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Original Research Article

CORRELATION OF SERUM VITAMIN D, CALCIUM, AND ALBUMIN LEVELS WITH BONE MINERAL DENSITY IN YOUNG ADULTS: A CROSS-SECTIONAL STUDY

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ABSTRACT

Background: The World Health Organization has recognized India as one of the nations with the highest prevalence of lifestyle sickness. It is quickly becoming the capital of lifestyle-related diseases due to starvation and a shortage of food, which are the main issues in developing countries like India[1]. Studies suggest that a significant proportion of Indians, ranging from 4% to 26%, living in both rural and urban areas, irrespective of their age, may not have access to sufficient amounts of protein, calcium, and other essential vitamins. **Aim:** This cross-sectional study investigates the correlation between serum vitamin D, calcium, and albumin levels with bone mineral density (BMD) among young adults aged 18–25 years at GSVM Medical College, Kanpur, India.

Materials and Methods: A sample of 150 participants was analyzed using anthropometric measurements, dietary habits, physical activity, and biochemical assessments, including serum vitamin D, calcium, and albumin levels. BMD was measured using Dual-Energy X-ray Absorptiometry (DEXA).

Results: Revealed no statistically significant relationships between BMD and the serum levels of vitamin D, calcium, or albumin. Specifically, Pearson's correlation coefficients for these markers showed weak, non-significant associations with BMD. Regression analysis also demonstrated that age, BMI, and dietary habits did not predict BMD significantly.

Conclusion: These findings highlight that bone health in young adults is likely influenced by multiple factors beyond conventional biochemical markers, including lifestyle, genetic, and hormonal factors. The study emphasizes the importance of promoting balanced nutrition and regular physical activity to maintain bone health among young individuals.

Keywords: Bone mineral density, Vitamin D, Calcium, Albumin, Young adults, Nutrition, Lifestyle.

INTRODUCTION

The World Health Organization has recognized India as one of the nations with the highest prevalence of lifestyle sickness. It is quickly becoming the capital of lifestyle-related diseases due to starvation and a shortage of food, which are

the main issues in developing countries like India.[1] Studies suggest that a significant proportion of Indians, ranging from 4% to 26%, living in both rural and urban areas, irrespective of their age, may not have access to sufficient amounts of protein, calcium, and other essential vitamins.

A healthy individual needs to eat an appropriate amount of food to maintain ideal muscle mass and to support various metabolic processes. This is crucial for ensuring a long and productive lifespan.[2] Throughout life, bones undergo continuous remodeling. However, concerns arise due to aging, hormonal changes, poor nutrition, sedentary lifestyle, and medical conditions. Decreased bone density with age increases the risk of osteoporosis and fractures, which is exacerbated by hormonal shifts like menopause. Inadequate calcium and vitamin D intake, sedentary habits, and conditions like osteoporosis and arthritis further compromise bone health.

Dietary patterns play a pivotal role in bone health, influencing bone mineral density (BMD) and bone turnover rates. Several studies have highlighted the impact of calcium, vitamin D, protein, and other micronutrients on bone health outcomes.[3] It has been suggested that higher calcium and vitamin D intake is associated with increased BMD and reduced fracture risk.[4]

Bone mineral density (BMD) is used in clinical medicine as a marker for osteoporosis and the risk of fractures. The quantitative measurement of bone mass refers to the quantity of mineral matter (calcium) in g/cm2 of bones. The National Institutes of Health Consensus Development Panel on Osteoporosis Prevention, Diagnosis, and Therapy defines osteoporosis as a skeletal condition marked by decreased bone strength and an increased risk of fracture.[5] The strongest risk factor of fracture is low BMD.[6] This magnitude of connection is comparable to the relationship between blood pressure and cardiovascular events. Therefore, BMD assessment is often used as a diagnostic technique for osteoporosis. Individuals with greater body weights have higher BMDs.[7] and lower fracture risks.[8]

Optimal serum vitamin D, calcium, and albumin levels are vital for preserving bone health and regulating BMI in young individuals. Deficiencies in these nutrients can significantly affect skeletal and metabolic integrity

