# Correlation of Age, Weight and Body Mass Index with Bone Mineral Density using Dual–Energy X-ray Absorptiometry–Initial Experience in INMAS, Bogura

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## ABSTRACT

***Objectives:*** Worldwide osteoporosis is the major public health concern among the aging population. Body weight & Body Mass Index (BMI) are inversely related with the risk of the osteoporotic fractures. Low bone mineral density (BMD) is also a major risk factor for osteoporosis & its related fractures. Osteoporosis is becoming a burning issue within the elderly group of Bangladesh. There are several studies that have shown the significant relationship of age, body weight and BMI with BMD. Therefore, the objective of the recent study is to establish the relationship of age, weight and BMI with BMD, in patients attending for DEXA scan at INMAS Bogura.

Patients and methods: The cross-sectional observational study was carried out at INMAS Bogura from August 2023 to February 2024. A total of 64 patients referred for BMD estimation by DEXA scan, were included in this study.

***Result:*** In this study among 64 patients about 31.25% were male and 68.75% were female. About 20.31% were underweight, 40.62% were normal, 23.07% were overweight and 14.00% were obese. Less than 60 years of age were 48.43% and ≥60 years of age were 51.56%. In the right femur 40.62% were normal BMD, whereas 59.37% were low BMD. In the case of the left femur 46.87% were normal and 53.12% were low BMD. In spine BMD 23.47% were normal and 76.56% were low BMD. Moderate positive Pearson's correlation is found in between BMI with right femur T score (r= 0.43; p=<0.001), left femur T-score (r= 0.633; p=< 0.001) and lumbar spine T score (r= 0.475, p=< 0.001).

***Conclusion:*** Statistically significant association and moderate positive correlation was found in between BMI with right femur BMD, left femur BMD and lumbar spine BMD. Non-significant small negative correlation is found in between age with right femur BMD, left femur BMD and lumbar spine BMD. Statistically significant association and moderate positive correlation was also found in between weight with right femur BMD, left femur BMD and lumbar spine BMD.

***Keywords:*** Dual Energy X-ray Absorptiometry (DEXA), Bone Mineral Density, Body Mass Index, Osteopenia, Osteoporosis.

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## INTRODUCTION

Osteoporosis is a silent health problem that causes a major socio-economic problem, having an impact on mortality and morbidity (1). Osteoporosis is a bone disorder characterized by low bone mass, increased fragility, decreased bone quality, and increased risk of fracture. It is the world's most common metabolic disease of bone (2). Osteoporotic fractures are common among the elderly population, and low bone mineral density (BMD) is a major risk factor for osteoporosis and its related fractures (3). The World Health Organization (WHO) listed osteoporosis as the second global health problem, next to cardiovascular disease (4). Despite the harmful effects of osteoporosis, it is often undertreated, as it clinically remains silent until the manifestation of pain and fractures. Osteoporosis is an age-related disease, affecting females more than males (2). Body weight & BMI are considered strong factors for osteoporotic fractures. Higher BMI levels are associated with higher BMD scores, while obesity and overweight have been considered protective for bone health (5). BMI and body weight are inversely related to the risk of osteoporotic fractures (6). Several studies showed that postmenopausal lean women had reduced BMD scores (7). Previously it was considered that osteoporosis happened only in elderly populations, but now it has been found to occur in any age group whose conventional BMD has reduced to a critical threshold (8). Our country has a high incidence of osteoporosis and it affects a relatively younger age group in comparison to developed countries. BMD is an important investigation

