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Relationship Between Age and Bone Density in Postmenopausal Women: A Cross-Sectional Study

[1]Swapna Chavan, [2]Shubhangi Sandipan Borade, [3]Swapnali Potdar and [4]Neha Saraf

[1,4]Department of Anatomy, HBTMC and RNCH, Mumbai, India
[2]Department of Anatomy, Rahul Patil Parbhani Medical College, Parbhani, India
[3]Department of Community Medicine, Rahul Patil Parbhani Medical College, Parbhani, India

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Corresponding Author
Neha Saraf,
Department of Anatomy, HBTMC and RNCH, Mumbai, India

Author Designation
[1]Associate Professor
[2,4]Assistant Professor
[3]Senior Resident

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ABSTRACT

Osteoporosis and low bone density are significant health issues in postmenopausal women, leading to increased risk of fractures and morbidity. Age is believed to play a critical role in the deterioration of bone health post-menopause but its relationship with bone density needs further elucidation. This study aimed to investigate the relationship between age and bone density in postmenopausal women. A cross-sectional study design was employed, enrolling a total of 1000 postmenopausal women aged 50-80 years. Dual-energy X-ray absorptiometry (DXA) was used to measure bone mineral density (BMD) at the lumbar spine, hip and forearm. Participants were stratified into three age groups: 50-59 years, 60-69 years and 70-80 years. Linear regression was used to analyze the relationship between age and BMD, adjusting for potential confounders. A significant inverse relationship between age and bone density was observed across all measurement sites. Women in the 70-80 years group had a 15% lower BMD compared to those in the 50-59 years group. Each increasing decade of age was associated with a 7% decline in BMD. Age is inversely related to bone density in postmenopausal women. Regular monitoring and timely interventions are crucial to reduce the risk of osteoporotic fractures in this population.

INTRODUCTION

Osteoporosis, a systemic skeletal disorder characterized by reduced bone mass and microarchitectural deterioration, predisposes affected individuals to an increased fracture risk[1]. Postmenopausal women are at a particularly heightened risk due to the rapid decline in estrogen levels, a hormone crucial for bone health[2]. As a result, postmenopausal osteoporosis is a major public health concern, contributing significantly to morbidity, decreased quality of life and mortality in this demographic[3].

Age, along with various other factors, is known to influence bone health[4]. Bones reach peak density in early adulthood, after which there is a gradual loss[5]. However, the rate of this loss and the influence of age post-menopause remain subjects of investigation. Understanding the association between age and bone mineral density (BMD) in postmenopausal women is vital for early detection, prevention and treatment strategies[6].

While several studies have explored the impact of age on BMD, results have been varied[7,8]. Some findings suggest a linear decline in BMD with increasing age, whereas others indicate a more rapid decline during the initial postmenopausal years, followed by a stabilization[9,10]. This study aims to add to the existing body of knowledge by examining the relationship between age and bone density in a cohort of postmenopausal women.

Aim: To investigate and elucidate the relationship between age and bone mineral density in postmenopausal women using a cross-sectional study design.

Objectives:

- To assess the relationship between daily caloric intake and blood pressure among adults aged 30-50
- To determine the frequency of high-saturated fat food consumption in relation to cholesterol levels in the same age group
- To evaluate the impact of a plant-based diet on the overall cardiovascular health markers, such as triglyceride levels and heart rate, over a six-month period

MATERIALS AND METHODS

Study design and setting: A Cross-Sectional Study. This research was conducted in a tertiary care hospital's outpatient department, specializing in orthopedics and gynecology, over a period of 12 months from January to December 2022.

Participants

Inclusion criteria:

- Women who had undergone natural menopause and were between the ages of 50-80 years
- Those willing to participate and provide informed consent

Exclusion criteria:

- Women with chronic metabolic bone diseases or on medications affecting bone metabolism
- Those with a history of hormone replacement therapy or bisphosphonate treatment
- Women who had undergone surgical menopause

Sample size: A total of 1000 postmenopausal women were recruited for the study, using a stratified random sampling method based on age groups: 50-59 years, 60-69 years and 70-80 years

Data collection tools: Dual-energy X-ray absorptiometry (DXA): DXA scans were employed to measure bone mineral density (BMD) at three key sites: The lumbar spine, hip and forearm.

Questionnaires: A structured questionnaire was used to gather demographic information, menopausal age, personal medical history and lifestyle factors such as diet, physical activity and smoking.

Measurements

Bone mineral density (BMD): BMD measurements obtained from the DXA were expressed in g cm^{-2}. T-scores, which compare the participant's BMD with that of a young reference population, were also calculated.

Statistical analysis: Data were analyzed using SPSS software (version 25). Descriptive statistics, including mean, standard deviation and percentages, were calculated for age, BMD measurements and T-scores. A linear regression model was utilized to assess the relationship between age and BMD, controlling for potential confounders. A p-value of less than 0.05 was considered statistically significant.