- **Serum Vitamin D:** The amount of vitamin debye in the blood has an impact on Immune system performance, bone health, and general health, which is mostly received from food and sun exposure9. Low levels of 25-hydroxyvitamin D [25(OH)D] in the blood are indicative of vitamin D deficiency, which is linked to lower bone mineral density and a higher risk of fracture.[10]
- **Serum Calcium:** Calcium is required for many physiological functions, such as bone development, muscle contraction, nerve operation, and blood clotting. Vitamin D and parathyroid hormone control calcium.[11]
- **Serum Albumin:** The most prevalent protein in blood plasma is serum albumin, which is synthesized by the liver. Bone health and BMI may be affected by hypoalbuminemia, which is often a sign of malnutrition or underlying medical issues.[12]
- Apart from the direct effect of these nutrients on bone health, it is important to understand their interplay, which may indirectly affect bone health.
- During their hostel life, students are under immense academic pressure and have an irregular lifestyle. The consumption of junk food lacking sufficient nutrition and the food provided in the mess may not be sufficient to meet the dietary needs of individuals with proteins, minerals, and vitamins.

This study is done to create awareness among students and stakeholders in order to promote proper nutrition and hence bone health, enabling them physically as well as mentally.

MATERIALS AND METHODS

This cross-sectional study was conducted at GSVM Medical College and Associated Hospital, Kanpur, Uttar Pradesh, with approval from the Institutional Ehics Commiittee of Institute (EC/113/march/2024) among MBBS students staying in hostels aged between 18 and 25 years after informed consent. The data were collected using a predesigned proforma consisting of sociodemographic data, anthropometric data, and blood serum calcium, vitamin D, and albumin levels. 5 ml of venous blood was drawn in the morning from all study participants (it was not mandatory for the study participants to be in a fasting state). Samples were stored at 20°C until the tests were performed to ensure accuracy. All biochemical tests were performed in the institute using standard procedures for all reagents.

Serum Calcium level: The blood concentration of serum calcium was determined by the ARSEZNAZO procedure using a calorimeter (model CW02) and measuring it in mg/dl (kit manufactured by RECKON Diagnostics Pvt Ltd.)

Serum Vitamin D Level: The blood concentration of 25-hydroxyvitamin D (25(OH)D) was determined by measuring it in nanograms per milliliter (ng/mL) using ELISA LC-MS/MS method. kit manufactured by It functions as a marker of the body's vitamin D levels.

Serum Albumin Level: The blood albumin content was determined in grams per deciliter (g/dL) using bromocresol green dye-binding. Kit manufactured by ArkAY Pvt. Ltd.

Bone Mineral Density (BMD): Bone mineral content, quantified in grams per square centimeter (g/cm^2) was measured by Dual-Energy X-ray

Absorptiometry (DEXA) scans. BMD serves for the diagnosis of osteoporosis and the evaluation of fracture susceptibility.

Inclusion Criteria-

- Adults aged 18-25 years
- Participants providing informed consent
- Healthy individuals without acute or chronic illness

Exclusion criteria

- H/O, Hormonal or Vitamin D/Calcium supplementation
- Pregnant or lactating female

The details of students who completed the proforma were collected on a Microsoft Excel sheet. To examine statistical data, a statistical data analysis tool IBM SPSS Statistics "Statistical Package for the Social Sciences" version 26 was employed.

Statistics

Descriptive Statistics: Frequency distribution and percentage were used to summarize data.

Inferential Statistics: Multiple regression analysis was performed to determine whether the independent variables statically predicted the dependent variable (BMD). Pearson's correlation was performed to determine the relationship between the biochemical markers and BMD.

RESULTS

Demographic characteristics

Table 1 shows the demographic analysis of the study population, which consisted of 150 participants. Males constitute a larger proportion (58%) compared to females (42%). A total of 79.4% of the participants were between the ages of 18 and 21, while 20.6% were between the ages of 22 and 25. With respect to lifestyle characteristics, 52.6% of the participants indicated their involvement in physical activity, whereas 47.4% did not. Exactly 50% of individuals maintain a vegetarian diet, whereas the same number of people adopt a nonvegetarian diet. The prevalence of smoking was very low as 99.4% of individuals identified as nonsmokers and only 0.6% indicated engaging in smoking. The results indicate that the group studied consists mostly of young, physically active individuals who prioritize their health.

Table 2 presents the Anthropometric Measurements, Serum Biomarkers, and Bone Mineral Density of the Respondents

Relationship between Serum Vitamin D Levels and Bone Mineral Density (BMD) Among Respondents

Table 3 displays the results of the association analysis between the levels of Vitamin D in the blood and the density of minerals in the bones (BMD) of a total of 150 participants. The Pearson correlation coefficient was 0.013, demonstrating a very modest negative association between blood Vitamin D levels and BMD. However, this association was not statistically significant, as indicated by a p-value of 0.877 ($p > 0.05$). The absence of significance indicates that there was no substantial correlation between blood Vitamin D levels and BMD in this particular group, suggesting that changes in Vitamin D levels did not have significant implications on bone mineral density among the participants.

