ORIGINAL RESEARCH

Assessment of the Association of Obesity with Vitamin D Deficiency and Anaemia and Its Clinical Implications

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ABSTRACT
Background: In India, the prevalence of obesity is on the rise, with urban areas reporting rates between 13% and 50%. Obesity is a recognized risk factor for diabetes, high blood pressure, and cardiovascular diseases. The present study was conducted to assess the association of obesity with vitamin-D and anaemia. **Materials & Methods:** 70 patients aged 18 years or older with a BMI of 23 kg/m2 or higher and patients with diabetes and hypertension were enrolled. Measurements of anthropometry were taken. Height was assessed with a wall-mounted stadiometer, weight with calibrated electronic scales, and BMI was computed by dividing weight in kilograms by the square of height in meters. The consensus guidelines for Asian Indians defined overweight as a BMI ranging from 23 to 24.9 kg/m2 and obesity as a BMI of 25 kg/m2 or greater. **Results:** The mean age was 48.2±15.8 years, weight was 70.5±8.6 years, height was 16.3±3.2 meters, BMI (kg/m2) was 25.7±1.9, haemoglobin (g/dL) was 12.4±3.2 and vitamin-D level (ng/mL) was 23.8± 7.4. Out of 70 patients, 18 had anaemia and 52 had not. 14 patients had age <60 years and 4 had >60 years. There were 10 males and 8 females. 13 had hypertension and 5 had not. 12 had diabetes and 6 had not. 9 were obese and 9 were overweight. The difference was significant (P< 0.05). Out of 18 anaemic patients, 11 had vitamin-D (<30 ng/mL) and 7 had vitamin-D (>30 ng/mL). The difference was non- significant (P> 0.05). **Conclusion:** Individuals with high BMI, despite appearing healthy, were often found to have common issues of vitamin D deficiency and anaemia. This health issue requires attention, and early screening along with suitable treatment can enhance quality of life.
Keywords: Anaemia, Obesity, vitamin-D

INTRODUCTION

In India, the prevalence of obesity is on the rise, with urban areas reporting rates between 13% and 50%. Obesity is a recognized risk factor for diabetes, high blood pressure, and cardiovascular diseases.[1] Overweight and obesity, once thought to be issues exclusive to high-income countries, are now escalating dramatically in low- and middle-income countries, especially in urban areas. Due to lifestyle changes, high-pressure work environments, and the rise in consumption of nutritionally poor foods, obesity has become a major issue for many people today. With the rise in our patient interactions as physicians with individuals suffering from obesity, it has become crucial to examine the different effects of this condition.[2]

In India, the prevalence of obesity is on the rise, with urban areas reporting rates between 13% and 50%. Obesity is a recognized risk factor for diabetes, high blood pressure, and cardiovascular diseases.[3] Overweight and obesity, once thought to be issues exclusive to high-income countries, are now escalating dramatically in low- and middle-income countries, especially in urban areas. Due to lifestyle changes, high-pressure work environments, and the rise in consumption of nutritionally poor foods, obesity has become a major issue for many people today.[4] With the rise in our patient interactions as physicians with individuals suffering from obesity, it has become crucial to examine the different effects of this condition. As an inflammatory condition, obesity impacts haematological parameters in various ways. It is associated with a lack of iron. Obesity leads to elevated levels of cytokines such as Interleukin-6 (IL-6), which causes an increase in hepcidin expression and a subsequent decrease in iron absorption. Adipocytes may secrete hepcidin directly.[5]

AIM & OBJECTIVES

The present study was conducted to assess the association of obesity with vitamin-D and anaemia.

MATERIALS & METHODS

Study Design

This was a cross-sectional observational study aimed at evaluating the association between obesity, vitamin D deficiency, and anaemia among adults with a BMI of 23 kg/m² or higher. The study involved clinical assessments and laboratory investigations to gather relevant anthropometric and biochemical data.

Study Population

A total of 70 patients aged 18 years or older were included in the study. All participants had a Body Mass Index (BMI) $\geq$ 23 kg/m², and many were also diagnosed with type 2 diabetes mellitus and/or hypertension.

