***Original Article***

# Bone Mineral Density and Body Mass Index in Postmenopausal Women

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**Abstract**

*Osteoporosis is a typical medical issue that overwhelmingly influences postmenopausal women. A bone density test is the only test that can diagnose osteoporosis before a broken bone occurs. The aims of this study was to find out the relationship between bone mineral density (BMD) and body mass index (BMI) in postmenopausal females. This cross sectional descriptive study was carried out in the Institute of Nuclear Medicine and Allied Sciences (INMAS), Sylhet. Study subjects comprised of 117 postmenopausal women between ages 45 to 85 years, with a mean age of 60.8 ± 9.2 years, who underwent BMD scan from January 2018 to June 2019. Duration of the study was 5 months ( march 2019 to august 2019). BMD was measured by the Medilink Medix DR system. Findings of BMD of right femur showed osteopenia and osteoporosis (low BMD) in most of the women with under weight (81.0%) about one third (32.3%) of normal body weight and few (16.7%) of them over weight. Contrarily in left femur, low BMD was found in 08 (80.0%), 25 (40.3%) and 6 (16.7%) among underweight, normal, overweight patients respectively. According to BMI compare to the lumbar spine, low BMD was found in 48 (77.4%), 10 (100 %), 20 (55.6%), 03 (33.3%) among normal, underweight, overweight, and obese patients respectively. Relationship among BMD and BMI was found statistically significant in the both femurs (p < 0.001) and lumbar spine (p = 0.02). Low BMD was more severe in the 65-74 years' age group in both femurs 65.4% and 65-85 years' age group in lumbar spine 84.6% compare to other groups. The findings of this study reveal that low BMI and aging are associated with bone loss. Routine BMD checking in postmenopausal women might be important to initiate an early clinical intervention for osteoporosis.*

***Keywords:*** *Postmenopausal women, body mass index, bone mineral density test, DEXA.*

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## INTRODUCTION

Natural menopause defined as amenorrhea for twelve successive months, for which no other clear pathological or physiological cause is perceived.[1] Since average life expectancy is increasing, women everywhere on the world currently have to spend almost one-third of their lives in menopause years.[2] The menopause happens in an average of 46 – 51 years in Bangladeshi female[3] with an average life expectancy of 72 years.[4] Studies have reported that Asian women have a higher tendency for osteoporosis contrast with the Caucasian partners.[5] The achievement of peak bone density in adolescent years and the rate of bone mass reduction during postmenopausal years are the important factors contributing to bone wellbeing in old females.[6] Around 35% of postmenopausal females lose bone mineral significantly during this period and are at a great risk for osteoporosis and fragility fractures later in life.[7] The decrease in ovarian estrogen production is the fundamental determinant of this imbalance, but estradiol serum levels clarify just a little proportion of inter-individual variance of BMD and bone loss. BMI is used to categorize the different level adiposity and measures body mass composition more exactly than weight alone. Obesity influences numerus sequelae of menopause including bone mineral density. Increasing body mass also affects weight bearing on the muscles that influence bone formation.[8] Many other factors seem to be involved, such as age, lean and fat mass, race, genetic factors, exercise, and smoke. The reason for this study was to find the relationship between BMI and BMD in postmenopausal women for early diagnosis of low bone density to reduce the effect of osteoporosis.