Correlations between Serum Calcium and Bone Mineral Density (BMD) among respondents

Table 4 shows that the Pearson correlation coefficient between serum calcium levels and bone mineral density (BMD) was 0.144, indicating a weak negative association. However, with a p-value of 0.078, this relationship was not statistically significant, suggesting that the observed correlation could be due to chance rather than true effects. With a sample size of 150, these results imply that there is no strong or statistically significant link between serum calcium levels and BMD in this cohort.

Correlations Between Serum Albumin and Bone Mineral Density (BMD) among respondents

Table 5 presents the association analysis between serum albumin levels and bone mineral density (BMD) in the 150 participants. The Pearson correlation coefficient was 0.000, with a p-value of 0.996, suggesting that there was no statistically significant relationship between serum albumin and BMD (bone mineral density). The serum albumin levels had no substantial impact on bone mineral density in this study.

Table 1: Demographic analysis

Variables	Frequency	Percentage
Gender		
Female	63	42.0
Male	87	58.0
Age		
18–21	119	79.4
22-25	31	20.6
Physical Exercise		
No	71	47.3
Yes	79	52.7
Dietary Habit		
Veg	75	50
Nonveg	75	50
Smoking		
No	149	99.3
Yes	1	0.7

Table 2: Distribution of Anthropometric Measurements, Serum Biomarkers, and Bone Mineral Density Among Respondents

Variables	Frequency	Percentage
Height (in cm.)		
<150	3	2.0
150-159	50	33.3
160-169	47	31.3
170-179	43	28.6
180<=	7	4.6
Weight (kg)		
<40	1	0.6
40-54	39	26.0
55-69	83	55.3
70-84	21	14.0
85<=	6	4.0
Body Mass Index (BMI)		
<20	42	27.6
20-29	100	65.8
30-39	7	4.6
40<=	1	0.7
Serum Vitamin D (30-50 ng/ml)		
Severely Deficient	90	60
Deficient	35	23.33
Insufficient	7	4.67
Sufficient	18	12
High	0	0
Serum Calcium (8.5 – 10.5 mg/dl)		
Hypocalcemia	61	40.67
Normal	71	47.33
Hypercalcemia	18	12
Serum albumin(3.4 - 5.4 gm/dl)		
Low	22	14.67
Normal	66	44
High	62	41.33
Bone mineral density		
< -2.65	4	2.6
< -0.65	60	40.0
< 3.35	79	52.6
< 5.35	4	2.6
< 8.35	2	1.3
>= 8.35	1	o.6

Table 3: Correlations between Serum vitamin D level and BMD

		Bone mineral density
Serum vitamin D levels	Pearson Correlation	-.013
	Sig. (2-tailed)	.877
	N	150

Table 4: Correlations between Serum calcium and BMD

		Bone mineral density
Serum Calcium	Pearson Correlation	-0.144
	Sig. (2-tailed)	0.078
	N	150

Table 5: Correlations between Serum albumin and BMD

		Bone mineral density
Serum albumin(g/dL)	Pearson Correlation	.000
	Sig. (2-tailed)	.996
	N	150

Table 6: Multiple Regression Analysis

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	40.660	6	6.777	2.038	.064[b]
	Residual	475.610	143	3.326		
	Total	516.270	149			

a. Dependent Variable: Bone mineral density

b. Predictors: (Constant), Serum Vitamin D , Body Mass Index (BMI), DIET, Serum Calcium, AGE, Serum albumin(g/dL)

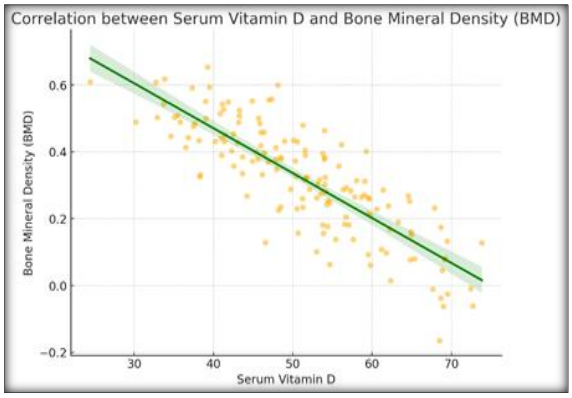

Figure 1: Illustration of Scatter plot showing the correlation between Serum Vitamin D levels and Bone Mineral Density (BMD)

