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EFFECTS OF SEDENTARY LIFESTYLE ON BONE MINERAL DENSITY IN INDIAN WOMEN

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ABSTRACT:
Background: Sedentary lifestyle is an emerging public health concern, particularly among women, and is associated with reduced bone mineral density (BMD) and increased risk of osteoporosis.
Objective: To evaluate the impact of sedentary lifestyle and body mass index (BMI) on BMD in Indian women.
Methods: A cross-sectional study was conducted on 65 women. Anthropometric measurements were recorded, and BMI was calculated. BMD was assessed using SONOST 3000 ultrasound densitometer and interpreted using WHO T-score criteria. Pearson correlation analysis was applied.
Results: Among participants, 50.77% had normal BMD, 47.69% had osteopenia, and 1.54% had osteoporosis. A strong negative correlation was observed between BMI and T-score ($r = -0.707$, $p = 0.001$), indicating reduced bone density with increasing BMI.
Conclusion: Sedentary lifestyle and higher BMI are significantly associated with decreased BMD. Early screening and lifestyle modification are essential to prevent osteoporosis in Indian women.

KEYWORDS: Bone mineral density, sedentary lifestyle, BMI, osteoporosis, Indian women

INTRODUCTION

Bone health is a crucial determinant of overall well-being, particularly among women who are at increased risk of osteoporosis due to hormonal changes and lower peak bone mass. Bone Mineral Density (BMD) is a key indicator of bone strength and fracture risk (Schini M et al., 2024). Globally, osteoporosis affects over 200 million women and is a major cause of morbidity and mortality due to fragility fractures (Liang H et al., 2021). The burden of low bone mineral density is increasing worldwide, especially in developing countries such as India, due to rapid urbanization and lifestyle transitions (Agrawal AC et al.,2023). Sedentary behavior, characterized by prolonged physical inactivity and reduced mechanical loading, has emerged as a significant modifiable risk factor contributing to decreased BMD and increased fracture risk (da Costa JC et al., 2025).

In India, multiple factors contribute to poor bone health, including inadequate dietary calcium intake, widespread vitamin D deficiency, and limited sun exposure due to sociocultural practices (Praveen PA et al.,2023). These factors, combined with reduced physical activity, accelerate bone loss, particularly in middle-aged and postmenopausal women (Xiaoya L et al., 2025). Physical activity plays a vital role in maintaining bone health by stimulating osteoblastic activity and promoting bone remodeling. Conversely, sedentary lifestyle reduces bone formation and leads to progressive decline in BMD (Wang XS et al., 2024). Body mass index (BMI) also plays a complex role in bone metabolism. While earlier studies suggested a protective role of higher body weight, recent evidence indicates that excess adiposity may negatively affect bone quality through chronic inflammation, altered adipokine secretion, and impaired osteoblast function (Forte YS et al.,2023).

Given these factors, understanding the relationship between sedentary lifestyle, BMI, and bone mineral density is essential for early identification of individuals at risk and for implementing preventive strategies. Therefore, this study aims to evaluate the impact of sedentary lifestyle and BMI on bone mineral density among Indian women.

MATERIALS AND METHODS

This study was conducted at Manipal Tata Medical College, Jamshedpur, India, over a period of three months.

Inclusion criteria

Apparently healthy adult women
Individuals with a predominantly sedentary lifestyle
Willingness for participation and give informed consent

Exclusion criteria

History of metabolic bone disorders (e.g., osteoporosis under treatment)
Chronic systemic illness (e.g., renal, hepatic, endocrine disorders)

Use of drugs that impact bone metabolism (e.g., corticosteroids, hormone replacement therapy)
Pregnancy or lactation
After the approval from institutional ethics committee, a total of 65 adult women were enrolled in this study. All participants have gone through written informed consent prior to inclusion in the study.
After application of the appropriate sample size calculation method, the sample size was approximately 67 participants. However, due to feasibility and availability during the study period, a total of 65 participants were included, which is considered adequate for exploratory analysis.

