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Effect of Physical Activities on Bone Mineral Density and Incidence of Fractures in Post-Menopausal Women

A Comparison of Presence and Absence of Other Concomitant Risk Factors

Background: Post-menopausal osteoporosis is one of the most important health problems. This condition frequently leads to bone fractures.

Objectives: To determine the effect of physical activities on bone mineral density (BMD) in post-menopausal women, regardless of any concomitant predisposing risk factors for osteoporosis.

Patients and Methods: BMDs of 174 consecutive post-menopausal women with a mean age of 59.7 years and a mean post-menopausal duration of 10.3 years were measured by dual energy X-ray absorptiometry (DEXA) technique. According to the reported T scores, risks of femur and lumbar vertebrae fractures were estimated. The correlation between physical activities, as well as other osteoporosis risk factors and the above-mentioned measured quantities was assessed.

Results: 68% of the individuals with no physical activities and 25% of those who had regular physical activities were in the osteoporotic range. The femoral fracture risk was significantly higher for those with no physical activities (50%) than those physically active subjects (19%). Moreover, risk of developing vertebral fracture was higher in the former group (74% *vs.* 35%). BMDs were significantly different between the two groups in general; ($p<0.001$) as well as between their subgroups without ($n=129$, $p<0.001$) and with ($n=45$, $p<0.01$) other risk factors for osteoporosis).

Conclusion: Physical activity has positive effects on BMD of post-menopausal women, resulting in their reduced likelihood of osteoporotic fractures, irrespective of presence or absence of other osteoporosis risk factors.

Keywords: Bone Mineral Densitometry, Post-menopause, Physical activities, Osteoporosis , Dual Energy X-ray Absorptiometry.

Introduction

Decreased bone mass is considered a common age-dependent process. However, when the process advances so that it results in a markedly increased risk of fracture, it is regarded as a disease.[1,2] Osteoporosis is the most common osseous metabolic disorder all over the world. The most dramatic problem with osteoporosis is the resultant fractures most commonly involving distal radius, neck of femur and vertebrae.

In osteoporosis, the matrix/mineral ratio is steadily preserved, nevertheless, bone mass is reduced generally.

In the past five decades, due to improved health care standards, life expectancy has generally increased, leading to a higher likelihood of osteoporotic fractures as well. These fractures are important health problems, both because of their higher mortality rate and their extremely costly management. Around 20% of the elderly with fractures of neck of femur die within the six months post-incident.

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The life-long likelihood of femoral neck fracture in Caucasian women is estimated to be 16.5% as compared with the lower probability of breast cancer (11%) studied in the same population.

Based on an estimation made by the Rheumatologic Research Center of Iran, approximately 2.5 million out of 5 million Iranian post-menopausal women (50%) are obviously at risk of osteoporosis and its major consequent fractures. According to the same report, osteoporosis-associated costs were about US$ 13 million and its mortality rate was estimated to be at least 5000 patients annually in Iran.[3]

Bone Mineral Density (BMD) is a feasible quantitative parameter measured by certain imaging modalities.

Dual energy X-ray absorptiometry (DEXA) is accepted as the standard and is the most widely used modality in bone mineral content and density measurements.[4] Patient's absorbed radiation dose in DEXA is extremely low, somewhat equal to the environmental daily background radiation absorption as estimated to be 0.0005 to 0.0090 milli-Sieverts (mSv), and about 1/2000 of a conventional standard chest X-ray. Although DEXA is better not to be done for pregnant women, if there is inadvertent exposure during pregnancy, there is no need to induce abortion.[5] Once the diagnosis of osteoporosis was made and after beginning of its treatment, central DEXA (of vertebrae and femoral neck) should be performed annually or biannually.[6]

In this technique, a Z score (BMD of the subject relative to that of the same age and gender normal population) and a T score (BMD of the subject relative to the highest BMD of the young people of the same gender) are reported.[7]