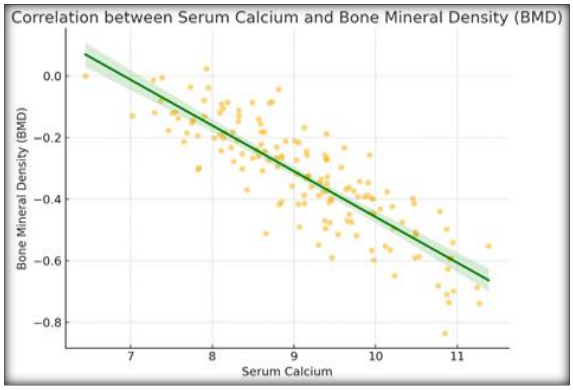

Figure 2: Illustration of Scatter plot showing the correlation between Serum calcium levels and Bone Mineral Density (BMD)

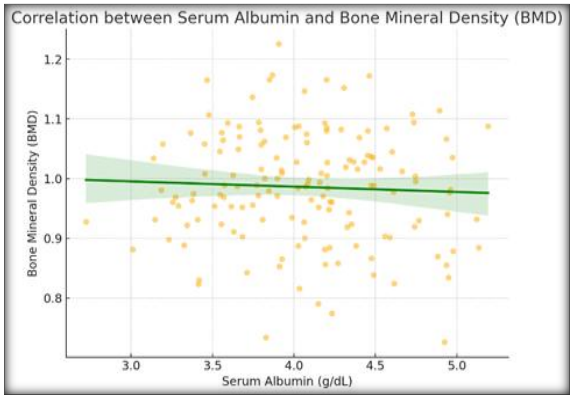

Figure 3: Scatter plot showing the correlation between Serum Albumin and Body Mineral density (BMD)

DISCUSSION

This study aimed to explore the complex relationships of serum Vitamin D, Calcium, and albumin levels with regard to bone mineral density (BMD) in young adults. In our study, there was a weak negative nonsignificant correlation between Vit. D to BMD (Table 3). On analyzingthe correlation between calcium and BMD, aa weak negative nonsignificant correlation was found (Table 4). PrevMithalal. (2024), fo found a weak correlationween vitamin debye levels and bone mineral density in young adults.[13] Sahota et al. (2023) also reported that vitamin D supplementation increased blood vitamin D levels but did not have a noticeable effect on bone mineral density.[14] These findings support the view that bone health is influenced by a combination of factors beyond vitamin D alone.[15]

Reid et al. (2024) observed only weak correlations between serum calcium and BMD in younger individuals, suggesting that factors such as physical activity and overall nutrition may be more influential in determining bone density.[16] Heaney et al. (2023) noted that while calcium is important for bone health, its impact on BMD might be less significant than other dietary and lifestyle variables, particularly in young populations.[17] Our study revealed no significant correlation between serum albumin levels and bone mineral density (BMD) among a cohort of 150 young adults, suggesting that serum albumin levels do not have a meaningful impact on BMD. Similarly, another study by Orwoll et al. (2009) also suggested that serum albumin might not be a significant predictor of BMD in younger populations,[18] but a study by Kwon et al. (2018) found that lower serum albumin levels were associated with lower BMD in older adults, indicating a potential link between nutritional status and bone health.[19]

The reasons for these non-significant correlations may be due to the threshold effect of the biochemical parameters below which the BMD might have been affected or due to the genetic makeup or hormonal status of the individual like Parathyroid hormone- which decreases BMD and Vit. K and Magnesium which increase BMD.

Multiple regression analysis that was done to predict BMD from age, BMI, and Dietary habits, which did not statistically significantly predict BMD, $F(6,143) = 2.038$, $p = 0.064$, $R2 = .079$.

CONCLUSION

The findings of the study revealed no statistically significant relationship between vit. D levels and BMD. This implies that other variables, such as physical activity and nutritional habits, may have a greater impact on bone health in young adults. There is also statistically insignificant relationship between blood calcium levels and BMD, also there is no obvious correlation was observed between BMD and blood Albumin levels. This finding highlights the intricate nature of bone health, suggesting that it is affected by a diverse interaction of variables that goes beyond conventional dietary indicators.

Limitations

The results may not be applicable to larger/variate/other age groups due to limited and specialized sample size.

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