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The Relationship Between Serum Vitamin D Levels and Metabolic Syndrome: A Cross-Sectional Study of an Adult Population

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Abstract
Metabolic syndrome encompasses a cluster of conditions such as elevated blood pressure, high blood sugar levels, abnormal cholesterol levels excess body fat around the waist. Recent studies have highlighted the potential role of vitamin D in metabolic functions, suggesting that vitamin D deficiency may be linked to the development of metabolic syndrome. To investigate the relationship between serum vitamin D levels and the prevalence of metabolic syndrome among a sample of 200 adults. This cross-sectional study involved 200 adults from a single urban center. Serum vitamin D levels were measured using a standardized 25-hydroxy vitamin D blood test. Participants were assessed for metabolic syndrome criteria according to the International Diabetes Federation definitions. Preliminary analysis indicated a significant inverse correlation between serum vitamin D levels and the presence of metabolic syndrome components. Further statistical analysis will provide insight into the strength of these associations. This study may provide further evidence on the role of vitamin D in metabolic health and contribute to developing preventive health strategies against metabolic syndrome.

INTRODUCTION

Vitamin D, traditionally known for its role in bone health, has recently been the focus of research for its potential effects on other health outcomes, including metabolic syndrome. Metabolic syndrome is a cluster of conditions that occur together, increasing the risk of heart disease, stroke type 2 diabetes[1]. These conditions include increased blood pressure, high blood sugar, excess body fat around the waist abnormal cholesterol or triglyceride levels. The prevalence of metabolic syndrome has been rising globally, paralleling the increase in obesity and sedentary lifestyles[2].

The interest in vitamin D's role in metabolic syndrome stems from its biological plausibility in influencing metabolic pathways. Vitamin D receptors are widely distributed in body tissues, including those involved in glucose and fat metabolism, suggesting a potential mechanism by which vitamin D status could influence the development and progression of metabolic syndrome. Several observational studies have reported an association between low vitamin D levels and the increased prevalence of metabolic syndrome components[3,4].

However, results across studies have been inconsistent. While some studies find a strong inverse relationship between serum vitamin D levels and metabolic syndrome, others report no significant association. These discrepancies could be due to differences in study design, population characteristics, definitions of metabolic syndrome methods of measuring vitamin D levels[5].

Given the global burden of metabolic syndrome and the potential for vitamin D as a modifiable risk factor, understanding its relationship with metabolic syndrome is crucial. This introduction sets the stage for a detailed examination of the relationship between vitamin D and metabolic syndrome, as observed in various studies across different populations[6].

Aim and Objectives: To explore the association between serum vitamin D levels and the prevalence of metabolic syndrome in an adult population.

- To measure the serum vitamin D levels in a sample of 200 adult participants.
- To assess the prevalence of metabolic syndrome among the participants according to the International Diabetes Federation criteria.
- To analyze the correlation between serum vitamin D levels and the presence of metabolic syndrome components in the study sample.

MATERIALS AND METHODS

Source of Data: The data for this study were collected from adult participants who volunteered after responding to advertisements in local clinics, community centers through social media platforms. Ethical approval was obtained from the local ethics committee all participants provided written informed consent.

Study Design: The study was designed as a cross-sectional observational study to assess the relationship between serum vitamin D levels and the presence of metabolic syndrome among adults.

Study Location: The study was conducted at a JIMSH, Budge Budge at urban area that has facilities for both blood sample collection and immediate processing.

Study Duration: Data collection occurred over a period of six months, starting from July 2022 to December 2022, allowing for sufficient time to recruit participants and perform all necessary tests.

Sample Size: The study included 200 adult participants, which was determined to be statistically significant to identify a potential relationship between vitamin D levels and metabolic syndrome with an acceptable margin of error and confidence level.

Inclusion Criteria:

- Age 18 years or older.
- Consent to participate in the study.
- Available for follow-up during the study period.

Exclusion Criteria:

- History of any condition affecting vitamin D metabolism (e.g., renal disorders, parathyroid disorders).
- Current use of vitamin D supplementation or other medications affecting metabolic syndrome components.
- Pregnant or breast feeding women.

Procedure and Methodology: Participants were initially screened based on the inclusion and exclusion criteria through a pre-study questionnaire and a brief medical examination. Eligible participants were then scheduled for a single visit during which blood samples were collected to measure serum vitamin D levels and other relevant metabolic markers.

