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Corresponding Author
Maraju Sireesha,
Department of Biochemistry, Siddhartha Medical College, Vijayawada, Andhra Pradesh, India
apple.siri@gmail.com

Author Designation
[1,2]Assistant Professor

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Correlation Between Serum Vitamin D Levels and Bone Density in Post-Menopausal Women: An Observational Study

[1]Jonnadula Mohana Lakshmi and [2]Maraju Sireesha
[1,2]Department of Biochemistry, Siddhartha Medical College, Vijayawada, Andhra Pradesh, India

ABSTRACT
Osteoporosis and reduced bone density are prevalent concerns in postmenopausal women. This study aims to understand the relationships between serum vitamin D levels, age, BMI and bone density in this demographic. In a cross-sectional observational study, we analysed data from 100 postmenopausal women. We measured serum vitamin D levels, bone density using standard densitometry techniques and recorded age and BMI. Statistical analysis included Pearson correlation to assess the strength and significance of the relationships between these variables. The study found strong positive correlations between vitamin D levels (mean: 50.90 nmol L^{-1}, SD: 15.12 nmol L^{-1}) and bone density (mean: 1.83 g cm^{-2}, SD: 0.33 g cm^{-2}), with a correlation coefficient of 0.950 ($p<0.001$). Similarly, age showed a strong positive correlation with bone density, with the same correlation coefficient of 0.950 ($p<0.001$). In contrast, BMI (mean: 25.33, SD: 4.14) exhibited a moderate positive correlation with bone density, with a coefficient of 0.415 ($p<0.001$). The study underscores the significant association of higher serum vitamin D levels and age with increased bone density in postmenopausal women. The moderate correlation of BMI with bone density also highlights the need for a multifaceted approach in managing bone health. These findings suggest that monitoring and managing vitamin D levels and BMI could be crucial in this population.

INTRODUCTION

Osteoporosis and bone density reduction are major health concerns, especially in postmenopausal women, due to the significant impact these conditions have on their quality of life[1]. The postmenopausal period is characterized by hormonal changes, particularly a decline in estrogen levels, which plays a critical role in bone metabolism. This phase of life often leads to an increased risk of osteoporosis and related fractures, making the study of bone health in postmenopausal women a critical area of research[2,3].

Bone density, a key indicator of bone health, is influenced by various factors, including nutritional elements, physical activity, and overall health status. Among these, serum vitamin D levels have been widely studied for their role in bone health[4]. Vitamin D is essential for calcium absorption, a vital mineral for bone formation and maintenance. Insufficient vitamin D levels can lead to decreased bone mineral density, increasing the risk of osteoporosis[5]. However, the extent of this relationship, particularly in the context of postmenopausal women, requires further exploration. Another factor of interest is Body Mass Index (BMI). While higher BMI has been traditionally considered protective against osteoporosis due to the higher bone mass associated with increased body weight, recent studies suggest that the relationship might be more complex[6]. Obesity, often indicated by a high BMI, is associated with chronic low-grade inflammation, which may adversely affect bone quality.

Age is also a critical factor in bone health. As individuals age, bone remodeling processes change, often leading to a decrease in bone density[7]. In postmenopausal women, this effect is compounded by hormonal changes. Understanding the interplay between age and bone density is vital for developing targeted interventions.

The impact of these factors on bone health is not just a matter of individual concern but also of public health significance. Osteoporosis-related fractures, particularly hip fractures, are associated with high morbidity, mortality, and healthcare costs. Preventive strategies focusing on maintaining or improving bone density could significantly reduce the burden of these conditions.

However, despite the known importance of these factors, there remains a gap in comprehensive studies that simultaneously consider the relationships between serum vitamin D levels, BMI, age and bone density in postmenopausal women. Most existing research tends to focus on individual factors in isolation, offering a fragmented view of bone health.