## MATERIALS AND METHODS

This retrospective study was conducted in the Institute of Nuclear Medicine and Allied Sciences (INMAS), Sylhet. Study subjects comprised of 117 postmenopausal women between ages 45 to 85 years, with a mean (± SD) age of 60.8 (± 9.2) years, who were investigated BMD test from January 2018 to June 2019. The following inclusion criteria were used: age more than 45 years, natural menopause without hormone replacement therapy. Exclusion criteria were surgical menopause, taking steroid, history of bony trauma. Medilink Medix DR system was used to measure the BMD in the lumbar spine at the level of L1 to L4, right and left femur by a technician, and the interpretation was done by two nuclear medicine physicians. The output from the BMD examination includes images of the body part scanned, quantitative data from the scanned area including the bone mineral content (BMC), BMD, T-scores, and Z-scores, and a graph fitting the patient data to the reference population. The WHO criteria were used to groups the respondents based on BMD results[9]. Height was measured by measuring scale. Weight was measured by a weight machine. BMI was calculated from the weight and height by the formula weight (kg)/ [height (m)]$^2$. First, the variables were analyzed in descriptive means and standard deviations. For continuous variables, including mean ± standard deviation (SD), and categorical data were presented as count and percentage (%). Chi-square test was used for statistical analysis. The variables considered were age, BMI, and BMD. It was considered significant when P-value less than 0.05. We examined the relationship between BMD (T score) and BMI by bivariate Pearson's correlation for each study. Statistical analyses were done by IBM SPSS Statistics 25.

## RESULTS

Table I Shows the study population consisted of 117 postmenopausal women. Age ranged from 45 to 85 years. The mean and standard deviation of age was 60.82 ± 9.22 years. The mean and standard deviation of lumbar spine T-score, right femur T-s core, and left femur T-score were-1.95 ± 1.60, -0.44 ± 1.23, and - 0.50 ± 1.3 respectively. The mean and standard deviation of BMI was 24.04 ± 4.23 kg/m$^2$

Table II Shows in this study, the respondents were grouped into four age groups. Around 45.3 % in the study were in the age group of 55-64 years. Approximately 53.0 %, 30.8% and 8.5% of the study subjects were normal, overweight and underweight respectively. A detailed depiction is given in .

**Table I: General traits of the participants (mean ± standard deviation)**

| | Min | Max | Mean ± SD |
|---|---|---|---|
| BMI | 15.11 | 38.21 | 24.04 ± 4.23 |
| Age (in years) | 45.00 | 85.00 | 60.82 ± 9.22 |
| Right Femur T-score | -4.70 | 2.50 | -0.44 ± 1.23 |
| Left Femur T-score | -4.20 | 2.40 | -0.50 ± 1.3 |
| Lumber Spine T-score | -5.50 | 2.20 | -1.95 ± 1.60 |

Table III Shows this study also showed that about 2.6%, 5.1% and 39.3% had osteoporosis in the right femur, left femur and lumbar spine, respectively. The postmenopausal women suffered from osteopenia in the right femur, left femur and lumbar spine of about 26.5 %, 8.2% and 29.9% respectively. According to BMI, around 100%, 100% and 66.7% obese subjects had normal BMD in right femur, left femur and lumbar spine respectively. In contrast to that, around 20%, 30% and 90% underweight subjects had osteoporosis in right femur, left femur and lumbar spine respectively. A detailed description is given in

**Table II: Distribution of study subjects according to age and BMI.**

| Variables | | Group | Number | Percentage |
|---|---|---|---|---|
| BMI | Underweight | 10 | 8.5 | |
| | Normal | 62 | 53.0 | |
| | Overweight | 36 | 30.8 | |
| | Obese | 09 | 7.7 | |
| Age (in Years) | | 45-54 | 25 | 21.4 |
| | 55-64 | 53 | 45.3 | |
| | 65-74 | 26 | 22.2 | |
| | 75-85 | 13 | 11.1 | |

Table IV Shows for additional analysis, the entire group based on the DEXA scan was grouped as low BMD and

