ORIGINAL RESEARCH

Correlation between Obesity with Vitamin-D Deficiency and Anaemia: A Cross-sectional Study

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ABSTRACT

Background: Obesity, a growing public health concern, has been increasingly associated not only with metabolic and cardiovascular complications but also with micronutrient deficiencies. Among these, vitamin D deficiency and anaemia are notable yet often underdiagnosed conditions in overweight and obese individuals. The physiological alterations in adiposity, such as inflammation, sequestration of nutrients, and hormonal imbalances, may contribute to these deficiencies. **Aim:** To assess the association of obesity with vitamin D deficiency and anaemia among adult patients in a tertiary care hospital setting. **Materials and Methods:** This hospital-based cross-sectional study was conducted in the Department of Medicine on 110 adult participants aged 18–60 years using a consecutive sampling method. Participants were classified into normal, overweight, and obese groups based on BMI using WHO guidelines for the Asian population. Serum 25-hydroxyvitamin D levels were estimated using the CLIA method, and anaemia was defined per WHO criteria based on haemoglobin concentration. Statistical analysis was conducted using SPSS v25.0, with p-values <0.05 considered significant. **Results:** Out of 110 participants, the majority were in the 31–45 age group (41.82%), and 43.64% were obese. Vitamin D deficiency was significantly more prevalent in obese individuals (79.17%) compared to those with normal BMI (35.29%) ($p < 0.001$). Similarly, anaemia prevalence rose with BMI: 62.50% in obese vs. 29.41% in normal BMI participants ($p = 0.002$). A strong correlation was observed between vitamin D deficiency and anaemia; 63.08% of vitamin D-deficient individuals were also anaemic, compared to 25.58% in those with sufficient vitamin D levels ($p < 0.001$). Mean values of both vitamin D and haemoglobin declined significantly with increasing BMI. **Conclusion:** The study demonstrates a significant association between obesity and both vitamin D deficiency and anaemia. The inverse relationship between BMI and these micronutrient levels emphasizes the importance of integrated nutritional assessment in obese individuals. Routine screening for vitamin D and haemoglobin levels may aid in early identification and management of deficiencies, thus preventing associated complications.

Keywords: Obesity, Vitamin D deficiency, Anaemia, Body Mass Index

INTRODUCTION

Obesity has emerged as a major global health concern, with its prevalence steadily increasing in both developed and developing countries. According to the World Health Organization (WHO), more than 1.9 billion adults were overweight in 2016, and of these, over 650 million were classified as obese.[1] Obesity is associated not only with metabolic syndromes such as type 2 diabetes mellitus and cardiovascular diseases but also with micronutrient deficiencies, including vitamin D deficiency and anaemia.[2]

Vitamin D plays a crucial role in calcium and phosphate homeostasis and bone health. However, in recent years, its non-skeletal effects have gained attention, particularly its role in immunity, insulin regulation, and cardiovascular health.[3] Obese individuals are particularly susceptible to vitamin D deficiency due to volumetric dilution and sequestration of vitamin D in adipose tissue, which reduces its bioavailability.[4] Moreover, decreased outdoor physical activity and sun exposure, common in obese individuals, further exacerbate this deficiency.[5]

Anaemia, defined as a decreased concentration of hemoglobin in the blood, remains a significant public health issue, particularly in developing countries. Although iron deficiency is the most common cause, other nutritional deficiencies, chronic inflammation, and altered iron metabolism also contribute to anaemia, especially among individuals with increased body fat.[6] Obesity-related chronic low-grade inflammation may interfere with iron metabolism by upregulating hepcidin levels, thereby reducing iron absorption and availability.[7]

AIM AND OBJECTIVES

To assess the association of obesity with vitamin D deficiency and anaemia among adult patients in a tertiary care hospital setting.

MATERIALS AND METHODS

Study Design

This was a hospital-based cross-sectional study designed to assess the association of obesity with Vitamin D deficiency and anaemia among adult patients.

Study Place

The study was conducted in the Department of Medicine, Government Medical College and Hospital, Bettiah, West Champaran, Bihar, India.

Study Period

The study was carried out over a period of two year, from January 2022 to December 2023.

Inclusion Criteria

- Adults aged 18 to 60 years
- BMI ≥ 18.5 kg/m² (including normal, overweight, and obese categories as per WHO classification for Asian populations)
- Willing to provide informed written consent
- Willing to undergo anthropometric measurements, blood sampling, and laboratory investigations

Exclusion Criteria

- Pregnant or lactating women
- Individuals who had taken Vitamin D or iron supplements in the previous three months
- Known cases of chronic kidney disease, liver disease, malignancy, or chronic inflammatory disorders
- Recent history of acute infection or surgery (within the past 4 weeks)

Ethical Considerations

Approval for the study was obtained from the Institutional Ethics Committee prior to data collection. Informed written consent was obtained from each participant before enrollment.

