Original Research Article

International Journal of Health Sciences and Research
Vol.13; Issue: 5; May 2023
Website: www.ijhsr.org
ISSN: 2249-9571

Effect of Body Mass Index on Bone Mineral Density: A Retrospective Review

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DOI: https://doi.org/10.52403/ijhsr.20230502

ABSTRACT

Background: There have been studies investigating the relationship between body mass index (BMI) and bone mineral density (BMD) with findings focused on association between the two variables. The aim of this study was to further investigate the prevalence of osteoporosis and ascertain how BMD varies by gender and age in an average adult Nigerian.
Methodology: A total of 68 participants were examined. The participants underwent standard BMD scans of the femur and lumbar using a Dual-Energy X-ray Absorptiometry (DXA). BMI was measured as weight in kilograms by height in meters square
Results: The findings of this study revealed that the prevalence of osteoporosis was 10.3%. There was association between DEXA values and BMI. There was significant difference between age, gender and BMD. BMD scores for femur and lumbar were higher in subjects younger than 45 years compared to subjects in their middle age and elderly. Males have significantly higher BMD values
Conclusions: The results suggest lower BMI is an indication for low BMD. BMD can be used for screening test for osteoporosis. Female gender is more prone to osteoporosis. Age is a factor to consider as middle aged and elderly subjects more at risk of osteoporosis.

Keywords: Dexa scan, body mass index, osteoporosis

INTRODUCTION

Obesity and osteoporosis are two essential and growing public health issues throughout the world. [1,2] Reduced bone mass, poor bone structure, and decreased bone strength are all signs of osteoporosis, which raises the risk of fracture. [3] The most frequent metabolic condition in the elderly is osteoporosis, which is linked to increased morbidity and death.[4] In industrialized nations, the prevalence of osteoporosis has been mentioned to range from 13% to 34% [5,6,7], and this number is expected to rise as lifesyles expectancy improves.[8] Low bone mineral density (BMD) is a key risk factor for osteoporosis and the fractures that go along with it [9]. Fractures are expected to become more common as the world's population grows older.[9,10]

Older age, menopause, sedentary lifestyle, smoking, hyperthyroidism, and body mass index (BMI) have all been shown to enhance the risk of osteoporosis.[11, 12] While some studies indicated a greater prevalence of osteoporosis in persons with a low BMI and increased bone density in people with a high BMI (overweight/obesity), others reported decreased bone density in obese subjects. [13, 14]

Osteoporotic fractures are linked to an increased risk of death, as well as being one of the most common causes of disability and morbidity globally.[4] As a result, these fractures impose a financial burden on society in the form of direct and indirect medical expenditures, which are expected to reach $25.3 billion in the United States by 2025.[15] Obesity, on the other hand, is still debated as to whether it is protective or not against pathologic fractures.[16, 17] Obesity and fracture risk are complicated relationships that appear to vary based on bone location[18, 19] and may differ between men and women.[20] For example, a prior meta-analysis of the relationship between fracture risk and BMI found that low BMI was a risk factor for hip and all osteoporotic fractures, but a protective factor for tibia fractures, whereas high BMI was a risk factor for humerus and elbow fractures.[21]. Furthermore, while multiple studies have consistently demonstrated that individuals with obesity have a greater actual bone mineral density [22], it appears that changed bone quality may be a primary driver of fracture risk in this population. Due to the equivocal reported effects for the effect of BMI on BMD, this study was conducted to assess the relationship between BMD and BMI in an average adult Nigerian. We hypothesized that BMI would influence BMD and vary by gender and age

MATERIALS & METHODS

This cross-sectional study was conducted on Nigerian men and women who were referred to Cedarcrest Hospitals, Abuja, Nigeria for bone densitometry. Verbal and written consents were obtained and subjects who were Nigerian citizens and were older than 18 years were included in the study. Subjects were excluded if they were pregnant or lactating, smokers had chronic diseases or consumed medications that affect BMD, as well a positive family history for osteoporosis.