**Table III: Distribution of bone mineral density according to independent factors for lumbar spine and right femur**

| Independent factors | | Status of bone mineral density | | |
|---|---|---|---|---|
| | | Normal N (%) | Osteopenia N (%) | Osteoporosis N (%) |
| **Right Femur** | | | | |
| **BMI** | Underweight | 2 (20.0) | 6 (60.0) | 2 (20.0) |
| | Normal | 42 (67.7) | 19 (30.6) | 1 (1.6) |
| | Overweight | 30 (83.3) | 6 (16.7) | 0 |
| | Obese | 9 (100) | 0 | 0 |
| **Age (in Years)** | 45-54 | 24 (96.0) | 1 (4.0) | 0 |
| | 55-64 | 44 (83.0) | 9 (17.0) | 0 |
| | 65-74 | 9 (34.6) | 15 (57.7) | 02 (7.7) |
| | 75-85 | 6 (46.2) | 6 (46.2) | 1 (7.7) |
| | Total | 83 (70.9) | 31 (26.5) | 3 (2.6) |
| **Left Femur** | | | | |
| **BMI** | Underweight | 2 (20.0) | 5 (50.0) | 3 (30.0) |
| | Normal | 37 (59.7) | 23 (37.1) | 2 (3.2) |
| | Overweight | 30 (83.3) | 5 (13.9) | 1 (2.8) |
| | Obese | 9 (100) | 0 | 0 |
| **Age (in Years)** | 45-54 | 23 (92.0) | 2 (8.0) | 0 |
| | 55-64 | 41 (77.4) | 11(20.8) | 1(1.9) |
| | 65-74 | 9 (34.6) | 15 (57.7) | 02 (7.7) |
| | 75-85 | 5 (38.5) | 5 (38.5) | 3 (23.1) |
| | Total | 78 (66.7) | 33 (8.2) | 6 (5.1) |
| **Lumbar spine** | | | | |
| **BMI** | Underweight | 0 | 1 (10.0) | 9 (90.0) |
| | Normal | 14 (22.6) | 22 (35.5) | 26 (41.9) |
| | Overweight | 16 (44.4) | 10 (27.8) | 10 (27.8) |
| | Obese | 6 (66.7) | 2 (22.2) | 1 (11.1) |
| **Age (in Years)** | 45-54 | 10 (40.0) | 10 (40.0) | 5 (20.0) |
| | 55-64 | 20 (37.7) | 18 (34.0) | 15 (28.3) |
| | 65-74 | 4 (15.4) | 5 (19.2) | 17 (65.4) |
| | 75-85 | 2 (15.4) | 2 (15.4) | 9 (69.2) |
| | Total | 36 (30.8) | 35 (29.9) | 46 (39.3) |

normal BMD. We considered osteopenia and osteoporosis as low BMD and rest as normal BMD. About 34 (29.1%), 39 (33.3%) and 81 (69.2%) subjects low BMD in right femur, left femur and lumbar spine respectively. Statistically significant association (p= <0.001) was found between different age groups and low BMD in the right femur, left femur but lack of association in lumbar spine (p =0.08). According to BMI compare to the right femur, low BMD was found in 08 (80.0%), 20 (32.3%), 06 (16.7%) among underweight, normal and overweight patients but all the obese patient had normal BMD. Contrarily in left femur, low BMD was found in 08 (80.0%), 25 (40.3%), 06 (16.7%), 0 among underweight, normal, overweight and obese patients. According to BMI compare to the lumbar spine, low BMD were found in 48 (77.4%), 10 (100 %), 20 (55.6%), 3 (33.3%) among normal, underweight, overweight, and obese patients respectively. Association between BMD and BMI was found statistically significant in the right femur (p < 0.001), left femur (p < 0.001) and lumbar spine (p = 0.02). Low BMD was more severe in the 65-74 years' age group in both femurs (65.4%) and 65-85 years' age group in lumbar spine (84.6%) compare to other groups. The details are depicted in

Correlation of BMI with right femur T score and lumbar spine T score were measured by Pearson's correlation