Study Place

The study was conducted in the Department of Medicine at Lord Buddha Koshi Medical College & Hospital, Saharsa, Bihar, India where participants were recruited during their routine medical visits.

Study Duration

The study was conducted over a period of one years and seven months, from June 2021 to December 2022.

Inclusion Criteria

- Adults aged $\geq$ 18 years
- BMI $\geq$ 23 kg/m² (as per Asian Indian guidelines)
- Patients diagnosed with type 2 diabetes mellitus and/or hypertension
- Willing to provide informed written consent

Exclusion Criteria

- Pregnant or lactating women
- Patients on vitamin D supplementation
- Known cases of malabsorption syndromes or chronic liver/kidney disease
- Any acute illness or recent hospitalization (within the last 3 months)
- Non-consenting individuals

Ethical Considerations

The study was conducted in accordance with the Declaration of Helsinki. Ethical clearance was obtained from the Institutional Ethics Committee (IEC) before commencing the study. All participants provided written informed consent before inclusion.

Study Procedure

- Anthropometric measurements were taken:
  - Height measured using a wall-mounted stadiometer (in meters)
  - Weight measured using a calibrated electronic weighing scale (in kilograms)
  - BMI was calculated using the formula:
  - $\text{BMI}=\text{weight (kg)}/(\text{height (m)})^2$
- Blood samples were collected to measure:
  - Serum 25(OH) vitamin D levels using standard chemiluminescence immunoassay
  - Haemoglobin levels to assess anaemia based on WHO criteria
- Other parameters such as age, gender, medical history, comorbidities were recorded.

Outcome Measures

- Primary Outcomes:
  - Prevalence of vitamin D deficiency in overweight and obese individuals
  - Prevalence of anaemia
- Secondary Outcomes:
  - Association between BMI and vitamin D levels
  - Association between BMI and haemoglobin levels

Statistical Analysis

- Data was compiled and analyzed using SPSS (Statistical Package for the Social Sciences) or a similar statistical tool.
- Descriptive statistics were used to summarize demographic data.
- Inferential statistics such as chi-square test, t-test, or Pearson correlation were employed as appropriate.
- A P-value < 0.05 was considered statistically significant.

RESULTS

Table 1: Baseline characteristics of the study population based on comparison by Vitamin D status

Parameter	Vitamin D Deficient (n=40)	Vitamin D Sufficient (n=30)	p-value
Age (years)	47.8 ± 9.4	45.8 ± 8.1	0.351
BMI (kg/m²)	25.9 ± 1.8	25.4 ± 2.2	0.315
Haemoglobin (g/dL)	11.8 ± 1.4	13.6 ± 1.2	0.000
Vitamin D (ng/mL)	15.1 ± 2.9	34.3 ± 5.7	0.000

Table 1 show the baseline characteristics among patients with vitamin D deficiency (<20 ng/mL) and those with sufficient vitamin D levels (>30 ng/mL). A significant difference was observed in haemoglobin levels between vitamin D deficient and sufficient individuals (11.8 ± 1.4 g/dL vs. 13.6 ± 1.2 g/dL; $p < 0.001$). Vitamin D deficient individuals had significantly lower haemoglobin levels, suggesting a potential association between vitamin D deficiency and anaemia. Although mean BMI was higher among the deficient group (25.9 vs. 25.4 kg/m²), the difference was not statistically significant ($p = 0.315$), indicating that vitamin D deficiency may not be solely driven by adiposity. There was a significant difference in serum 25(OH) vitamin D levels between the two groups (15.1 ± 2.9 ng/mL vs. 34.3 ± 5.7 ng/mL; $p < 0.001$).