Height and weight were measured using stadiometers and weighing scales respectively while bone densitometry was taken with a densitometer. Weight and height were measured to the nearest 0.1 kg and 0.5 cm, respectively, when the subjects wore light clothes and no shoes. Body mass index (BMI) was calculated as the ratio of weight (kg) to height squared (m2). Participants were classified according to the WHO classification [23]: underweight (<18.5 kg/m2), normal weight (18.5–24.9 kg/m2), overweight (25.0–29.9 kg/m2), and obesity class I (30.0–34.99 kg / m2), obesity class II (35.0–39.99 kg/m2), and obesity class III (>40.0 kg/m2). Measurements of Bone Mineral Density(g/cm2), was made using a DXA (GE Aria Bone densitometer). The scanner was calibrated daily against the standard calibration block supplied by the manufacturer to control for possible baseline drift. T- and Z-scores were also obtained. These scores displayed on the reference tab and are efficient and quick way to diagnose osteoporosis. Moore (2008) explains that "the T-score compares the subject to the optimal bone density of a young healthy individual" and the Z score "compares the subject's density to sex and age-matched individuals".[24] In addition, a DEXA report can display a chart with T-scores to show how the individual compares to the database from NHANES (National Health and Nutrition Examination Survey) to inform if he or she is above, below, or at average.

According to the WHO, T-scores represent the number of standard deviations below or above the average BMD. Based on the T-scores, patients are classified as follows: normal (>−1.0), osteopenic (−1.0 to −2.5), and osteoporotic (≤−2.5) [Blake and Fogelman 2007]. All the data were collected in consistency with the recommendations of the International Society for Clinical Densitometry.[25]

than 0.05 were considered significant.

STATISTICAL ANALYSIS

We used Microsoft Excel® for data entry and the Statistical Package for the Social Sciences version 26 (SPSS Inc., Chicago, IL, USA) for data analysis. Criteria such as mean, standard deviation (S.D) and frequency distribution table of age, height, weight, and BMI of the participants were used. Kolmogorov-Smirnov test was applied to check for normality of the data. Due to small sample size and failed normality test, non-parametric approach was used for the analysis. Pearson-Correlation Coefficient test was applied to study the relationship between BMI and DEXA values. P values less

RESULT

The study population consisted of 68 participants. Distribution of gender showed that 69.1% were females and the remaining were males. Age range was from 26 to 90 years. The mean and standard deviation of age was 2.35 ± 0.641. The respondents were classified into three broad age groups, less than 45 years of age (8.8%), 45–65 years (47.1%), and greater than 65 years and above (44.1%). This represents young, middle aged and elderly respectively. The mean ± SD weight was 77.99 ± 18.78 kg while height was 159 ± 12.53 meters. About 57.4% of the participants were obese, 17.6% were overweight, and 22.1% had normal BMI while only 2.9% were underweight. Figure 1 shows the results of the DEXA scans for 68 respondents, 25.0% were osteopaenic and 10.3% had osteoporosis. 64.7% had normal DEXA scan results. The details of DEXA scan results are given in Table 1. The mean ± SD BMD was 0.949 ± 0.22 g/cm³, TF (T score for femur) was -0.407 ± 1.72 and ZF (Z score for femur) was -0.513 ± 1.44. For the lumbar region, the mean ± SD for BMD (g/cm³) was 1.13 ± 0.228, TL (T score for lumbar spine) was -0.467 ± 2.32 and ZL (Z score for lumbar spine) was -0.445 ± 1.97. Table 1 revealed that there was statistically significant difference in BMD parameters between genders (BMD femur; P=0.007, BMD lumbar; P<0.003). The males had higher BMD values for femur and lumbar (femur; 44.10, lumbar; 44.95).