According to the World Health Organization (WHO) definitions, if the measured T score is within -1 and +2.5 SD of the normal quantities, BMD is regarded as normal. If the T score is between -1 and -2.5 SD of the normal, the BMD is considered to be osteopenic, and whenever T score measures less than -2.5 SD, it is referred to as osteoporotic.[6]

According to the Canadian Medical Association, bone mineral densitometry is recommended in all men and women aged 65 or higher.[8]

Primary osteoporosis caused by low estrogen level comprises 95% of all the cases. Secondary osteoporosis can be due to a variety of causes, including long-term use of glucocorticoids or heparin, renal failure, hyperthyroidism, primary hyperparathyroidism, hyper-function of adrenal gland, consumption of diets low in calcium,[9] upper intestinal surgical resection, etc.

The major risk factors for developing osteoporosis are as follows:

1- Small physical habitus and low body weight,

2- Familial history of osteoporosis,

3-Premature menopause or bilateral oophorectomy,[10]

4- Cigarette smoking,

5- Alcohol consumption, and

6- History of taking medications which result in osteoporosis, or suffering from diseases predisposing patients to osteoporosis.

Generally, women have less bone mass than men at the same age group. However, regardless of gender, the maximal osseous mass is present at approximately 30 years of age.[11]

Long-standing inactivity or a low activity level results in a diminished bone mass. Moreover, it was shown that regular physical activities can improve the neuro-muscular function, reducing the likelihood of osteoporosis and preventing falls among the elderly people.[1,11-14] It is believed that the higher incidence of osteoporotic fractures in the urban inhabitants as compared with those of the rural areas has been attributed to their relatively inactive lifestyle.[15,16]

Generally, athletes have more bone mineral contents than non-athletes.[17,18] Nonetheless, it seems that exercise cannot augment BMD in post-menopausal women, rather it reduces mineral loss during this period.[19]

Doing moderate-impact endurance exercises after the fourth decade of life has been shown to attenuate the loss of height through aging, in both men and women.[20] There are many studies implying site-specific adaptation of the certain locations of the skeleton, leading to their more pronounced BMD enhancement, relevant to the type of exercise.[1,7,11,13,17,21-29]

Although there are many preliminary reports on the relationship between BMD in post-menopausal women and physical activities, to the best of our knowledge, none has directly compared the groups who possess or lack other osteoporotic risk factors. In the current study we intended to assess the relationship between physical activities and BMD in post-menopausal women, when certain other osteoporosis risk factors are present or absent.

Patients and Methods

During a 6-month period from April 2003 to September 2003, 174 consecutive post-menopausal women, aged 43 to 75 (mean: 59.7) years who were referred to Dr. Tabarrok Bone Mineral Densitometry Center were enrolled into this study. The exclusion criteria included institution of any medical treatments for osteoporosis less than 3 years, or more than 20 years gap between menopause and bone densitometry, and body weight more than 50% of the optimal value for age and height.

All of the subjects filled out a self-administered questionnaire before the densitometry and their height and weight were measured using a tape measure and a pre-calibrated scale (Sohnle Co, Germany).

Bone mineral densitometry of the first to fourth lumbar vertebrae (L_1-L_4) and the femoral neck was performed, using DEXA technique (DPX-MD, Lunar Radiation, Madison, WI, USA).

We defined "physical activities" as any regular exercises of at least one hour duration per week over the last 10 years.

Risk factors for osteoporosis consisted of those mentioned earlier in the introduction.

Based on the information gathered from the questionnaires, the subjects were divided into four groups: Those who performed physical activities and had other osteoporosis risk factors (n=22), those who did not perform any physical activities but had osteoporosis risk factors (n=23), those who performed physical activities but did not have any risk factors (n=61), and those who neither performed physical activities nor had any risk factors (n=68) .

Data analyses were performed using SPSS® for Windows™, ver. 11.0 software. Chi-square test was used and the level of significance was set at $p<0.05$.

Results

The mean±SD age of participants was 59.7±7.2 years. The mean±SD post-menopausal duration was 10.3±5.8 years.

The mean and SD bone density (g/cm³) values of lumbar vertebrae and femoral neck, with their corresponding T scores are summarized in Table 1.