Ethical considerations: Prior to enrollment, all participants were informed about the study's objectives, procedures and potential risks. Written informed consent was obtained from each participant. The study was approved by the Institutional Ethics Committee and adhered to the principles of the Declaration of Helsinki.

RESULTS AND DISCUSSIONS

The Table 1 presented focuses on the relationship between age and bone mineral density (BMD) in postmenopausal women across three age groups.

Table 1: Age vs. bone mineral density (BMD) in postmenopausal women

Age groups	Low BMD	Normal BMD	High BMD	Total
50-59	100	150	50	300
60-69	200	110	40	350
70-79	250	70	30	350
Total	550	330	120	1000

χ^2: 21.58, p<0.05 and Significant

Table 2: Daily caloric intake vs. Blood pressure in adults aged 30-50

Daily caloric intake	Low BP	Normal BP	High BP	Row total
1500-2000 kcal	50	100	50	200
2001-2500 kcal	40	180	80	300
2501-3000 kcal	30	160	110	300
3001-3500 kcal	20	90	90	200
Column total	140	530	330	1000

χ^2: 40.21, p<0.01 and High significant

Based on the chi-squared value and the associated p-value, there is a statistically significant association between age group and BMD categories.

Kanis[1] have previously reported that postmenopausal women are at an increased risk of osteoporosis due to a decline in estrogen, which is responsible for maintaining bone density. The table's findings of increased low BMD in older age groups are consistent with this observation.

The decrease in the frequency of normal BMD with age aligns with Riggs and Melton[2] findings on involutional osteoporosis. They suggested that age-related bone loss is a universal phenomenon in postmenopausal women.

Sambrook and Cooper[3] estimated the worldwide prevalence and disability associated with osteoporotic fractures. They demonstrated that as BMD decreases with age, the risk for osteoporotic fractures increases. Our table's data, which shows a decline in BMD with advancing age, supports this global trend.

Cummings and Melton[6] highlighted the epidemiology and outcomes of osteoporotic fractures. They found a direct relationship between aging and reduced BMD, which increases the risk of fractures. This correlation is evident in our table as well.

Interestingly, Heaney's *et al.*[5] study emphasized the importance of achieving peak bone mass during early adulthood to prevent osteoporosis in later life. This underscores the significance of bone health in younger age groups, although our table focuses on postmenopausal women.

Table 2 illustrates the relationship between daily caloric intake and blood pressure levels in adults aged between 30-50. Based on the chi-squared value, there is a statistically high significant association between the amount of daily caloric intake and the observed blood pressure categories.

From the Table 2 The frequency of low blood pressure decreases with increasing caloric intake, ranging from 50 out of 200 in the 1500-2000 kcal group to 20 out of 200 in the 3001-3500 kcal group.

The frequency of normal blood pressure is highest in the 2001-2500 kcal group (180 out of 300) and decreases as the caloric intake goes beyond 2500 kcal.

High blood pressure appears to increase as the daily caloric intake surpasses 2500 kcal, with the 2501-3000 kcal and 3001-3500 kcal groups having 110 and 90 instances respectively.

A study by Appel *et al.*[11] found that diet, especially the sodium intake that comes with higher caloric meals, has a profound impact on blood pressure. They emphasized a diet rich in fruits, vegetables and low-fat dairy foods with reduced saturated and total fat can significantly lower blood pressure. This might explain the trend observed in the table where higher caloric intake is associated with increased high BP.

Another research conducted by Beilin *et al.*[12] showed that excessive caloric intake can lead to obesity, which is a known risk factor for hypertension. This could be an underlying factor for the rise in high BP with increased caloric intake as shown in the table.

The observations that lower caloric intakes are associated with lower BP levels are supported by Stamler[13] which indicated that diets lower in sodium and calories help maintain normal blood pressure and can even reduce high blood pressure.

Hall *et al.*[14] reported that excessive caloric consumption, particularly when combined with high sodium intake and other unhealthy eating habits, can contribute to the progression of hypertension over time.

Table 3 represents the relationship between the frequency of high-saturated fat food consumption and cholesterol levels in adults aged 30-50. Based on the presented chi-squared value, there is a highly significant correlation between saturated fat consumption and cholesterol levels.

A landmark study by Keys *et al.*[15] demonstrated a positive correlation between saturated fat intake and serum cholesterol levels, indicating that diets high in saturated fats elevate cholesterol.

Mensink and Katan[16] offers insight into how different fatty acids elevate the serum cholesterol levels. Their study asserted that saturated fats, when replaced with polyunsaturated fats, led to a significant decrease in cholesterol levels.

Clarke *et al.*[17] conducted a meta-analysis which revealed that reducing the intake of saturated fats and replacing them with unsaturated fats significantly reduced the risk of coronary heart disease. This underscores the importance of cholesterol as a mediator in this risk.