**Table IV: Association between independent factors and bone mineral density**

| Independent factors | | Status of bone mineral density | | P-value |
|---|---|---|---|---|
| | | Normal N (%) | Low BMD N (%) | |
| | | Right Femur | | |
| BMI | Underweight | 2 (20.0) | 8 (80.0) | <0.001 |
| | Normal | 42 (67.7) | 20 (32.3) | |
| | Overweight | 30 (83.3) | 6 (16.7) | |
| | Obese | 9 (100) | 0 (0) | |
| Age (in Years) | 45-54 | 24 (96.0) | 1 (4.0) | <0.0001 |
| | 55-64 | 44 (83.0) | 9 (17.0) | |
| | 65-74 | 9 (34.6) | 17(65.4) | |
| | 75-85 | 6(46.2) | 7(53.8) | |
| | Total | 83 (70.9) | 34 (29.1) | |
| | | Left Femur | | |
| BMI | Underweight | 2 (20.0) | 8 (80.0) | <0.001 |
| | Normal | 37 (59.7) | 25 (40.3) | |
| | Overweight | 30 (83.3) | 6 (16.7) | |
| | Obese | 9 (100) | 0 (0) | |
| Age (in Years) | 45-54 | 23 (92.0) | 2 (8.0) | <0.0001 |
| | 55-64 | 41 (77.4) | 12 (22.6) | |
| | 65-74 | 9 (34.6) | 17(65.4) | |
| | 75-85 | 5(38.5) | 8(61.5) | |
| | Total | 78 (66.7) | 39 (33.3) | |
| Lumbar spine | | | | |
| BMI | Underweight | 0 (0.0) | 10 (100) | 0.02 |
| | Normal | 14 (22.6) | 48 (77.4) | |
| | Overweight | 16 (44.4) | 20 (55.6) | |
| | Obese | 6 (66.7) | 3 (33.3) | |
| Age (in Years) | 45-54 | 10 (40.0) | 15 (60.0) | 0.08 |
| | 55-64 | 20 (37.7) | 33(62.3) | |
| | 65-74 | 4(15.4) | 22(84.6) | |
| | 75-85 | 2 (15.4) | 11 (84.6) | |
| | Total | 36 (30.8) | 81 (69.2) | |

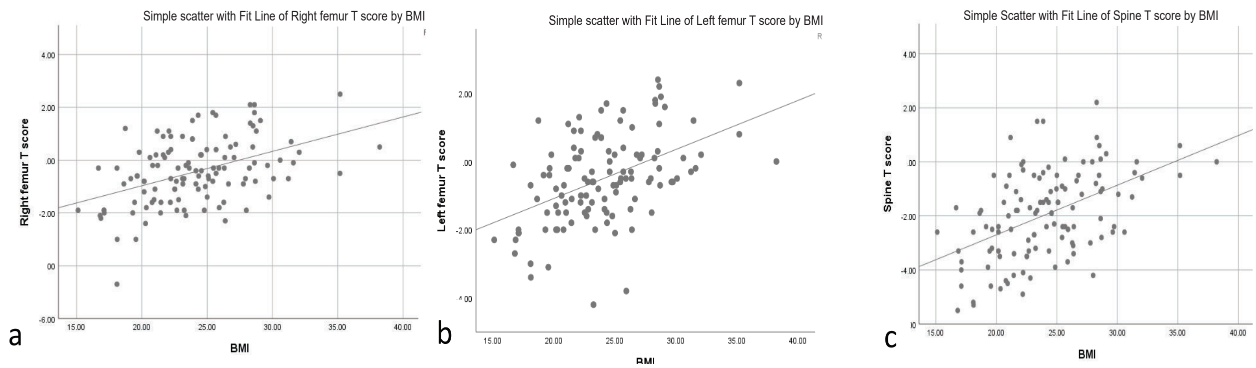


**Figure 1:** *Scatter diagram demonstrating a positive correlation between BMI (kg/m2) and T score of the right femur(a), left femur (b) and lumbar spine (c)*


**Figure 2:** *Scatter diagram displaying a negative correlation between age and T score of the right femur (a) left femur (b) and lumbar spine (c)*

coefficient test. Positive significant Pearson's correlation was observed between BMI with right femur T score (r= 0.448; p=<0.001) fig-1a, left femur T score (r= 0.469; p=<0.001) fig-1b and BMI with lumbar spine T score (r=0.485, p <0.0001) Fig -1c. Pearson's correlation coefficient test showed inverse relationship between age and BMD both right femur (r =-0.464, p < 0.0001) fig 2a, left femur (r =-0.503, p < 0.0001) fig 2b and lumbar spine (r =-0.371, p < 0.0001) fig 2c.