Study Population

Sampling Technique

A consecutive sampling technique was used. Patients attending the outpatient and inpatient departments of the Department of Medicine during the study period were screened and enrolled based on eligibility criteria.

Study Procedure

Data Collection

- Demographic data (age, sex, relevant medical history) were recorded using a pre-designed structured questionnaire.
- Anthropometric measurements were taken under standardized conditions:
  - Height was measured to the nearest 0.1 cm using a stadiometer.
  - Weight was measured to the nearest 0.1 kg using a calibrated digital scale.
  - BMI was calculated as weight (kg) divided by height squared (m²).

BMI Classification (WHO Asia-Pacific Guidelines):

- Normal weight: 18.5–22.9 kg/m²
- Overweight: 23.0–24.9 kg/m²
- Obese: ≥25.0 kg/m²

Laboratory Investigations

- Venous blood samples were collected in the morning after an overnight fast, using aseptic precautions.

- Vitamin D (25-hydroxyvitamin D) levels were estimated using the Chemiluminescent Immunoassay (CLIA) method.
  - Vitamin D deficiency: <20 ng/mL
- Hemoglobin levels were measured using an automated hematologyanalyzer.
  - Anaemia defined as per WHO:
    - Males: Hb <13.0 g/dL
    - Females: Hb <12.0 g/dL
- Additional investigations like complete blood count and serum calcium levels were done when necessary to identify or rule out potential confounders.

Outcome Measures

- Primary outcomes:
  - Prevalence of Vitamin D deficiency in different BMI categories
  - Prevalence of anaemia in different BMI categories
- Secondary outcomes:
  - Association between BMI and combined deficiency of Vitamin D and anaemia

Statistical Analysis

- Data entry was done in Microsoft Excel and statistical analysis was performed using SPSS version 25.0.
- Descriptive statistics:
  - Quantitative variables: Mean ± Standard Deviation (SD)
  - Categorical variables: Frequency and percentage
- Inferential statistics:
  - Chi-square test for categorical variables
  - Student's t-test or ANOVA for continuous variables as applicable
- A p-value <0.05 was considered statistically significant.

RESULTS

Table 1: Distribution of Study Participants by Age and Gender (n = 110)

Variable	Number (n)	Percentage (%)
Age Group (years)		
18–30	28	25.45%
31–45	46	41.82%
46–60	36	32.73%
Gender		
Male	58	52.73%
Female	52	47.27%

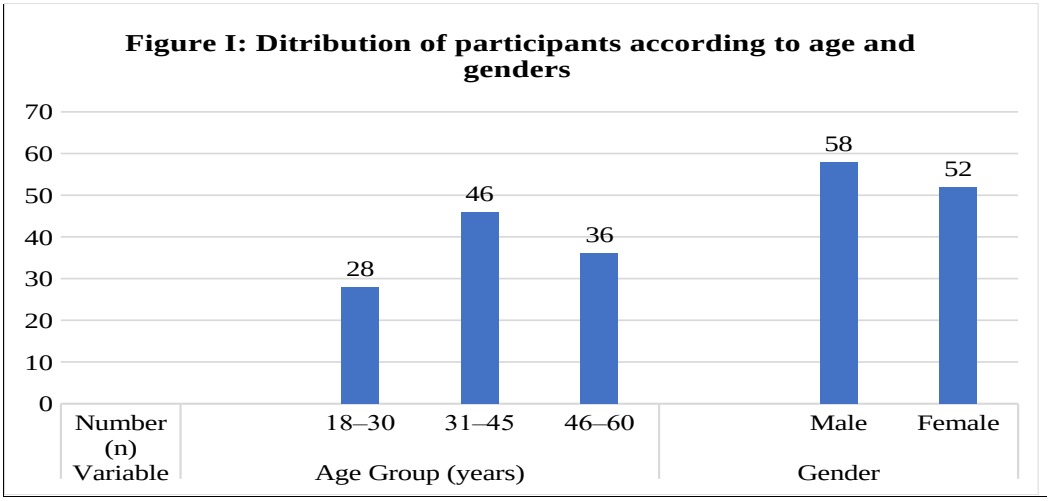

Table 1, figure I shows among the 110 study participants, the most represented age group was 31–45 years, accounting for 46 individuals (41.82%), followed by the 46–60 year age group with 36 individuals (32.73%), and the 18–30 age group comprising 28 participants (25.45%). The gender distribution was relatively balanced, with a slight male predominance; 58 participants (52.73%) were male, and 52 (47.27%) were female. This demographic spread suggests that the sample was fairly representative of the adult population typically seen in outpatient and inpatient departments of the hospital.