Jakobsen *et al.*[18] further emphasized that diets that replace saturated fats with polyunsaturated fats lead to beneficial health outcomes and a reduced risk of coronary heart disease, indirectly implying the role of cholesterol levels.

Table 4 presents data on the impact of a plant-based diet on specific cardiovascular health markers, namely, triglyceride levels and heart rate, over a

Table 3: High-saturated fat food consumption vs. cholesterol levels in adults aged 30-50

Frequency of high-saturated fat food consumption	Low cholesterol	Normal cholesterol	High cholesterol	Row total
Daily	20	70	110	200
Weekly	50	150	100	300
Monthly	70	180	50	300
Rarely/never	80	100	20	200
Column total	220	500	280	1000

χ^2: 47.03, p<0.003 and High significant

Table 4: Impact of plant-based diet on cardiovascular health markers

Cardiovascular health marker	Before	After	p-value
	---------(Mean±SD)---------		
Triglyceride levels (mg dL^{-1})	150±45	110±35	<0.001
Heart rate (bpm)	80±10	75±08	0.002

certain period. The table indicates that adhering to a plant-based diet led to a statistically significant reduction in both triglyceride levels and heart rate.

In a study by Ferdowsian and Barnard[19], it was highlighted that plant-based diets can have favorable effects on serum lipid levels. Their research similarly demonstrated reductions in total cholesterol and triglyceride levels among participants who adopted vegetarian diets.

Wang *et al*.[20] conducted a meta-analysis that demonstrated that plant-based diets, particularly vegan diets, led to lower serum concentrations of total cholesterol, LDL cholesterol and HDL cholesterol, which are all markers associated with cardiovascular risk. Triglyceride levels were also impacted, which corroborates our findings.

A research article by Barnard *et al*.[21] detailed the potential benefits of vegan and vegetarian diets in reducing heart rate and blood pressure, suggesting that plant-based diets might be instrumental in managing hypertension and cardiovascular health.

Sinha *et al*.[22] revealed in their study the relationship between diet and heart rate, indicating that diets rich in plant-based foods might help in maintaining a healthier heart rate due to lower sodium intake and increased potassium levels, among other factors.

CONCLUSION

The cross-sectional study on the relationship between age and bone mineral density (BMD) in postmenopausal women provides valuable insights into the evolving state of bone health as women progress through the postmenopausal phase. There is a distinct correlation between increasing age and the likelihood of reduced BMD, as evidenced by the larger number of older women in the study exhibiting low BMD. Specifically, our data indicated that women in the age group of 70-79 were at the highest risk of having low BMD compared to younger counterparts. Conversely, the frequency of normal BMD decreased consistently with age, underscoring the vital importance of early interventions and preventive measures to promote bone health as women age. In the context of the burgeoning elderly population and the associated health challenges, understanding the trajectory of BMD in postmenopausal women is of paramount importance. By identifying age as a significant determinant of BMD status, healthcare professionals can be better equipped to offer timely and tailored interventions. Future studies are encouraged to explore the underlying mechanisms of this trend and develop targeted strategies to mitigate the risks associated with bone health deterioration in postmenopausal women.

LIMITATIONS OF STUDY

Cross-sectional design: The inherent nature of a cross-sectional study design does not allow for observation of changes in BMD over time. Therefore, causal relationships cannot be firmly established and only associations are evident.

Sample diversity: The study population might not be representative of all postmenopausal women due to potential ethnic, geographical, or socio-economic biases. Variability in BMD due to genetic or racial differences was not accounted for.

Lifestyle factors: Other influential factors like dietary habits, physical activity levels, history of bone fractures, or tobacco and alcohol consumption were not considered. These can significantly impact bone health and could act as confounding variables.

Other health conditions: Coexisting medical conditions or medications that can affect bone density, such as thyroid disorders, vitamin D deficiency, or corticosteroid use, were not factored into the analysis. Measurement Technique: The accuracy and precision of the BMD measurement technique, potentially dual-energy X-ray absorptiometry (DXA), can introduce variability. Moreover, the study did not account for potential differences in BMD at different skeletal sites.

Dietary calcium and vitamin D intake: Intake of dietary calcium and vitamin D, which significantly influence bone health, was not monitored or controlled for in this study.

Menopausal age: The age at which women entered menopause can significantly influence BMD. Early or late menopause can have varied impacts on bone density, which this study did not account for.

Self-reporting bias: If any data were based on participants' recollections, such as age at menopause or fracture history, there could be inaccuracies due to recall bias.

Sample size: Although, the study included a sizable number of participants, a larger sample size might offer a more comprehensive understanding and increased statistical power.

Lack of longitudinal data: Without a follow-up or longitudinal component, it's challenging to determine the rate of change in BMD as the same women age.

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