There was significant difference between age and BMD (P<0.05). BMD scores for femur and lumbar were higher in subjects younger than 45 years compared to subjects in their middle age and elderly. There was also significant difference between gender and BMD scores on femur and lumbar (P<0.05) with the males having higher BMD scores. (Table 2). The Pearson correlation coefficient revealed an insignificant but weak correlation between BMI and BMD for femur and lumbar spine (femur; r=0.17, P = 0.177; lumbar; r=0.16, p=0.205). There was also correlation between BMI and TF (r=0.13, P = 0.309). Z-score for femur also showed a significant weak correlation with BMI (r=0.31, P = 0.01). There was also a weak correlation between BMI and TL (r=0.15, P=0.231). (Table 3 and Figure 2-7).

Figure 1: Femoral T-score

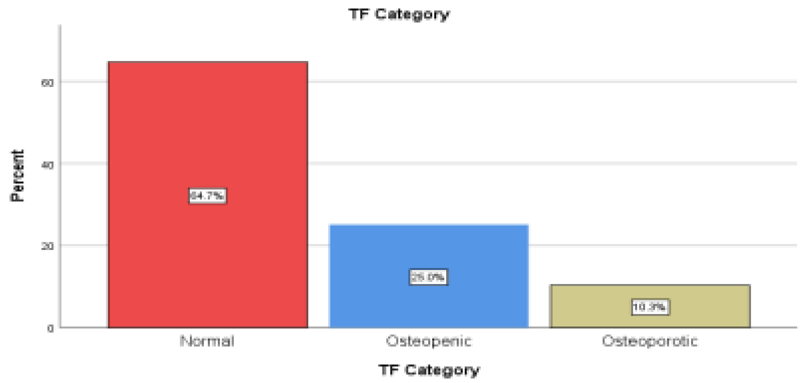


Table 1: Comparison of BMD Parameters between Gender (Mann-Whitney U Test)

Variable	Age group	Mean rank	p
BMD femur	Female	30.21	0.007
	Male	44.10	
BMD lumbar	Female	29.34	0.003
	Male	44.95	

Table 2: Comparison of Bmd Parameters Between Ages (Kruskal Walis)

Variable	Age group	Mean Rank	p
BMD femur	Young	47.00	0.007
	Middle aged	40.03	
	Elderly	26.10	
BMD lumbar	Young	40.83	0.027
	Middle aged	38.69	
	Elderly	27.41	

Table 3: Correlation between Bmi and Bmd Parameters

		BMD femur	TF	ZF	BMD lumbar	TL	ZL
BMI (Kg/m3)	r	0.17	0.13	0.31	0.16	0.15	0.06
	p	0.177	0.309	0.01	0.205	0.231	0.632

BMI, body mass index; TF, femoral T-score; ZF, femoral Z-score, TL, lumbar T-score; ZL, lumbar Z-score;