Statistically significant difference (p <.0001) was found between right femur and left femur T score.

## DISCUSSION

Osteoporosis is characterized as systemic skeletal disease described by low bone mass and micro-architectural deterioration of bone tissue, with a resulting increment in bone fragility and the risk of fracture.[10]

World Health Organization (WHO) criteria of osteoporosis (based on T-score) were used to evaluate the BMD status of the study population. Here normal BMD classified as T-score ≥-1, low bone mass (osteopenia) as T-score <-1and >-2.5 and osteoporosis as T-score ≤-2.5.

According to Classification by WHO, BMI below 18.5 $kg/m^2$ is considered underweight; a BMI between 18.5 and 24.99 $Kg/m^2$ is the ideal weight range; a BMI between 25 and 29.99 kg/ $m^2$ is classified as overweight; a BMI equivalent to or greater than $30kg/m^2$ is obese. (Giles, 2008).[11]

In our study, among 117 study subjects regarding BMI 30.8% were overweight, 7.7% were obese, 8.5% were underweight and the rest 53.0% had normal BMI. Mean (±SD) BMI was 24.04 (±4.23) with a range of 15.11-38.21 $kg/m^2$ which is slightly different from Samira et al [12] which may be due to geographical variation of the study population.

In the current study statistically positive correlation of BMD with BMI was found both in the right femur T score (r= 0.448; p=<0.001), left femur T score (r= 0.469; p=<0.001) and lumbar spine T score (r=0.485, p <0.0001). The findings of this study are similar to that of the previous studies.[12-16,20] It was additionally seen that nobody had a normal BMD value at lumbar spine in underweight group. Then again, in the overweight group 44.4%, 83.3% patients had normal BMD value at lumbar spine and both femoral neck respectively which showed statistically significant differences (P<0.001). These results are consistent with previous studies that reported increased BMD in overweight group may be due to the secretion of bone active hormones such as leptin and estrogen from adipocytes and insulin, amylin and pectin from pancreatic beta cell.[13,15]

In the present study, the inverse relationship was observed between age and BMD at right femur (r =-0.464, p < 0.0001, left femur (r =-0.503, p < 0.0001) and lumbar spine (r =-0.371, p < 0.0001). Very much comparative findings were observed in past various studies. Results showed low bone mass with advancing age in those studies [13-16]. However, there were no statistically significant difference (p =0.08) in different age groups and BMD category. The age-related decay of ovarian estrogen production and muscle strength may be responsible for low bone mass in those women.[2,15] BMD test is utilized to evaluate the strength of bone whereas BMI demonstrate the nutritional status of an individual.[15,16] BMI is a major determinant of BMD. BMI and femoral neck BMD observed was positively correlated in a cross-sectional study directed among postmenopausal women by Steinschneider et al (2003)[17]. The positive correlation between overweight and bone mass could be due to the influence of estrogen and mechanical load on skeleton [2,13,20].

Nguyen et al. [18] and Baheiraei et al.[19] additionally reported the consistent finding that lower BMD was related with lower BMI. The negative effect of low body weight on BMI is a decent marker for measurements of BMD.

## CONCLUSIONS

In postmenopausal women with propelling age, risk of osteoporosis increases with the diminishing BMD. When BMI increases, BMD increases with decreasing risk of osteoporosis. A better comprehension of the relation between BMD and BMI provides an opportunity for early intervention and treatment to prevent fracture which includes life style modification in the form of exercise, supplementation of calcium and vitamin D, fall prevention along with anti-resorption therapy when needed. Maintenance of adequate body mass is important for prevention of postmenopausal bone loss.

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