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*Original Article*

# Relationship between Body Composition and Osteoporosis among Postmenopausal Women

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**Keywords**
Osteoporosis; Bone density; Body composition; Women

**Abstract**

**Background:** Osteoporosis is a skeletal system disease characterized by decrease in bone mass density. The main outcome of this disease is the increased risk of fracture of the bones in areas tolerating the body weight, including the vertebrae, femurs, and even joints, such as the wrists, that do not tolerate weight. The present study was conducted with the objective to describe the relationship between body composition and osteoporosis among postmenopausal women.

**Methods:** This cross-sectional study was carried out on 50 postmenopausal women with osteoporosis in the age range of 45-65 years referred to Sina Hospital in Tabriz, Iran. Body mass, fat body mass, lean body mass, and bone density of the spine and femurs were measured. The skin fold thickness (SKF) was assessed using a caliper. Bone density was measured using the Dual Energy X-ray Absorptiometry (DEXA) method in the spinal column and femoral head areas. A multiple regression model was exploited to investigate the relationship between the components of body composition and the spinal bone density of the vertebrae and femurs.

**Results:** Among the components of body composition, a significant relationship was only observed between lean body mass and femoral neck bone density ($P < 0.050$, $R^2 = 0.271$) and spine bone density ($P < 0.050$ and $P = 0.088$).

**Conclusion:** The findings of this study suggested that lean body mass was one of the most powerful predictors of osteoporosis. Hence, women at risk of osteoporosis can be identified using this model and earlier preventative and therapeutic measures can be taken. Moreover, additional diagnostic costs for those who are not at risk can be prevented.

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## Introduction

Osteoporosis is the most common metabolic bone disease and a major cause of fractures causing increased mortality, disability, and medical costs.

The incidence rate of osteoporosis among Iranian women is 32.4% and 5.9% in the

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lumbar spine and femur, respectively.[1] This complication is more common among menopausal women compared to men. The disease often has no symptoms and becomes symptomatic in cases in which bone fracture occurs; especially in the vertebral column and pelvic regions.[2] Bone mass loss is one of the most important complications of menopause. It is often due to loss of ovarian hormones, especially estrogen, lack of mobility, belonging to a certain race (Asian), inadequate calcium, phosphorus, and vitamin D in the diet, smoking and high consumption of coffee, long-term use of corticosteroids and diuretics, some hormonal disorders, such as hyperthyroidism and parathyroidism, and sexual gland deficiency.[3,4] Ageing, body composition, metabolic factors, and postmenopausal hormonal levels; along with reduced physical activity, may provide conditions for weight gain, especially fat mass.[5] Numerous scientific studies have shown that both factors of obesity and thinness are important risk factors for osteoporosis. Body composition greatly affects bone mineral content (BMC) and bone density through the three mechanisms of mechanical pressure due to body mass index (BMI), muscle strength, and hormonal mechanisms.[6-8] Various studies have investigated the effects of anthropometric parameters like body mass and BMI on BMC and bone density.

Obesity is one of the factors affecting bone mass and is an intrusive factor for bone mineral density (BMD).[9] The total fat mass of the body has a positive correlation with BMD. The studies carried out by Gnudi et al.[10] and Reid et al.[7] emphasized that fat mass in women before menopause was a crucial determinant of bone density of the whole body.[11] They found a significant relationship between BMD and the thickness of the subcutaneous fat among adult women. Although there are opposing theories like the one proposed in the study by Zhao et al.[12] regarding the negative relationship between BMD and fat mass, the risk of osteoporosis was increased by a higher body fat rate in another study.[13] In a study by Weiler et al.,[14] it was shown that body fat had a negative relationship with BMC and bone density among women in the age range of 10-19 years. In the study by Lazcano-Ponce et al.,[15] it was concluded that body fat rate had an inverse relationship with lumbar spine bone density in Mexican women aged 9-24 years.

Epidemiological studies have shown that being overweight and loss of weight are associated with increased and decreased bone density, respectively.[16] Perhaps body weight is the strongest predictor of bone mass, and a positive correlation is reported between body weight and bone mass among women of all ages.[13] A low BMI indicates the risk of osteoporosis, and obesity interferes in bone density.[9]

Some researchers have reported that lean body mass has a positive correlation with BMD.[10] Perhaps muscular mass is predictive of these parameters.[17] In the study by Ellis et al.,[18] a very high correlation was found between muscle mass and BMC among young women. Bedogni et al.,[19] concluded that muscle mass was a strong predictor of bone mass content compared to fat mass. In another study, muscle tissue in the two areas of arms and legs had a significant positive correlation with peripheral bone density.[20]

Recognition of the factors affecting bone mass is essential, as controlling these factors can play a crucial role in preventing and treating osteoporosis. In this study, the relationship between the components of body composition (body weight, total body fat, and total lean body mass) and BMD and its potential effect on the T-scale was investigated among postmenopausal women. The present study was performed with the aim to investigate the possible relationships between body composition parameters and BMD among inactive individuals. Increased awareness of women regarding the relationship between body composition and osteoporosis as well as lifestyle changes can be effective strategies in the prevention and management of the disease.

