis D, Shaw J, et al. (1995) Gymnasts exhibit higher bone mass than runners despite similar prevalence of amenorrhea and oligomenorrhea. J Bone Miner Res 10: 26-35.

45. Duncan C, Blimkie C, Cowell C, Burke S, Briody J, et al. (2002) Bone mineral density in adolescent female athletes: relationship to exercise type and muscle strength. Med Sci Sports Exerc 34: 286-294.

46. Kohrt W, Ehsani A, Birge S (1997) Effects of exercise involving predominantly either joint-reaction or ground reaction forces on bone mineral density in older women. J Bone Miner Res 12: 1253-1261.

47. Kraemer W, Keuning M, Ratamess N, Volek J, McCormick M, et al. (2001) Resistance training combined with bench-step aerobics enhances women's health profile. Med Sci Sports Exerc 33: 259-269.

48. Chilibeck P, Davison K, Sale D, Webber C, Faulkner R (2000) Effect of physical activity on bone mineral density assessed by limb dominance across the lifespan. Am J Hum Biol 12: 633-637.