Table 1 : Measured variables in total study population (n=174)

Measured Variable	Mean	Standard Deviation	Range
Age (Years)	59.7	7.2	43 – 75
Postmenopausal Duration (Years)	10.3	5.8	3 – 20
Femoral Bone Mineral Density (g/cm³)	0.895	0.143	0.509 – 1.138
Vertebral Bone Mineral Density (g/cm³)	1.038	0.202	0.529 - 1.594
Femoral T Score	-0.865	1.3	-8 – +2
Vertebral T Score	-1.254	1.7	-5.6 – +3.3

Sixty-one (68%) of 91 subjects lacking physical activities and 21 (25%) of 83 who performed physical activities, were in the osteoporotic range (Table 2). The estimated femoral fracture risk in the former subjects revealed that 46 (50%) subjects had minimal to severe risks (Table 3), as compared with the significantly lower risk (19%) in the latter group. Also it was shown that the probability of femoral fracture in the high risk people of the former group was 7-fold the probability in the high risk women who performed some kinds of physical activities (7% *vs.* 1%).

The measured likelihood of vertebral fracture in 91 subjects who lacked any regular physical activities, as well as that of those 83 individuals who performed some physical activities, revealed a 26% risk-free ratio in the former group *vs.* a 65% risk-free ratio in the latter. Grading of the vertebral fracture risk in the remainder of these two groups is compared in Table 3.

Tables 4 and 5 summarize the relationship between the history of physical activities and the risk of femoral and vertebral fracture, in the groups with and without osteoporosis risk factors, respectively. The difference between BMDs of two groups was statistically significant ($p<0.05$), irrespective of the presence or absence of other osteoporosis risk factors.

The overall estimated p value for the relationship between BMD and physical activities in the post-menopausal women was <0.001. The p values were <0.001 and <0.01, respectively, when the women did not have and when they had risk factors for osteoporosis.

Table 2: Bone mineral density status in 174 individuals according to their history of physical activities

BMD Status	No. of Subjects (%)		
	With Physical activities	Without Physical activities	Total
Normal	62 (75)	30 (32)	92 (53)
Osteoporotic	21 (25)	61 (68)	82 (47)
Total	83 (100)	91 (100)	174 (100)

Table 3: Risk of femoral and vertebral fracture in 174 individuals, according to their history of physical activities

	No. of Individuals (%) with Risk of Femoral Fracture			No. of Individuals (%) with Risk of Vertebral Fracture		
	With Physical activities	Without Physical activities	Total	With Physical activities	Without Physical activities	Total
No Risk	67(81)	45(50)	112(65)	54(65)	24(26)	78(45)
Low Risk	11(13)	26(28)	37(21)	14(17)	24(26)	38(22)
Medium Risk	4(5)	14(15)	18(10)	9(11)	32(35)	41(23)
High Risk	1(1)	6(7)	7(4)	6(7)	11(13)	17(10)
Total	83(100)	91(100)	174(100)	83(100)	91(100)	174(100)

Table 4: Risk of femoral and vertebral fracture in 129 subjects with no osteoporosis risk factors, according to their history of physical activities

	No. of Individuals (%) with Risk of Femoral Fracture			No. of Individuals (%) with Risk of Vertebral Fracture		
	With Physical activities	Without Physical activities	Total	With Physical activities	Without Physical activities	Total
No Risk	50(82)	34(50)	84(65)	41(67)	18(26)	59(46)
Low Risk	8(13)	19(28)	27(21)	9(15)	18(26)	27(21)
Medium Risk	3(5)	11(16)	14(11)	6(10)	26(39)	32(25)
High Risk	0(0)	4(6)	4(3)	5(8)	6(9)	11(9)
Total	61(100)	68(100)	129(100)	61(100)	68(100)	129(100)

Table 5: Risk of femoral and vertebral fracture in 45 individuals with osteoporosis risk factors, according to their history of physical activities