Table 2: Baseline characteristics of the study population based on comparison by anaemia status

Parameter	Anaemic (n=35)	Non-Anaemic (n=35)	p-value
Age (years)	51.3 ± 8.3	46.1 ± 7.7	0.008
BMI (kg/m²)	26.1 ± 1.8	25.6 ± 2.0	0.316
Haemoglobin (g/dL)	10.7 ± 1.1	13.7 ± 1.1	0.000
Vitamin D (ng/mL)	19.4 ± 4.3	24.5 ± 5.2	0.000

Table 2 show the participants were grouped based on anaemia status (as per WHO criteria: <13 g/dL for males and <12 g/dL for females. Anaemic patients were significantly older compared to non-anaemic individuals (51.3 ± 8.3 vs. 46.1 ± 7.7 years; $p = 0.008$). Vitamin D levels were significantly lower in anaemic patients (19.4 ± 4.3 vs. 24.5 ± 5.2 ng/mL; $p < 0.001$), strengthening a possible link between anaemia and vitamin D deficiency. No significant difference in BMI was noted between anaemic and non-anaemic patients ($p = 0.316$), suggesting that BMI may not independently influence anaemia in this population, although obesity-related inflammation remains a plausible mediator.

Table 3: Association of Diabetes, Hypertension, and BMI with Anaemia

Parameters	Variables	Anaemia		P value
		Yes (18)	No (52)	
Age	<60	14	35	0.05
	>60	4	17	
Gender	Male	10	30	0.02
	Female	8	22	
Hypertension	Yes	13	20	0.03
	No	5	32	
Diabetes	Yes	12	22	0.04
	No	6	30	
BMI	Obese	9	28	0.75
	Overweight	9	24	

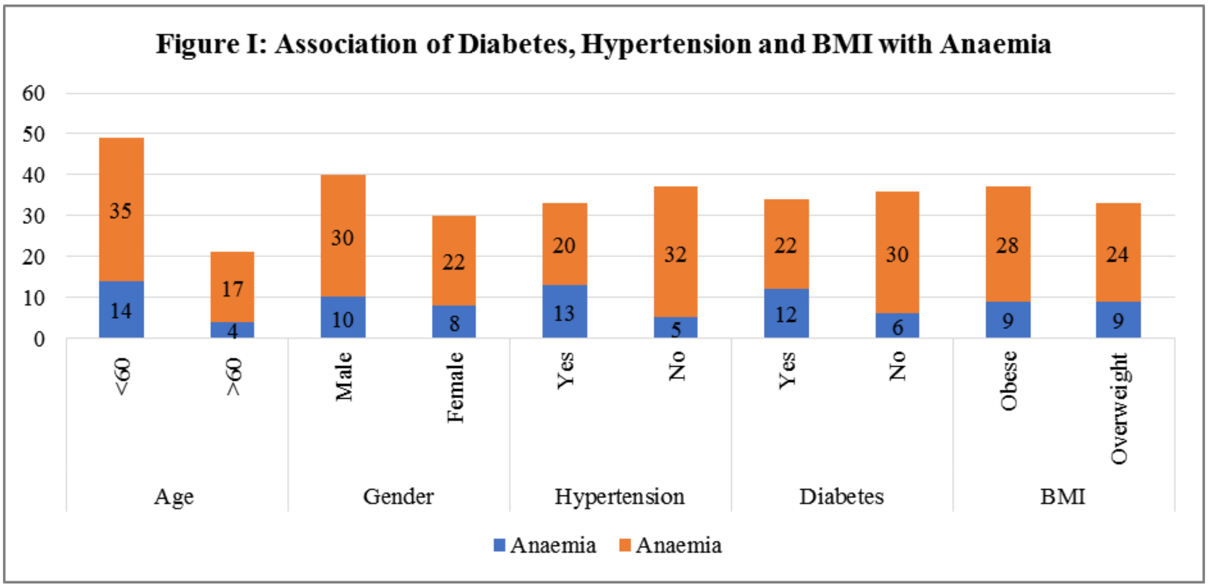

Table 3, figure I show that out of 70 patients, 18 had anaemia and 52 had not. 14 patients had age <60 years and 4 had >60 years. There were 10 males and 8 females. 13 had hypertension and 5 had not. 12 had diabetes and 6 had not. 9 were obese and 9 were overweight. The difference was significant (P< 0.05).