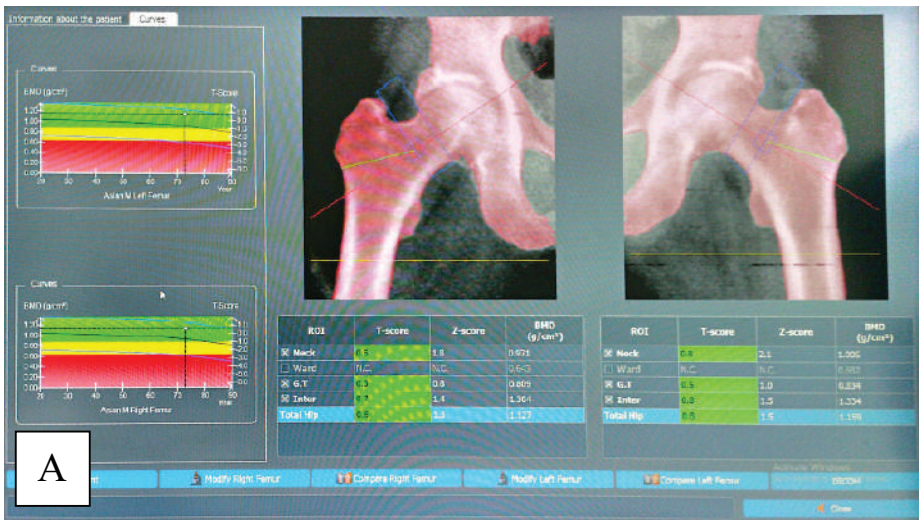
for assessment of bone quality and is used to assess osteoporotic status of the bone for prevention of osteoporotic fractures. With increasing age, the bone becomes naturally thin as the bone breaks down faster than the new bone formation. As a consequence, bone calcium and other bone minerals are lost, and they become less dense, lighter, and more brittle in weight (9). The World Health Organization described osteoporosis as a progressive systemic skeletal disease, characterized by low bone mass and microarchitectural deterioration of bone tissue, resulting in an increased fragility and susceptibility to fractures (10). The clinical importance of osteoporosis is the tendency of the fractures that arise globally. In the UK, approximately 536,000 new fragility fractures occur each year, within which are 79,000 hip fractures, 66,000 forearm fractures, and 322,000 other fractures. This type of fracture is responsible for severe pain and disability to individuals with an annual cost to the National Health Service (NHS) of over £4.4 billion, estimated in 2010. Usual sites for fragility fractures include the vertebral bodies, distal radius, proximal humerus, pelvis, and proximal femur. Hip fractures account for around 50% of the total cost of fractures to the UK annually, and approximately 53% of individuals suffering from hip fractures are unable to live independently and die within 12 months of the fractures (11). So from the public health and clinical point of view, it is essential to clarify the role of BMI, age, and weight with BMD. Our study contributes to this issue by evaluating the relationship between age, weight, BMI, and BMD among the people referred for DEXA scans at a single nuclear medicine center.

## PATIENTS AND METHODS

The cross-sectional observational study was carried out in a single center at INMAS Bogura. Patients who were referred for DEXA scans from September 2023 to February 2024 form the study population. The interpretation was done by an expert nuclear medicine physician. BMI was calculated by weight in kg and height in $m^2$, while BMD was measured by DEXA scan by using the unit $gm/cm^2$. The WHO criteria were used to classify respondents based on DEXA scan results (Table 1). The result of the DEXA examination includes images from the body part scanned (Figure 1), quantitative data from the scanned area, including the bone mineral content (BMC), BMD, scanned area, T-score, and Z-score, and a graph in which the patient fits within the reference subjects.

**Table 1: The WHO criteria to define osteoporosis and osteopenia by T-score**

| Terminology | T-score definition |
|---|---|
| Normal | T≥-1.0 |
| Osteopenia | -2.5<T<-1.0 |
| Osteoporosis | T≤-2.5 |