## Methods

The statistical population of the study consisted of postmenopausal women with osteoporosis referring to the bone density measurement center of Sina Hospital in Tabriz, Iran. After the provision of oral and written explanations to postmenopausal women referring to the hospital, 50 subjects were randomly selected from among the volunteers who had the required conditions for participation in the study. Afterwards, the study process was completely described to the subjects and a written consent was obtained from each of them. After assessing the responses of the volunteers to the researcher-made descriptive-health questionnaires, subjects with the following characteristics were excluded from the study: volunteers who smoked, suffered from hyperthyroidism, parathyroidism, insulin dependent diabetes mellitus (IDDM), digestive system diseases, metabolic and nutritional diseases, and cancer, or those who used anticonvulsant and anticancer drugs.

***The study variables included the following:*** Body mass indicates the amount of material constituting a body and is calculated in kg.

Fat body mass shows the excessive accumulation of fat in the body. Fat body mass is calculated through multiplying the fat percentage by the resulting mass.

Lean body mass is often referred to the pure tissue of the body, including muscles, bone, organs, liquids, and any other tissue lacking fatty tissues and lipids, and is obtained by subtracting the fat mass from the body mass.[21]

Body mineral density (or BMD) is the mass of calcium salts per unit volume.[22] The non-invasive Dual Energy X-ray Absorptiometry (DEXA) method was utilized to measure bone density in femurs and the lumbar spine.

***Study measurement tools:*** 1) Medical information questionnaire and consent form

2) 160 kg digital scale equipped with height-meter with a precision of 0.1 kg (Model DLT-411, Germany) for measuring body weight and height of the subjects

3) Dynamic caliper made in Iran with a precision of 0.5 mm for measuring the skin thickness of the subjects

4) Bone density measurement device (DEXA, Model 4500 HOLOGIC QDR, Belgium)

***Study implementation method:*** Calculation of body fat content: The body fat content was estimated using the Katch-McArdle method and the thickness of the skin behind the arm and under the scapula were measured. Then, the fat body weight was obtained by multiplying the fat percentage by body weight; afterwards, the lean body weight was calculated by subtracting fat weight from total body weight. In addition, BMI was calculated by dividing the weight in kg by the square of height in m.[22]

Bone density: The non-invasive DEXA method was exploited to measure bone density in femurs and the lumbar spinal column. This method is often used to diagnose osteoporosis among postmenopausal women and sometimes among men in addition to determining the risk of bone fractures. Moreover, this method is used to follow the progression of osteoporosis treatment. The DEXA bone density measurement method is simple, fast, non-invasive, and painless. The irradiation rate is very low in this test. This method is easy for both patients and doctors.

***Statistical analysis:*** Descriptive statistics including rate, mean, percentage, standard deviation (SD), graphs, and tables were used to describe the data. The Smirnov-Kolmogorov (K-S) test was used to assess the normal distribution of data. In addition, a multiple regression model was exploited to analyze the data. The significance level of the hypotheses was considered as $\alpha = 0.05$. The SPSS software (version 15.0, SPSS Inc., Chicago, IL, USA) was used for the entry and statistical analysis of the data.

## Results

In the first step, the statistical data have been described. The mean, SD, minimum, and maximum of the data are presented in table 1.

**Table 1.** General and physiological characteristics of the subjects

| Variables | Mean | SD | Minimum | Maximum |
|---|---|---|---|---|
| Age (year) | 58.70 | 5.70 | 46.00 | 65.00 |
| Age at menopause (year) | 46.90 | 5.20 | 35.00 | 56.00 |
| Body mass (kg) | 66.98 | 12.26 | 44.00 | 100.00 |
| Fat body mass (kg) | 15.61 | 4.93 | 6.52 | 30.69 |
| Lean body mass (kg) | 51.40 | 8.06 | 33.70 | 69.30 |
| BMI (kg/m$^2$) | 26.44 | 4.60 | 16.16 | 40.65 |
| Spinal bone density (g/cm$^2$) | 0.73 | 0.07 | 0.54 | 0.87 |
| Femoral bone density (g/cm$^2$) | 0.75 | 0.13 | 0.40 | 1.12 |

SD: Standard deviation; BMI: Body mass index

The data obtained for the spinal bone density variable were categorized into 4 groups; the spinal bone density of 6%, 20%, 46%, and 28% of the participants was 0.54-0.60, 0.61-0.70, 0.71-0.77, and 0.78-0.87 g/cm², respectively (Figure 1).