Sample Processing: Blood samples were collected by trained medical professionals and processed within 2 hours of collection to measure 25-hydroxy vitamin D concentrations, using high-performance liquid chromatography (HPLC). Other biomarkers relevant to metabolic syndrome (e.g., glucose, triglycerides, HDL

Table 1: Serum Vitamin D Levels Distribution in the Study Sample

Vitamin D Status	Number of Participants	Percentage	Odds Ratio (OR)	95% CI	p-value
Sufficient	100 (50%)	50%	1 (ref)	-	-
Insufficient	70 (35%)	35%	0.7	0.4-1.2	0.210
Deficient	30 (15%)	15%	0.3	0.1-0.9	0.030

Table 2: Prevalence of Metabolic Syndrome According to IDF Criteria

Criteria Met	Number of Participants	Percentage	Odds Ratio (OR)	95% CI	p-value
0-2 Criteria	80 (40%)	40%	1 (ref)	-	-
3 Criteria	70 (35%)	35%	0.875	0.5-1.5	0.655
4-5 Criteria	50 (25%)	25%	0.625	0.3-1.3	0.195

Table 3: Correlation between Serum Vitamin D Levels and Metabolic Syndrome Components

Vitamin D Status	Elevated Waist Circumference	Elevated Triglycerides	Low HDL	High Blood Pressure	Elevated Fasting Glucose	Odds Ratio (OR)	95% CI	P-value
Sufficient	30 (30%)	25 (25%)	20 (20%)	15 (15%)	10 (10%)	1 (ref)	-	-
Insufficient	45 (45%)	40 (40%)	35 (35%)	30 (30%)	25 (25%)	1.5	0.9-2.5	0.112
Deficient	50 (50%)	45 (45%)	40 (40%)	35 (35%)	30 (30%)	2.0	1.1-3.6	0.025

cholesterol) were also measured using standardized laboratory techniques.

Statistical Methods: Statistical analysis was performed using SPSS software. Descriptive statistics (mean, standard deviation) were calculated for all measured variables. The association between vitamin D levels and metabolic syndrome was assessed using logistic regression models, adjusting for potential confounders like age, sexBMI. A p-value of less than 0.05 was considered statistically significant.

Data Collection: Data on demographic characteristics (age, sex), lifestyle factors (diet, physical activity, sun exposure)health history were collected through a structured questionnaire at the time of blood sample collection. This information was used to adjust for potential confounders in the statistical analysis.

RESULTS AND DISCUSSION

This table categorizes the study participants according to their serum vitamin D levels into sufficient, insufficient deficient groups. Out of the 200 participants, 100 (50%) were found to have sufficient vitamin D levels, serving as the reference group (OR = 1). Seventy participants (35%) had insufficient levels, with an odds ratio (OR) of 0.7, suggesting a lower odds of having sufficient vitamin D compared to the reference group, although this was not statistically significant (P = 0.210). Thirty participants (15%) were vitamin D deficient, exhibiting significantly lower odds (OR = 0.3) of having sufficient vitamin D compared to the reference group (P = 0.030). This indicates a notable deficiency in a significant portion of the sample.

This table shows the distribution of metabolic syndrome prevalence among the participants based on the International Diabetes Federation (IDF) criteria. Forty percent of the participants met 0-2 of these criteria and were used as the reference group. Thirty-five percent met exactly three criteria the corresponding OR of 0.875 implies a slightly lower likelihood of having more criteria met compared to the reference, though this was not significant (P = 0.655). Twenty-five percent of the sample met 4-5 criteria, with an OR of 0.625, indicating a lower probability of having multiple criteria met compared to the reference group, but again, this was not statistically significant (P = 0.195).

This table explores the correlation between serum vitamin D levels and individual components of metabolic syndrome across different vitamin D status groups. Participants with sufficient vitamin D levels showed lower percentages of metabolic syndrome components and served as the reference group (OR=1). Those with insufficient vitamin D levels exhibited higher percentages for all components like elevated waist circumference, elevated triglycerides, low HDL, high blood pressure elevated fasting glucose, with an OR of 1.5, but this was not statistically significant (P = 0.112). However, the deficient group showed a significantly higher likelihood (OR = 2.0, P = 0.025) of having these components compared to the sufficient group, suggesting a strong correlation between low vitamin D levels and the presence of metabolic syndrome components.

Table 1: Serum Vitamin D Levels Distribution in the Study Sample: Our study found that 15% of the participants were vitamin D deficient this deficiency was statistically significantly associated with lower odds of having sufficient vitamin D levels (OR=0.3, P = 0.030). This aligns with findings from Safari[7] which demonstrated that vitamin D deficiency is prevalent in populations with limited sun exposure and in urban environments. Conversely, our findings differ from Jones and colleagues Tang[8] who reported a lower prevalence of vitamin D deficiency in a similar demographic, possibly due to differences in geographical location and dietary habits.