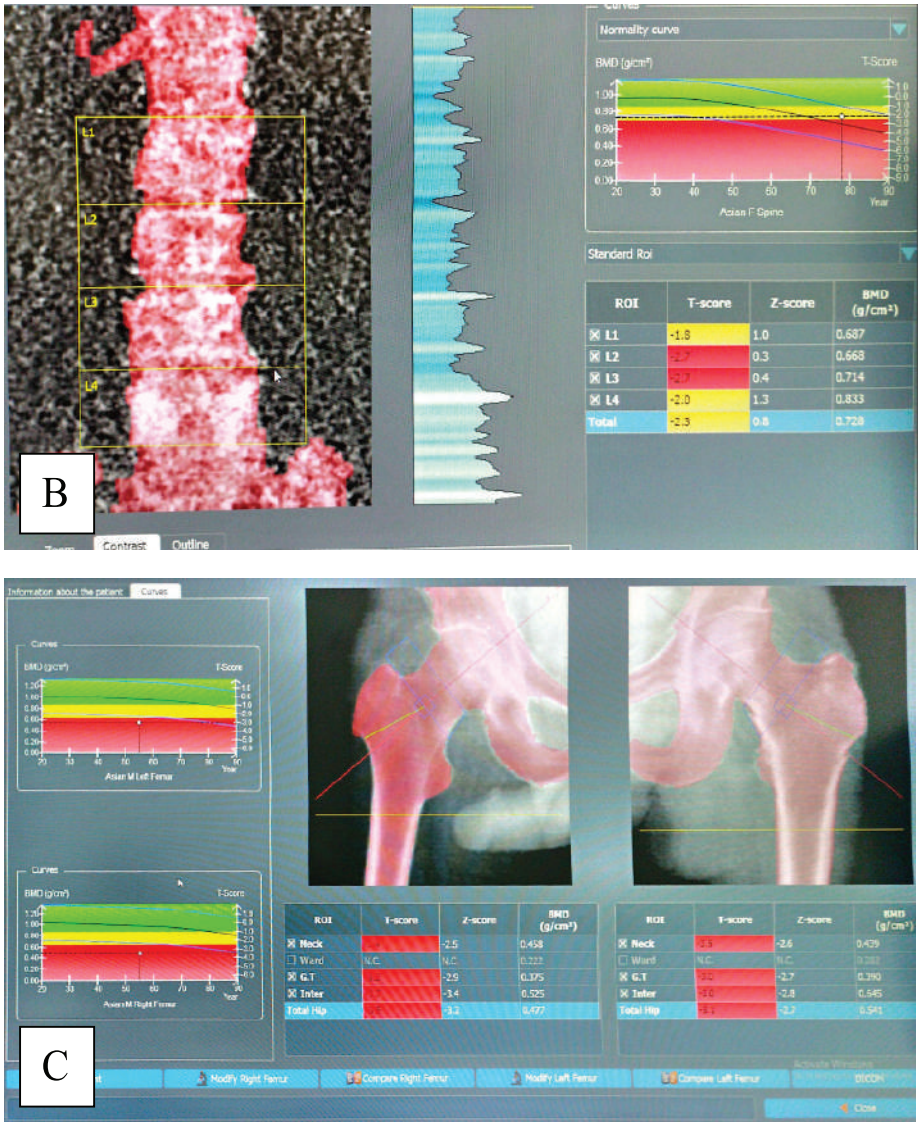



**Figure 1: Representative images of DEXA scans showing normal BMD measurement of both femora (A), low BMD measurement indicating osteopenia at lumbar spine (B), and very low BMD measurement indicating osteoporosis at both femora (C).**

## STATISTICAL ANALYSIS

It includes socio-demographic features and descriptive analysis to rule out the correlation between age, body weight, and BMI with BMD. First of all, the variables were analyzed in descriptive means and standard deviation. Continuous variables, including mean ± standard deviation (SD), and categorical data were presented as count and percentage. The statistical test for the study was the chi-square test. The variables were gender, age, body weight, and BMI. P value <0.05 was considered significant. The relationship of age, body weight, and BMI with BMD (T-score) was examined by bivariate Pearson's correlation coefficient for each study. An IBM SPSS Statistics 25 performed the statistical analysis; two-tailed $p < 0.05$ was considered statistically significant.

## RESULT

The study population contained 64 participants, with female preponderance and mean age ± SD 56.75 ± 11.05 years (range 19 – 75 years). The mean ± standard deviation of weight and BMI were 54.90 ± 13.32 kg and 23.68 ± 5.50 kg/m2, respectively (Table 2).

**Table 2: Groupwise distribution of study subjects according to gender, BMI & age**

| Variables | Group | Number | Percentage (%) |
|---|---|---|---|
| **Gender** | Male | **20** | **31.25** |
| | Female | **40** | **68.75** |
| **BMI** | Underweight | **13** | **20.31** |
| | Normal | **26** | **40.62** |
| | Overweight | **15** | **23.07** |
| | Obese | **09** | **14.00** |
| **Age** | ＜60 | **31** | **48.43** |
| | **≥60** | **33** | **51.56** |

The mean ± standard deviation of right femur T-score, left femur T-score, and lumbar spine T-score were -0.89 ± 1.74, -1.09 ± 1.35, and -2.13 ± 1.51, respectively. Table 3, 4, 5 shows distribution of study subjects in normal, osteopenia and osteoporosis groups according to their age, gender and BMI.