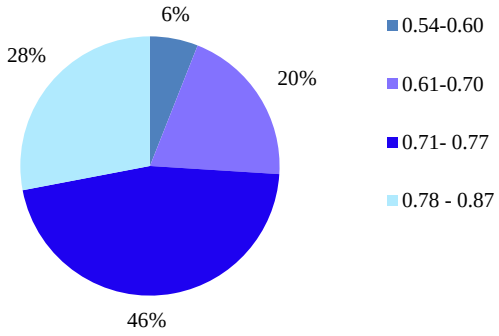


**Figure 1.** Spinal bone density (g/cm$^2$)

In addition, the data obtained for the femoral bone density variable of the participants were categorized into 6 groups; the femoral bone density of 4, 12, 18, 32, 28, and 6 percent of the participants was 0.40-0.50, 0.51-0.60, 0.61-0.70, 0.71-0.80, 0.81-0.90, and 0.91-1.12 g/cm², respectively (Figure 2).

The multiple linear regression test was utilized to investigate the presence of a relationship between subsets of body composition and spinal and femoral bone density. The body composition subsets accounted for 4 variables including body mass, fat body mass, lean body mass, and BMI as a predictor variable. Moreover, spinal bone density, and then, femoral bone density were considered as the index variables. The test results are given in table 2.

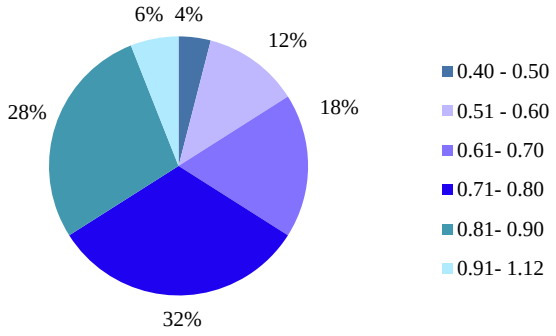


**Figure 2.** Femoral bone density

Based on the regression refinement, the only variable with the conditions of presence in the model is lean body mass. In addition, since the significance level of the one-way analysis of variance (ANOVA) test between the residues and regression also indicates the significance of the model ($P < 0.05$), it can be declared that a significant relationship was only observed between the variable of lean body mass and the spinal bone density variable. The number $R^2 \times 100 = 8.8$ indicated that the model has been fitted for 8.8% of the

**Table 2.** Results of multivariable regression test on the relationship between subsets of body composition and spinal and femoral bone density

| Predictive variable | R | $R^2$ | F | P-value | Variables meeting the conditions of presence in the model based on the results |
|---|---|---|---|---|---|
| Lean body mass (Spine) | 0.297 | 0.088 | 4.64 | 0.036 | Lean body mass |
| Lean body mass (Femur) | 0.521 | 0.271 | 17.89 | 0.001 | Lean body mass |
| Body fat mass | | | | | |
| Body mass | | | | | |

R: Correlation coefficient; $R^2$: Coefficient of determination; F: Standard statistic

variances, in other words, 8.8% of the factors affecting the spinal bone density has been recognized based on this model. The results of fitting the regression coefficients in order to complete the significant regression model derived from lean body mass resulted in an intercept and the lean body mass coefficient of 0.599 and 0.003, respectively. Therefore, the regression equation for estimating spinal bone density was obtained as follows:

Spinal bone density = 0.599 + (0.003 × Lean body mass)

The positive coefficient of the lean body mass in the regression model indicated that there was a positive relationship between the lean body mass variable and the spinal bone density variable, in other words, spinal bone density increased and decreased with increase and decrease in lean body mass, respectively. Moreover, the coefficient of 0.599 was the constant number (intercept) in the fitted linear regression model.

Furthermore, based on the refinement of regression of the femur area, lean body mass was the only variable meeting the conditions of presence in the model ($P < 0.05$). The number $R^2 \times 100 = 27.1$ indicated that 27.1% of the factors affecting femoral bone density were identified using this model. The regression equation for estimating femoral bone density was derived from this equation:

Femoral bone density = 0.298 + (0.009 × Lean body mass).

The number 0.009 was the coefficient of the lean body mass variable in the model and its positive value indicated that there was a positive relationship between the lean body mass variable and the femoral bone density variable, in other words, femoral bone density increased and decreased with increase and decrease in lean body mass, respectively. Moreover, the coefficient of 0.298 was the constant number (intercept) in the fitted linear regression model.

## Discussion

In the present study, the relationship between body composition (body mass, fat body mass, and lean body mass) and bone density was investigated among postmenopausal women with osteoporosis. The findings of this study suggested that lean body mass had a positive correlation with spinal and femoral bone density. However, body mass and fat body mass had no relationship with spinal and femoral bone density.