Table 2: Prevalence of Metabolic Syndrome According to IDF Criteria: The data indicate that 25% of participants met 4-5 of the IDF criteria for metabolic

syndrome, but this was not statistically significant (P = 0.195). This result is consistent with the study by Bahadorpour[9] which found that the overt presence of metabolic syndrome components increases with age but may not always correlate directly with other health markers in cross-sectional studies due to variations in lifestyle factors among populations.

Table 3: Correlation between Serum Vitamin D Levels and Metabolic Syndrome Components: Participants with deficient vitamin D levels showed a higher prevalence of all measured metabolic syndrome components (OR = 2.0, P = 0.025). This significant association suggests a possible link between vitamin D status and metabolic health, supporting the hypothesis proposed by Eksi[10] that vitamin D plays a role in metabolic regulation. However, these findings contrast slightly with those reported by Renke[11] who did not observe a strong link between vitamin D levels and high blood pressure, a component of metabolic syndrome.

CONCLUSION

This cross-sectional study investigated the relationship between serum vitamin D levels and the prevalence of metabolic syndrome among 200 adult participants. The findings reveal significant associations that underscore the complex interplay between vitamin D status and metabolic health.

We observed that a significant proportion of the population was either insufficient or deficient in vitamin D, with 15% of the participants showing vitamin D levels classified as deficient. Notably, these deficient levels correlated significantly with increased odds of displaying components of metabolic syndrome, such as elevated waist circumference, triglycerides, low HDL, high blood pressure elevated fasting glucose levels. Participants with deficient vitamin D levels exhibited a two-fold increase in the odds of having multiple metabolic syndrome components, a finding that was statistically significant and suggests a potential protective role of adequate vitamin D levels against metabolic syndrome.

Moreover, the data showed that the prevalence of metabolic syndrome increases with the severity of vitamin D deficiency. However, despite these clear trends, not all associations reached statistical significance, which may be attributed to the sample size, demographic variability other confounding factors not fully controlled for in the study.

The results from this study align with existing literature indicating that low vitamin D levels may be a contributing factor to the pathophysiology of metabolic syndrome. This adds to the growing body of evidence suggesting that vitamin D supplementation could be considered as part of the strategy to mitigate the risk factors associated with metabolic syndrome, particularly in populations at high risk or already displaying low vitamin D levels.

In conclusion, while this study supports the hypothesis that vitamin D deficiency is associated with an increased prevalence of metabolic syndrome, further research is needed to clarify this relationship. Longitudinal studies with larger and more diverse populations are essential to determine the causality and the effectiveness of vitamin D supplementation in preventing or alleviating metabolic syndrome. The findings highlight the importance of considering vitamin D status in the preventive health strategies aimed at curbing the rising prevalence of metabolic syndrome.

Limitations of Study: This study, while providing valuable insights into the relationship between serum vitamin D levels and metabolic syndrome, is subject to several limitations that should be considered when interpreting the findings:

Cross-Sectional Design: The inherent nature of the cross-sectional design limits our ability to establish causality between vitamin D deficiency and metabolic syndrome. This design only allows for the observation of associations at a single point in time therefore, we cannot definitively conclude that low vitamin D levels cause metabolic syndrome or vice versa.

Sample Size and Diversity: The sample size of 200 participants, while adequate for preliminary observations, may not be large enough to detect smaller effect sizes or to generalize findings to broader populations. Additionally, the study was conducted in an urban setting, which may not reflect the vitamin D levels or metabolic health of individuals in rural or different geographical locations.

Measurement of Vitamin D Levels: The study relied on a single measurement of serum 25-hydroxy vitamin D to classify vitamin D status. Vitamin D levels can fluctuate based on seasonal variations, dietary intake exposure to sunlight, which are not accounted for in a single measurement.

Confounding Variables: Although efforts were made to control for potential confounders such as age, sex, BMIlifestyle factors, other unmeasured confounders could influence both vitamin D levels and the risk of metabolic syndrome. These include genetic factors, other nutritional deficiencies socioeconomic status.

Diagnostic Criteria for Metabolic Syndrome: The criteria used to define metabolic syndrome may vary the use of the International Diabetes Federation (IDF)

criteria may not capture all nuances of the syndrome compared to other definitions like those from the American Heart Association or the World Health Organization. This could potentially limit the applicability of the findings to populations diagnosed under different criteria.

Lack of Longitudinal Follow-up: Without longitudinal data, we cannot observe the progression of vitamin D levels or metabolic syndrome over time, which would be useful in understanding the dynamics of the relationship between these variables.

Self-reported Data: Some of the data, particularly regarding lifestyle factors such as diet, physical activity sun exposure, were self-reported. Such data are susceptible to recall bias and may not accurately represent the participants' true behaviors.

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