Figure 2: Scatter Plot between BMD Femur and BMI

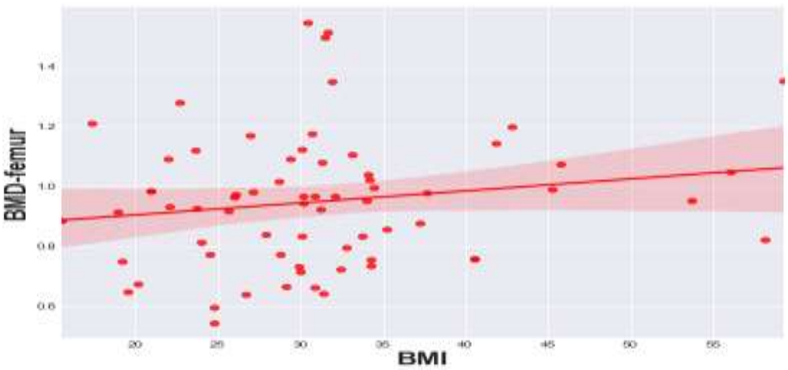


Figure 3: Scatter Plot between Tf and BMI

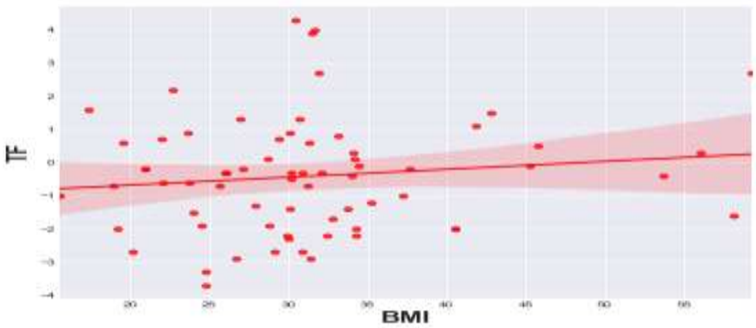


Figure 4: Scatter Plot between Bmf Lumbar and BMI

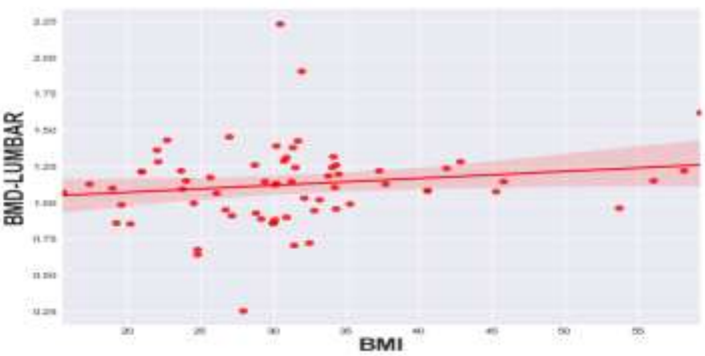


Figure 5: Scatter Plot between Zf and BMI

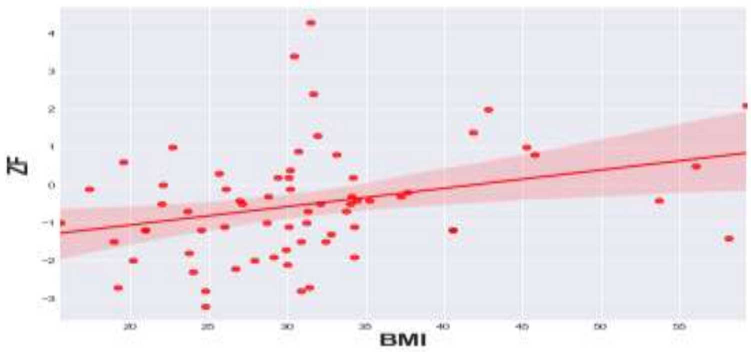


Figure 6: Scatter Plot between Tl and BMI

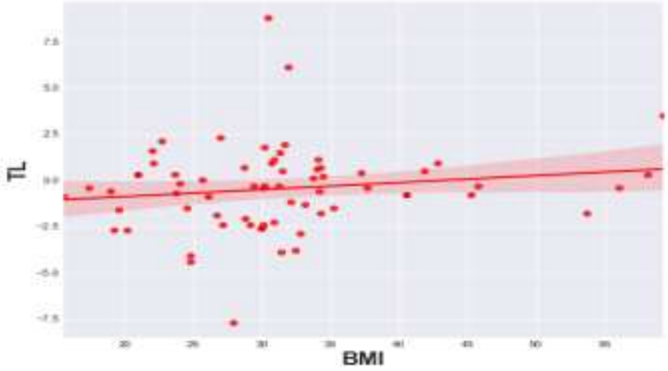
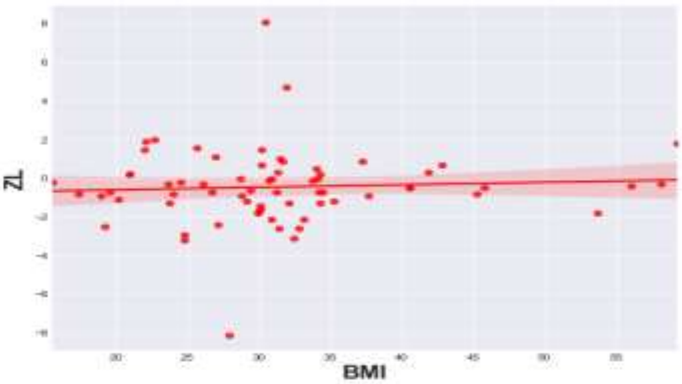