Data collection
Anthropometric measurements
Height and weight were measured using a stadiometer and calibrated weighing scale respectively. Body mass index (BMI) was calculated using the formula: BMI = weight (kg) / height (m^2).
Assessment of bone mineral density
Bone Mineral Density (BMD) was measured using a SONOST 3000 ultrasound bone densitometer. The results were expressed as T-scores and interpreted according to World Health Organization (WHO) criteria (Table 1) .
Assessment of sedentary lifestyle
Sedentary behavior was assessed based on self-reported physical activity levels. Participants with minimal physical activity and prolonged sitting duration were categorized as having a sedentary lifestyle.

Statistical analysis
All statistical analyses were performed using Microsoft excel and Minitab version 17. Descriptive statistics were expressed as mean ± standard deviation (SD). Pearson's correlation coefficient was used to determine the association between BMI and BMD (T-score). A p-value of <0.05 indicated statistically significant.

RESULTS
A total of 65 participants were included in the study and categorized into three age groups: 26–35 years (n = 20), 36–45 years (n = 19), and >45 years (n = 26).
Baseline characteristics
The anthropometric parameters of the study population are summarized in Table 2. The mean height, weight, and body mass index (BMI) varied across age groups. Participants aged 26-35 years had a mean height of 162.35 ± 5.33 cm, mean weight of 68.00 ± 5.09 kg, and mean BMI of 25.80 ± 1.63 kg/m^2. In the 36-45 years group, the mean height, weight, and BMI were 159.68 ± 5.44 cm, 64.31 ± 5.52 kg, and 25.24 ± 2.08 kg/m^2, respectively. Participants aged >45 years demonstrated a higher mean BMI (28.28 ± 2.35 kg/m^2), along with a mean height of 157.54 ± 4.87 cm and weight of 70.15 ± 5.97 kg.

Bone mineral density distribution
Based on the World Health Organization (WHO) classification (Table 1), 33 participants (50.77%) had normal bone mineral density (BMD) (T-score ≥ −1.0), 31 participants (47.69%) were classified as osteopenia (T-score between −1.0 and −2.5), and 1 participant (1.54%) was osteoporosis (T-score ≤ −2.5) (Table 3).
Correlation between BMI and T-score
Pearson's correlation analysis demonstrated a statistically significant negative correlation between BMI and T-score ($r = -0.707$, $p < 0.001$) (Table 4). This finding indicates that increasing BMI was associated with lower T-scores in the study population.

Graphical representation
The scatter plot (Figure 1) illustrates the inverse relationship between BMI and T-score, confirming the results of the correlation analysis.

Table 1: WHO definition of osteoporosis and osteopenia

Terminology	**T-score definition**
Normal	T≥ -1.0 and above
osteopenia	T < -1.0 to -2.5
osteoporosis	T ≤ -2.5
Established osteoporosis	T ≤ -2.5 in presence of one or more fragility fractures

Table 2: Anthropometric data

Age (year)	**Number of participants**	**Height (Mean± SD)**	**Weight (Mean± SD)**	**BMI kg/m2 (Mean± SD)**
26-35	20	162.35±5.33	68.00±5.09	25.80±1.63
36-45	19	159.68±5.44	64.31±5.52	25.24±2.08
Above 45	26	157.54±4.87	70.15±5.97	28.28±2.35

Table 3: BMD values in percentages

T-score for BMD	No. of subjects	Percentage (%)
T≥ -1.0 and above	33	50.77
T < -1.0 to -2.5	31	47.69
T ≤ -2.5	01	01.54

Correlation coefficient between BMT and T score calculated using Karl Pearson's correlation coefficient. The r value was -0.70 with p value 0.00. P value less than 0.05, shows the significant negative correlation between BMT and T score.

Table 4: Correlation of BMI with T score

Correlation BMI with T score		
r value	p value	Significant
-0.707	0.00	

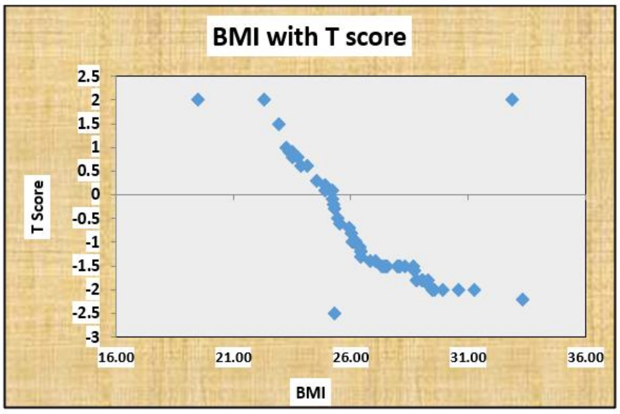

Figure 1: Correlation of BMI with T score

DISCUSSION

The present study evaluated the relationship between body mass index (BMI) and bone mineral density (BMD) among adult participants, with particular emphasis on T-score distribution and its clinical implications. The findings revealed a high prevalence of osteopenia and a significant inverse relationship between BMI and T-score.