We found no relationship between body mass and bone density among postmenopausal women with osteoporosis; this result is in contrast to the results of some other studies. Gudmundsdottir et al.[23] declared that women with fixed body mass were less likely to lose their bone density in comparison to those who had experienced weight loss. This difference could be associated with the mass of excess fat in the study subjects, as body mass alone would not increase bone density, unless lean body mass is high. In this study, bone density decreased with increasing age. Rico et al.[17] concluded that bone density depended both on height and body mass. In another study carried out by Lindsay et al.,[24] it was concluded that body mass has a positive correlation with bone density and it is an effective factor in spinal fractures.[12,13]

Kirchengast et al.[25] reported that individuals with low body mass had less bone density; hence, they were more prone to fracture risk.

The results of the present study revealed that there was no relationship between fat body mass and bone density among postmenopausal women with osteoporosis. In other studies, it was declared that women with osteoporosis had a body fat mass independent of bone density.[26]

Kirchengast et al.[25] conducted an investigation among middle-aged women and men and concluded that higher fat tissue, which was associated with bone density loss among women, may be due to decreased conversion of androgens to estrogen.

The studies conducted by Cui et al.,[27] Lekamwasam et al.,[28] Pasco et al.,[29] Leslie et al.,[30] Wu et al.,[31] Yamauchi et al.,[32] Kontogianni et al.,[33] Capozza et al.,[34] and Di

Monaco et al.[35] showed a positive correlation between body fat mass and bone density among women and men. In the present study, body fat mass, not skeletal muscle mass, was an index for bone density among women with pelvic fracture. It can be concluded that soft tissue composition has a significant effect on bone health, while fat mass plays a protective role in bone density among postmenopausal women. Other studies have reported the independent action of body fat mass on bone density through estrogen, leptin, insulin, or amylin.[36,37]

Among women without osteoporosis, body fat mass also affects bone density, indicating that there is a correlation between fat mass and increased bone density.[38] These findings indicate that fat mass plays a significant role in femoral bone density among women before menopause. The estrogen reduction among postmenopausal women was noted as the possible cause of this issue in the study by Sherk et al.;[39] estrogen reduction predicted changes in fat mass of spinal fat density. However, in the studies performed by Hsu et al.,[13] Pasco et al.,[29] and Blum et al.[40], it was noted that fat mass had a negative relationship with bone mass. Rayalam et al.[41] in an investigation on obesity and osteoporosis concluded that there was an inverse relationship between fat cells and osteoblasts in marrow among obese old individuals. In their study, Russell et al.[42] noted that total fat was a negative predictor of bone density among young girls. In addition, peripheral fat was an inverse determining factor of bone density among obese individuals. This relationship may be due to adipokines and a chronic inflammatory condition. In this study, bone density was lower among obese girls with higher peripheral fat. The inverse relationship between peripheral fat and bone density was also indicated in the study by Gilsanz et al.[43]

The results of our study revealed a positive correlation between lean body mass and bone density among postmenopausal women with osteoporosis. Several studies have shown that lean body mass is associated with bone density among women and men.[11,27,39,44,45]

In a study by Kirchengast et al.[25] on middle-aged women and men, it was found that bone density and fracture risk, respectively, decreased and increased among individuals of both sexes with lower weight and muscle mass. Among subjects with predominant lean body mass, this variable had a better relationship with bone density compared to fat mass. Therefore, lean body mass can be a major predictor of BMC among women. In another study, it was concluded that lean body mass has a positive effect on bone density.[46] In the above-mentioned studies, it was concluded that muscles are responsible for applying a mechanical pressure on bones; thus, they perform a positive action on bone mass. Lean body mass may be an independent predictor of bone density among middle-aged men (40 years old) and the main anthropometric component for determining bone density. However, contradictory results have been reported in other studies, especially for older men.[13] In another study, it was noted that there was no relationship between lean body mass and bone density.[47] This difference could be due to the T-score of the community or because of the difference in the algorithm of separation of muscle mass from fat mass among the DEXA devices.

The subjects in the present study included inactive old women with osteoporosis, the genetic, physiological, and hormonal characteristics of whom were uncontrolled factors of early menopause. This was a limitation of the present study.

Lean body mass and fat body mass together make up 95% of total body mass and the remaining 5% is bone mass. Lean body mass has been reported as a predictor of bone mass through its mechanical stretching on the skeleton.[48]

## Conclusion

In the present study, lean body mass suggested to be the dominant factor determining bone density among

postmenopausal women with osteoporosis. Therefore, it is recommended that women spend more time on exercise and maintain a healthy lifestyle to increase lean body mass tissue in their youth and pre-menopausal age.

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## Conflict of Interest

Authors have no conflict of interest.

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