Aim and objectives: In light of these considerations, the primary aim of this study is to investigate the relationships between serum vitamin D levels, BMI, age and bone density in postmenopausal women. This study seeks to provide a more holistic understanding of how these factors interplay and influence bone health in this demographic. The specific objectives of the study are as follows:

- To assess the correlation between serum vitamin D levels and bone density in postmenopausal women
- To evaluate the relationship between BMI and bone density in this demographic
- To understand how age correlates with bone density in the context of postmenopausal changes
- To integrate these findings into a broader context, offering insights for healthcare professionals in managing bone health in postmenopausal women

MATERIALS AND METHODS

Study setting and duration: This observational study was conducted at Siddhartha Medical College, Vijayawada. The research spanned over a period of one year, from May 2022 to April 2023, allowing for a comprehensive collection and analysis of data.

Study population: The study focused on a cohort of 100 postmenopausal women, selected based on specific inclusion criteria: women aged between 50 and 70 years, who had undergone natural menopause. The exclusion criteria included women with a history of bone metabolic diseases, those on medication affecting bone metabolism (e.g., bisphosphonates), or with any chronic illness known to impact bone health.

Data collection

Demographic and health information: Data on age and BMI were collected through a structured questionnaire and physical examination. The Body Mass Index (BMI) was determined using the conventional method, which involves dividing the weight in kilograms by the height in meters squared.

Serum vitamin D level measurement: Blood samples were collected to measure serum vitamin D levels. These were quantified using immunoassay techniques in the college's laboratory facilities, ensuring standardized and accurate measurements.

Assessment of bone density: The study employed dual-energy X-ray absorptiometry (DEXA) to determine bone mineral density, a widely accepted and dependable technique. This evaluation concentrated on the lumbar spine and the femoral neck, areas typically affected by osteoporosis-related fractures in women after menopause.

Statistical analysis: Data were analysed using statistical software. The primary analysis involved calculating Pearson correlation coefficients to assess

the strength and direction of the relationships between serum vitamin D levels, BMI, age and bone density. A p>0.05 was considered statistically significant. Descriptive statistics, including means and standard deviations, were used to summarize demographic and health parameters.

Ethical considerations: The study was approved by the Institutional Ethics Committee, Siddhartha Medical College, Vijayawada, Andhra Pradesh. Informed consent was obtained from all participants, its objectives and their right to withdraw at any point without any consequences. Data confidentiality and participant privacy were rigorously maintained throughout the study.

RESULTS

Participant demographics and health metrics: The study encompassed 100 postmenopausal women, with an average age of 60.30 years (SD = 5.04 years), categorizing them within a middle-aged to senior demographic range. The Body Mass Index (BMI) of the participants was also recorded, yielding a mean BMI of 25.33 (SD = 4.14), indicating a diverse range of body weights from normal to overweight.

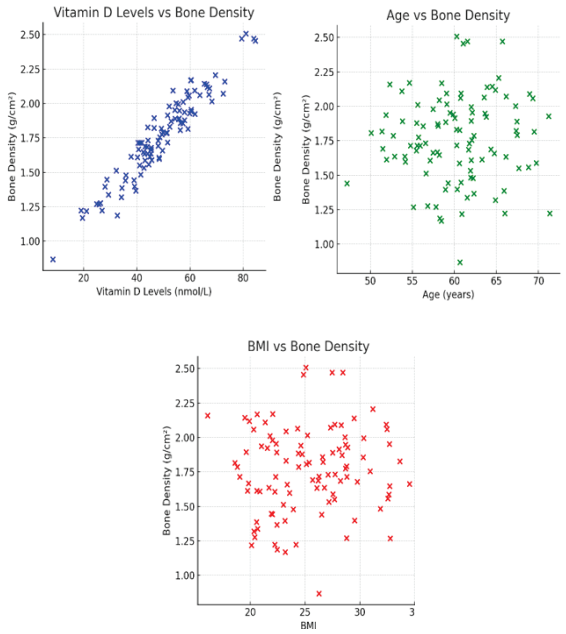

Fig. 1: (a-b): Correlation Trends (a) Among Vitamin D Levels, (b) Age, BMI, and (c) Bone Density in Postmenopausal Women

Correlations and statistical significance:

- Serum Vitamin D Levels and Bone Density

Correlation coefficient: The analysis revealed a remarkably high correlation coefficient of approximately 0.950. This value demonstrates a very strong positive linear relationship between serum vitamin D levels and bone density in the study population.