Figure 7: Scatter Plot between Zl And Bmi



DISCUSSION

Obesity and bone loss have been the two major and fast growing public worries worldwide. [1, 2] Osteoporosis and its accompanying fractures are linked to low bone mineral density (BMD) [8]. The effects of BMI on BMD in a typical adult Nigerian were demonstrated in this study. Based on T-score, the prevalence of osteoporosis was found to be 10.3 percent in this study. According to a research from Iran, the prevalence of osteoporosis ranged between 4% and 17%. [26, 27] According to studies from the East Mediterranean Region, the prevalence of femoral spine fractures is 24.4 percent and 16.8 percent, respectively, with a greater frequency among women (24.4 percent in women vs. 20.5 percent in males). [28] The Pearson correlation revealed a significant association between ZF and BMI (r=0.31. P=0.01), according to the results of the Pearson correlation. BMI and other DEXA readings (TF; r=0.13, TL; r=0.15) also had an association (TF; r=0.13, TL; r=0.15). Although the association was weak, all correlations between BMI and DEXA values in the femur and lumbar spine were directly proportional, suggesting that an increase in BMI might result in greater DEXA values and vice versa. Previous research has found that as BMI rises, BMD rises as well. [29, 30] According to some research, this association occurs because a high body weight can stimulate bone remodeling to compensate for the high mechanical strain. [31, 32] Another study found that having a higher BMI raises the levels of leptin, which helps to maintain the connection by increasing osteoblast development and activity. [33, 34] Low bone mineral density (BMD) is a key risk factor for osteoporosis and fractures. [35]

Through the effects of bone-derived substances such as osteocalcin and osteopontin, the human bone has been regarded an endocrine organ that affects body weight management and glucose homoeostasis. [36-38] A strong relationship between age and BMD was discovered in this investigation. Participants younger than 45 years old had greater femur and lumbar BMD scores than subjects in their middle age and elderly.

In line with these findings, other investigations have found that younger people had a greater BMD than older people.In congruent to this findings, some studies have revealed a higher BMD in younger subjects as compared to older subjects. [39-41] Also from this study, there was significant difference gender and BMD scores on femur and lumbar ($P<0.05$). We also found out that males have a significantly higher BMD scores. Males' bone and muscle changes throughout puberty are dominated by rising testosterone and IGF-1 levels, which result in increased muscular growth and strength. Bone mass, but not total cross-sectional area, tends to expand more rapidly in ratio to muscle area in girls with lower testosterone levels and greater estrogen levels.

Increases in testosterone fuel large increases in muscle, resulting in muscle forces that coincide with large increases in bone dimensions and strength in females, whereas in men, increases in testosterone fuel large increases in muscle, resulting in muscle forces that coincide with large increases in bone dimensions and strength. [42] Saadati and Miri et al (2021) reported that there was no significant difference between gender and BMD. However this finding was in line with the findings of previous studies conducted in South Korea and Iran. [43, 44] A drawback was the small sample size compared to prior epidemiological research. This study was likewise restricted to a single location. It is suggested that more study be undertaken at numerous sites and with bigger samples in order to extrapolate the findings to the entire population.

Future research could look into the relationship between socioeconomic status, educational attainment, and physical activity level.

CONCLUSION

The findings of this study revealed a lower prevalence of osteoporosis compared previous studies. There was also significant difference between BMD for femur and lumbar spine with gender. We also found out from our study that BMD differs across all age groups. Furthermore, there was a weak correlation between BMI and BMD parameters except ZL.

Declaration by Authors

Ethical Approval: Approved

Acknowledgement: None

Source of Funding: None

Conflict of Interest: The authors declare no conflict of interest.

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How to cite this article: Kelechukwu Onuoha, Khadijat Ajiboye, Kingsley Ekwe et.al. Effect of body mass index on bone mineral density: a retrospective review. *Int J Health Sci Res.* 2023; 13(5):11-19.
DOI: *https://doi.org/10.52403/ijhsr.20230502*

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