In this study, nearly half of the participants (47.69%) were classified as osteopenic, while only 1.54% were osteoporotic. This suggests that reduced bone mass is relatively common even in apparently healthy individuals and may represent a critical window for early intervention. Previous studies have similarly reported a substantial burden of low bone mass in middle-aged populations, emphasizing the importance of early screening and preventive strategies (Prabha V and Stanly A M., 2025).

The anthropometric analysis demonstrated an increasing trend in BMI with advancing age, with the highest BMI observed in participants aged above 45 years. This is consistent with established evidence that age-related metabolic changes and reduced physical activity contribute to increased adiposity. However, in contrast to the traditionally accepted protective role of higher BMI on bone mass, the present study demonstrated a statistically significant negative correlation between BMI and T-score ($r = -0.707$, $p < 0.001$).

The relationship between BMI and BMD remains complex and somewhat controversial. Several studies have reported a positive association, suggesting that higher BMI may increase BMD through mechanical loading and hormonal influences (Song J et al., 2020). Similarly, a recent systematic review and meta-analysis reported a moderate positive correlation between BMI and BMD in postmenopausal women (Cai S et al., 2025). However, other studies have highlighted that obesity may not always be protective and can even have detrimental effects on bone quality, depending on fat distribution and metabolic factors (Li Y 2022).

The negative correlation observed in the present study may be explained by several mechanisms. Increased adiposity, particularly visceral fat, is associated with chronic low-grade inflammation, which promotes osteoclastogenesis and inhibits osteoblast activity. Additionally, adipokines and inflammatory cytokines such as interleukin-6 and tumor necrosis factor-alpha contribute to increased bone resorption. Furthermore, mesenchymal stem cells may preferentially differentiate into adipocytes rather than osteoblasts in individuals with higher BMI, leading to reduced bone formation.

Another contributing factor could be vitamin D deficiency, which is commonly observed in individuals with higher BMI due to sequestration in adipose tissue. Reduced vitamin D bioavailability can impair calcium absorption and negatively affect bone mineralization. Moreover, BMI does not differentiate between fat mass and lean mass, and this limitation may obscure the true relationship between body composition and bone health. Studies evaluating trabecular bone score and body composition have emphasized that lean mass may have a more beneficial effect on BMD compared to fat mass (Kim YS et al., 2017).

The findings of this study contribute to the growing body of evidence suggesting that BMI alone may not be a reliable predictor of bone health. Instead, a more comprehensive assessment incorporating body composition, fat distribution, and metabolic factors may be required for accurate evaluation of osteoporosis risk.
Despite these findings, the study has certain limitations. The relatively small sample size and cross-sectional design limit causal inference. Additionally, the use of BMI as a surrogate marker for adiposity does not account for differences in fat and lean mass distribution. Future studies with larger populations, longitudinal designs, and advanced imaging techniques such as dual-energy X-ray absorptiometry (DEXA) are warranted to better elucidate these relationships.

CONCLUSION

The present study demonstrates a high prevalence of osteopenia among the study population, indicating that reduced bone mineral density is common even in apparently healthy adults. A statistically significant negative correlation was observed between body mass index (BMI) and T-score, suggesting that higher BMI may be associated with lower bone mineral density in this cohort.
These findings challenge the traditionally held notion that increased BMI has a protective effect on bone health and highlight the need for a more nuanced understanding of the relationship between adiposity and bone metabolism. BMI alone may not be a reliable predictor of bone health, and assessment of body composition and metabolic factors should be considered for a more accurate evaluation.
Early screening for bone mineral density, particularly in individuals with higher BMI and advancing age, may help in identifying those at risk and implementing timely preventive strategies. Further large-scale, longitudinal studies are warranted to better elucidate the complex interplay between BMI, body composition, and bone health.

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