**Table 3: Bone Mineral Density status of study population for right femur**

| Independent factor | | Number of patients in different Bone Mineral Density status | | |
|---|---|---|---|---|
| | | Normal | Osteopenia | Osteoporosis |
| **Gender** | Male | 05 | 12 | 03 |
| | Female | 21 | 19 | 04 |
| **BMI** | Underweight | 02 | 06 | 05 |
| | Normal | 10 | 14 | 02 |
| | Overweight | 06 | 10 | 00 |
| | Obese | 08 | 01 | 00 |
| **Age (years)** | <60 | 12 | 17 | 02 |
| | ≥60 | 14 | 14 | 05 |

**Table 4: Bone Mineral Density status of study population for left femur**

| Independent factor | | Number of patients in different Bone Mineral Density status | | |
|---|---|---|---|---|
| | | Normal | Osteopenia | Osteoporosis |
| Gender | Male | 06 | 08 | 0 |
| | Female | 24 | 15 | 05 |
| BMI | Underweight | 01 | 0 | 06 |
| | Normal | 13 | 11 | 02 |
| | Overweight | 08 | 05 | 03 |
| | Obese | 08 | 01 | 00 |
| Age (years) | <60 | 14 | 11 | 0 |
| | ≥60 | 16 | 12 | 05 |

**Table 5: Bone Mineral Density status of study population for lumbar spine**

| Independent factor | | Number of patients in different Bone Mineral Density status | | |
|---|---|---|---|---|
| | | Normal | Osteopenia | Osteoporosis |
| Gender | Male | 04 | 07 | 09 |
| | Female | 11 | 12 | 21 |
| | Underweight | 02 | 01 | 1 |
| BMI | Normal | 05 | 07 | 14 |
| | Overweight | 02 | 09 | 05 |
| | Obese | 06 | 02 | 1 |
| Age | <60 | 09 | 09 | 1 |
| (years) | ≥60 | 06 | 10 | 17 |

From these tables, it can be observed that irrespective of gender, BMI and age, osteopenia is more common in both femurs, whereas osteoporosis is more common in lumbar spine. Table 6 shows Pearson's correlation analysis between independent variables and BMD. Moderate positive correlations were found in case of weight and BMI (figure 2). A non-significant small negative correlation is noted in case of age.

**Table 6: Pearson's correlation analysis between age, weight and BMI with BMD**

| BMD | Age (years) | Weight (Kg) | BMI (Kg/m$^2$) |
|---|---|---|---|
| **Right femur T-score** | r=-0.173<br>p <0.001 | r=0.454<br>p <0.001 | r=0.430<br>p <0.001 |
| **Left femur T-score** | r=-0.207<br>p <0.001 | r=0.583<br>p <0.001 | r=0.633<br>p <0.001 |
| **Lumbar Spine T-score** | r=-0.180<br>p <0.001 | r=0.448<br>p <0.001 | r=0.475<br>p <0.001 |

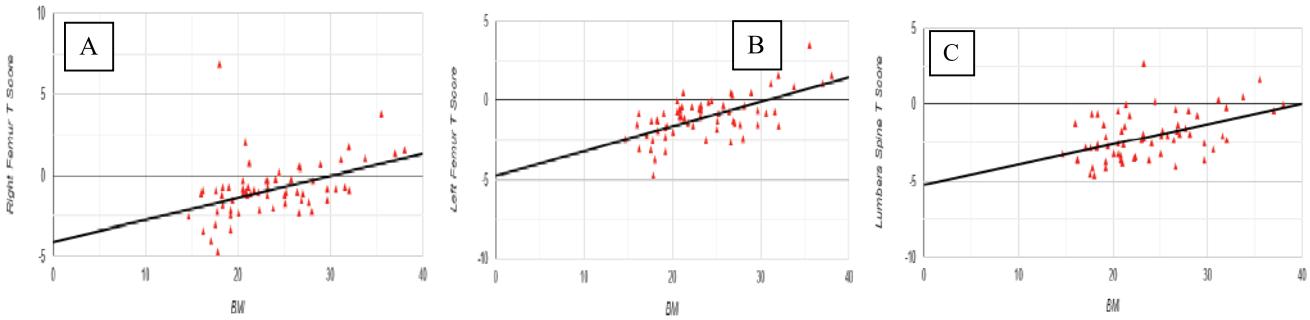



**Figure 2: Scattered diagrams showing moderate positive correlations between BMI (Kg/m2) and right femur T score (A), left femur T score (B), and lumbar spine T score (C).**