Table 2: Distribution of Study Participants by BMI Category

BMI Category (kg/m²)	Number of Participants (n=110)	Percentage (%)
Normal (18.5–22.9)	34	30.91%
Overweight (23.0–24.9)	28	25.45%
Obese (≥25.0)	48	43.64%

Table 2, shows thataccording to the WHO BMI classification for Asian populations, the majority of participants were obese, with 48 individuals (43.64%) having a BMI of ≥25.0 kg/m². Overweight individuals (BMI 23.0–24.9 kg/m²) comprised 28 participants (25.45%), while the remaining 34 (30.91%) had normal BMI (18.5–22.9 kg/m²). The relatively high proportion of overweight and obese individuals reflects the increasing prevalence of adiposity in the adult Indian population and provides a robust sample to study its metabolic associations.

Table 3: Prevalence of Vitamin D Deficiency Across BMI Categories

BMI Category	Vitamin D Deficient (<20 ng/mL)	Sufficient (≥20 ng/mL)	Total	p-value
Normal (18.5–22.9)	12 (35.29%)	22 (64.71%)	34	
Overweight (23.0–24.9)	17 (60.71%)	11 (39.29%)	28	
Obese (≥25.0)	38 (79.17%)	10 (20.83%)	48	<0.001

Table 3 showsa significant trend was observed between rising BMI and prevalence of Vitamin D deficiency. Among individuals with normal BMI, 12 out of 34 participants (35.29%) were found to be Vitamin D deficient. This proportion increased markedly in the overweight group, where 17 of 28 participants (60.71%) were deficient. The highest prevalence was noted among the obese group, with 38 out of 48 individuals (79.17%) showing deficiency. The association was statistically significant with a p-value of <0.001, indicating a strong inverse relationship between BMI and Vitamin D status. This finding supports the hypothesis that obesity is associated with impaired Vitamin D bioavailability, possibly due to sequestration in adipose tissue.

Table 4: Prevalence of Anaemia Across BMI Categories

BMI Category	Anaemic	Non-Anaemic	Total	p-value
Normal (18.5–22.9)	10 (29.41%)	24 (70.59%)	34	
Overweight (23.0–24.9)	12 (42.86%)	16 (57.14%)	28	
Obese (≥25.0)	30 (62.50%)	18 (37.50%)	48	0.002

Table 4 shows that similar to Vitamin D deficiency, the prevalence of anaemia also showed a significant increase with higher BMI. Among participants with normal BMI, 10 individuals (29.41%) were anaemic. This figure increased to 12 (42.86%) in the overweight group and 30 (62.50%) among the obese category. The observed association was statistically significant (p = 0.002), suggesting that obesity is not only linked to micronutrient deficiencies like Vitamin D but also to an increased risk of anaemia. Potential mechanisms could include chronic inflammation associated with obesity impairing iron metabolism or dilutional effects due to increased plasma volume.

Table 5: Correlation Between Vitamin D Deficiency and Anaemia

Vitamin D Status	Anaemic (n)	Non-Anaemic (n)	Total (n)	p-value
Deficient (<20 ng/mL)	41 (63.08%)	24 (36.92%)	65	
Sufficient (≥20 ng/mL)	11 (25.58%)	32 (74.42%)	43	<0.001

Table 5 showswhen participants were stratified based on Vitamin D status, a significant correlation was found with anaemia. Among the 65 individuals who were Vitamin D deficient, 41 (63.08%) were also anaemic. In contrast, among the 43 participants with sufficient Vitamin D levels, only 11

(25.58%) were anaemic. This difference was highly significant ($p < 0.001$), indicating that Vitamin D deficiency may play a contributory role in the pathogenesis of anaemia, potentially through modulation of erythropoiesis or inflammatory pathways.

Table 6: Mean Vitamin D and Haemoglobin Levels by BMI Category

BMI Category	Mean Vitamin D (ng/mL) ± SD	Mean Haemoglobin (g/dL) ± SD
Normal (18.5–22.9)	27.4 ± 6.1	13.4 ± 1.1
Overweight (23.0–24.9)	19.2 ± 5.3	12.5 ± 1.3
Obese (≥25.0)	14.6 ± 4.8	11.7 ± 1.5

Table 6 shows themean values for serum Vitamin D and haemoglobin further reinforced the inverse relationship with increasing BMI. Participants in the normal BMI group had the highest mean Vitamin D level (27.4 ± 6.1 ng/mL) and haemoglobin concentration (13.4 ± 1.1 g/dL). These values declined progressively across the overweight group (Vitamin D: 19.2 ± 5.3 ng/mL; Hb: 12.5 ± 1.3 g/dL) and were lowest in the obese group (Vitamin D: 14.6 ± 4.8 ng/mL; Hb: 11.7 ± 1.5 g/dL). This pattern supports the quantitative impact of increasing adiposity on both micronutrient absorption/storage and hematologic parameters.