	No. of Individuals (%) with Risk of Femoral Fracture			No. of Individuals (%) with Risk of Vertebral Fracture		
	With Physical activities	Without Physical activities	Total	With Physical activities	Without Physical activities	Total
No Risk	17 (77)	11(48)	28(62)	13(58)	6(26)	19(42)
Low Risk	3 (13)	7 (30)	10(22)	5(23)	6(26)	11(24)
Medium Risk	1 (5)	3 (13)	4(9)	3(14)	6(26)	9(20)
High Risk	1 (5)	2 (9)	3(7)	1(5)	1(5)	6(13)
Total	22 (100)	23 (100)	45(100)	22(100)	23(100)	45(100)

Discussion

Our study indicated a significant correlation between the history of physical activities and BMD in the post-menopausal women, regardless of the presence or absence of other risk factors for development of osteoporosis.

This finding is in parallel with some previous preliminary studies.[13,18,22,26,27,29,30] These investigations are difficult to compare, however, because of their considerable variation in type and duration of the exercise and also the age, gender and general health status of the studied individuals. Nevertheless, a all of the studies showed a positive correlation between exercise and BMD.

Most of these studies disclosed the influence of the loaded weight on mineralization of certain weight-bearing structures, and that it highly depends on the type of physical activities performed. Suominen showed that the highest BMD was observed in strength and power-trained athletes, meanwhile, endurance exercises, such as running or swimming had lesser impact on maximal BMD.[18]

In our study, physical activities included any regular long-lasting physical activities, and therefore the specific effect on BMD of a given exercise could not be evaluated specifically. This may be considered as a limitation of our study.

Sinaki *et al*, in their study evaluated the relationship between physical activities, strength of back extensor muscles and vertebral BMD on 68 healthy post-menopausal women and found a positive correlation between these factors.[27] Shangold reported that resistance training could increase both the muscular strength and BMD.[26]

However, our study results are in contrast with some other reports.[1,19,21,23] Rundgren *et al*, assessed 15 post-menopausal women with a mean age of 72 years who exercised an hour twice a week, for six months. There was no increase in the calcaneal BMD in this group, but the mean bone mineral content was significantly higher than the control age-matched group. Therefore, they concluded that physical activities did not increase the skeletal mineral content, but rather significantly reduced the bone loss rate.[19]

In a study, Heinonen *et al*, studied 98 women who were randomly assigned to a training group doing weight-bearing exercises for 18 months and a control group. Measurements using DEXA technique demonstrated a considerably increased BMD in the weight-bearing bones (like the femur) than the non-weight-bearing bones (such as the radius).[1]

In another study, Cohen *et al*, compared 17 rowers participating in training programs for seven months with 8 age-matched subjects (control) and showed that the DEXA measured lumbar spine and femoral BMD quantities were not statistically different.[21]

Puntila and coworkers examined 2025 women aged 48-58 years, of whom 881 had taken part in recreational and competitive physical activities during their adolescence. DEXA technique revealed a significantly higher BMD of lumbar vertebrae in the active group. Their femoral BMDs, nonetheless, were not significantly different.[24]

Similarly, Neville and colleagues[23] studied the influence of peak strain sport activities on BMDs of 242 men and 212 women, using DEXA. They concluded that the high peak strain activities had positive impacts on lumbar spine BMD in men but not in women. Lack of such significant effect in women, perhaps was due to their lower rate of participation in such activities.[31] Yet, it must be noted that their study was performed on a younger age group than ours.

Our study had some limitations. First of all, the sports in our study are not type-specified and thus could not be appropriately compared with each other or with other studies of this kind.

The second is that our research was confined to measurements of BMD in lumbar spine and femoral neck regions, which is certainly not indicate BMD in other sites nor indicates alterations in the total body BMD. The third limitation is our inability to reliably obtain, and hence compare, the information regarding the age of beginning the physical activities and the statement of their physical activities during adolescence and middle-age.

In conclusion, the effects of these limiting factors on post-menopausal women's BMD have yet to be determined in future studies.

Acknowledgment

We sincerely appreciate the assistance of Ms. Saemian, Ms. Falahat and Ms. Azad in this investigation.

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