## DISCUSSION

DEXA is the recognized method for estimation of BMD with good accuracy and acceptable precision errors. WHO has recognized DEXA as the best densitometric technique for estimation of BMD (12). The DEXA technique provides accurate diagnosis of osteoporosis, fracture risk estimation, and monitoring of the patients undergoing treatment. To identify patients with low BMD is a vital step to reduce the risk of osteoporotic fractures (9). In a study, Nahar et al. showed 2% of osteoporosis and 24.3% of osteopenia in the right femur, 34.2% of osteoporosis and 27% of osteopenia in the lumbar spine (9). Mou et al. showed 29.1% of osteoporosis and 51.8% of osteopenia in the right hip, 34.6% of osteoporosis and 52.7% of osteopenia in the left hip, and 48.2% of osteoporosis and 37.3% of osteopenia in the spine (13). In this study we showed that 10.93% of osteoporosis and 48.43% of osteopenia in the right femur, 17.18% of osteoporosis and 35.93% of osteopenia in the left femur, and 46.87% of osteoporosis and 29.68% of osteopenia in the lumbar spine. Our study also showed that 40.62% were normal and 59.37% were low BMD in the right femur, while about 46.8% were normal, whereas 53.12% were low BMD in the left femur. About 23.43% were normal and 76.56% were low BMD in the lumbar spine. Nahar et al. also showed that in those ≥60 years of age, about 42.7% of subjects had low BMD, whereas 57.3% of subjects were normal in the right femur. About 72.0% of subjects had low BMD in the lumbar spine, and 28.0% ≥60 years is higher than among age groups <60 years (9, 14). A recent study showed that 81.81% of subjects had low BMD in the lumbar spine, whereas 18.81% were normal. This study also showed that 59.37% were low BMD and about 40.62% were normal BMD in the right femur in the age group ≥60 years. These findings were similar to the above-mentioned study. Our study showed that 84.6% of underweight were low BMD, 80.76% of normal were low BMD, 87.5% of overweight were low BMD, and 33.33% of obese were low BMD in the lumbar spine. Nahar et al. (9) showed that about 84.6% of underweight were low BMD, 48.9% of normal were low BMD, 54.3% of overweight were low BMD, and 30.8% of obese were low BMD in the lumbar spine. These studies had similarities in underweight individuals, which was the high percentage of low BMD. Our study also showed that obese individuals had relatively better bone density than the low body weight individuals, and obese individuals had a relatively low percentage of low BMD. In a study, Salamat et al. found that both BMI and weight were positively associated with BMD, and obesity significantly reduces the risk of osteoporosis (3); this finding is in accordance with our recent study. In accordance with the results of Dogan et al., Salamat et al., Lloyd et al., and Hoxha et al., the results of our recent study have demonstrated a positive correlation of weight and BMI with both femurs. Hoxha et al. found a negative relationship between age and femur BMD, which is similar to our studies (15, 3, 16, 5). However, our studies also showed the negative relationship between age and lumbar BMD. Nahar et al. found a positive significant Pearson's correlation between BMI and right femur BMD ($r = 0.347$; $p < 0.001$), BMI and left femur BMD ($r = 0.382$; $p < 0.001$), and BMI and lumbar BMD ($r = 0.397$; $p < 0.001$). Our recent studies also showed the moderate positive Pearson's correlation between BMI and right femur BMD ($r=0.43$; $p=<0.001$), BMI and left femur BMD ($r=0.633$, $p=<0.001$), and BMI and lumbar BMD ($r=0.475$, $p=<0.001$). Hoxha et al. found that there is a significant positive correlation between weight and lumbar spine BMD ($r = 0.241$), weight and femur neck ($r = 0.445$), and weight and total hip ($r = 0.502$). However, our studies also showed the significant positive correlation between weight and lumbar spine BMD ($r = 0.475$), weight and right femur neck ($r = 0.43$), and weight and left femur ($r = 0.633$). Hoxha et al. also showed that a significant positive correlation exists between BMI and lumbar spine BMD ($r = 0.187$), BMI and femur neck ($r = 0.348$), and BMI and total hip ($r = 0.483$), which is similar with our studies. Hoxha et al. also showed that a negative correlation exists between age and lumbar spine BMD ($r = -0.174$), age and femur neck ($r = -0.302$), and age and total hip ($r = -0.004$) (9, 5), which is similar to our studies where the r values between age and lumbar spine, age and right femur, and age and left femur are -0.1808, -0.1735, and -0.2074, respectively.

## CONCLUSION

The study shows a significant positive correlation between BMI and BMD, with underweight individuals more likely to experience low BMD. Increased body mass may be beneficial.

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