DISCUSSION

The present study, conducted on 110 adult participants, revealed that the majority of individuals were within the 31–45 years age group and that the gender distribution was nearly balanced, with a slight male predominance. This demographic profile is consistent with outpatient data from Indian tertiary care hospitals, where middle-aged adults form the bulk of those screened for metabolic and nutritional disorders. Similar age-related trends have been reported by Gupta et al. (2018), who found a high prevalence of Vitamin D deficiency in working-age adults attending primary health centers in India.[8]

Our study showed that 43.64% of participants were obese, 25.45% were overweight, and only 30.91% had a normal BMI. This high burden of adiposity echoes findings from previous Indian consensus data, as reported by Misra et al. (2009), where urbanization and sedentary lifestyle patterns were cited as key contributors to the obesity epidemic in Asian Indian populations.[9] Comparatively, a Korean cross-sectional study by Jeong et al. (2022) found 35.7% of adolescents to be overweight or obese, showing that the obesity trend spans across both adult and adolescent populations, though slightly lower than our adult cohort.[10]

One of the major findings of this study was the statistically significant inverse association between BMI and serum Vitamin D levels. Among obese participants, 79.17% were found to be Vitamin D deficient, compared to only 35.29% among those with normal BMI. This trend was consistent with the study by Vranić et al. (2019), which also demonstrated that higher adiposity correlates with lower circulating Vitamin D, possibly due to volumetric dilution or sequestration within fat tissue.[11] Additionally, Dogan et al. (2022) showed that Vitamin D levels were significantly reduced in individuals with high body fat percentages, supporting our observations.[12]

Comparative prevalence figures from Poudel et al. (2020), who conducted a hospital-based study in Nepal, reported that 72.8% of their adult patients had Vitamin D deficiency, aligning closely with our overall prevalence of 65.45%. These similarities emphasize that Vitamin D deficiency is not only widespread but also accentuated by increasing BMI, which is evident in both South Asian populations.[13]

Anaemia, another parameter evaluated in our study, showed a similar association with BMI. We found that 62.5% of obese participants were anaemic compared to 29.41% in the normal BMI group. This relationship was statistically significant and consistent with the observations by Qin et al. (2013) in Chinese women, where increasing BMI and waist circumference were associated with a higher prevalence of anaemia.[14] Similarly, Jeong et al. (2022), noted a 58.9% anaemia prevalence among overweight adolescents in Korea, emphasizing that this paradox of "obese anaemia" is a global health concern.[10]

Our results also showed a strong and significant correlation between Vitamin D deficiency and anaemia. Of the Vitamin D-deficient participants in our study, 63.08% were also anaemic, suggesting a possible contributory or synergistic relationship. This finding supports the theory proposed by Holick et al. (2011) that Vitamin D plays a regulatory role in hematopoiesis through

its influence on erythroid progenitor cells.[15] Kannan and Achuthan (2017) also reported similar findings among Indian medical students, where haemoglobin levels were positively correlated with Vitamin D concentrations, especially in individuals with higher BMI.[16]

The mean Vitamin D and haemoglobin values across BMI categories in our study further solidify the observed trends. Normal BMI participants had mean Vitamin D levels of 27.4 ng/mL and haemoglobin of 13.4 g/dL, whereas obese individuals had significantly lower levels (14.6 ng/mL and 11.7 g/dL, respectively). These reductions reflect cumulative nutritional insufficiencies as BMI increases. Comparable trends were observed by Purdy et al.[17], who documented that obesity leads to altered iron metabolism via chronic low-grade inflammation, and also by Dogan et al.[12], who found a consistent inverse correlation between Vitamin D levels and markers of physical function, including haematologic parameters.

LIMITATIONS OF THE STUDY

- The cross-sectional design prevents establishing causal relationships.
- Being hospital-based, results may not be generalizable to the community population.
- Seasonal variation in Vitamin D levels was not accounted for.
- Dietary intake, sun exposure, and physical activity—factors influencing Vitamin D and anaemia—were not assessed.
- Sample size was modest (n=110), limiting subgroup analyses and external validity.

CONCLUSION

This study highlights a significant association between obesity, Vitamin D deficiency, and anaemia in the adult population. As BMI increased, both serum Vitamin D and haemoglobin levels showed a marked decline, indicating the dual burden of micronutrient deficiency in obese individuals. The strong correlation between Vitamin D deficiency and anaemia further suggests a possible synergistic role in their pathophysiology. These findings underscore the need for routine screening of Vitamin D and haemoglobin levels in overweight and obese patients. Early detection and targeted nutritional interventions can help reduce the risk of long-term complications associated with these deficiencies.

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