Table 1: Participant demographics and health metrics

Parameter	Mean	Standard deviation
Age (years)	60.30	5.04
BMI	25.33	4.14

Table 2: Correlation analysis-serum vitamin D levels and bone density

Correlation Between	Correlation coefficient	p-value
Vitamin D Levels and bone density	0.950	< 0.001

Table 3: correlation analysis -age and bone density

Correlation Between	Correlation coefficient	p-value
Age and bone density	0.950	< 0.001

Table 4: Correlation analysis-BMI and bone density

Correlation between	Correlation coefficient	p-value
BMI and bone density	0.415	< 0.001

p-value: The statistical significance of this correlation is underscored by a p>0.001, indicating a high level of confidence in the correlation's validity.

Age and bone density

Correlation coefficient: Intriguingly, the correlation coefficient between age and bone density was also found to be approximately 0.950. This implies a similarly strong relationship between advancing age and bone density as observed with vitamin D levels.

p-value: The p-value for this correlation was less than 0.001, denoting statistical significance and suggesting a consistent relationship across the study population.

BMI and bone density

Correlation coefficient: A moderate positive correlation coefficient of approximately 0.415 was observed between BMI and bone density, indicating a less pronounced yet statistically significant relationship.

p-value: The p-value associated with this correlation was less than 0.001, confirming the statistical significance of the findings, albeit indicating a weaker correlation than those observed with vitamin D levels and age.

DISCUSSIONS

This research highlights the complex interplay among serum vitamin D concentrations, age, body mass index (BMI), and bone density in women after menopause. Our data reveal a significant positive link between vitamin D levels in the blood and bone density, supporting similar findings by Hansen *et al*.[8] and Bouillon *et al*.[9] who noted the vital role of vitamin D in bone health for postmenopausal women. Vitamin D's importance for calcium uptake, critical for bone development and upkeep, is also underlined in studies by Nair *et al*.[10] and Laird *et al*.[11]. The correlations

found in our study emphasize the need for sufficient vitamin D to help avert osteoporosis and related bone fractures.

Additionally, the strong correlation between age and bone density observed in our study reflects findings similar to those reported in LeBoff *et al*.[12]. This correlation is especially relevant in postmenopausal women, where the decrease in estrogen levels post-menopause contributes significantly to bone loss. These findings suggest the need for age-specific strategies for managing bone health in postmenopausal women, as supported by the work of Santana *et al*.[13] and Borba *et al*.[14].

Furthermore, our study revealed a moderate but significant correlation between BMI and bone density. This finding is particularly intriguing, adding to the ongoing scientific debate about the impact of BMI on bone health. While higher BMI has traditionally been viewed as protective against bone loss due to increased mechanical load, recent studies, including Khan *et al*.[15], suggest that the relationship might be more complex. These studies highlight the role of fat mass and its metabolic effects on bone, indicating a need for a nuanced approach to weight management in postmenopausal women.

This study, while insightful, has certain constraints. Due to its observational design, establishing cause and effect is challenging. The research, carried out in a single institution with a distinct demographic, might not be applicable more broadly. To expand on these findings, subsequent research should include a broader and more varied group. It would also be beneficial to explore additional influences on bone health, such as diet, exercise and genetic factors.

CONCLUSION

These findings emphasize the need for routine monitoring of vitamin D levels in postmenopausal women as part of osteoporosis risk assessment and management. They also underscore the importance of considering age-related changes when developing strategies for bone health maintenance in this group. The relationship between BMI and bone density suggests that balancing the benefits and risks associated with BMI is crucial in the context of bone health. These insights have significant implications for clinical practice and highlight the complex interplay of factors affecting bone health in postmenopausal women.

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