Table 4: Association between Vit D Deficiency and Anaemia

Vitamin-D	Anaemia		Total	P value
	Yes (18)	No (52)		
Vitamin-D (<30 ng/mL)	11	21	32	0.71
Vitamin-D (>30 ng/mL)	7	31	38	

Table 3 shows that out of 18 anaemic patients, 11 had vitamin-D (<30 ng/mL) and 7 had vitamin-D (>30 ng/mL). The difference was non- significant (P> 0.05).

DISCUSSION

The principal circulating form of vitamin D and a standard marker of vitamin D status is serum 25-hydroxyvitamin D [25(OH)D]. An inverse relationship between serum 25(OH)D levels and cancer risk has been documented in multiple studies.[6,7] It has also been reported that regular intake of vitamin D is linked to a reduced incidence of cancer. In addition, elevated plasma 25(OH)D levels correlate with enhanced survival rates in prostate, breast, lung, colorectal, and ovarian cancers. Improved survival has been demonstrated with a better vitamin D status at the time of diagnosis and treatment, adjusted for the season of diagnosis.[8] The present study was conducted to assess the association of obesity with vitamin-D and anaemia.

A significant difference was observed in haemoglobin levels between vitamin D deficient and sufficient individuals (11.8 ± 1.4 g/dL vs. 13.6 ± 1.2 g/dL; $p < 0.001$). This finding supports the hypothesis that vitamin D deficiency may be linked to anaemia, potentially due to its role in erythropoiesis and inflammatory regulation. Vitamin D receptors are present on erythroid progenitor cells, and vitamin D may enhance erythropoietin sensitivity and iron metabolism.[9,10] Although mean BMI was higher among the deficient group (25.9 vs. 25.4 kg/m²), the difference was not statistically significant. This finding aligns with previous reports where obesity was associated with lower vitamin D due to sequestration in adipose tissue, but not always significantly so in all cohorts.[11]

Anaemic patients were significantly older compared to non-anaemic individuals (51.3 ± 8.3 vs. 46.1 ± 7.7 years; $p = 0.008$), which may reflect the age-related risk of anaemia, potentially from chronic inflammation, reduced erythropoietin production, or nutritional deficiencies.[12]

Vitamin D levels were significantly lower in anaemic patients (19.4 ± 4.3 vs. 24.5 ± 5.2 ng/mL; $p < 0.001$), strengthening the hypothesis of a bi-directional relationship between vitamin D status and anaemia. Several studies have

indicated that vitamin D deficiency contributes to functional iron deficiency by increasing hepcidin expression, an iron regulatory hormone.[13]
Parikh et al.[14] examined the relationships between calciotropic hormones and body adiposity in healthy adults. Serum intact PTH, 25-hydroxy vitamin D, and 1,25-vit D were measured in the post-absorptive state in 302 healthy adults who were Caucasian (n = 190; 71% female), African-American (n = 84; 89% female), and of other race/ethnicity (n = 28; 61% female). Results from the 154 obese subjects [body mass index (BMI) 37.3 +/- 5.8 kg/m^2; range, 30.1-58.2 kg/m^2] were compared with those from 148 non-obese (BMI 25.6 +/- 2.9 kg/m^2; range, 18.0-29.9 kg/m^2, age-, race-, and sex-matched participants. Body composition was measured by dual energy x-ray absorptiometry. Serum intact PTH was positively correlated with both BMI (r = 0.42; P < 0.0001) and body fat mass (r = 0.37; P < 0.0001). Serum 25-hydroxy vitamin D was negatively correlated with BMI (r = -0.4; P < 0.0001) and body fat mass (r = -0.41; P < 0.0001). Serum 1,25-vit D was also negatively correlated with BMI (r = -0.26; P < 0.0001) and body fat mass (r = -0.25; P = 0.0001). Serum 1,25-vit D was significantly lower in obese than non-obese subjects (105.7 +/- 41.1 vs. 124.8 +/- 36.7 pmol/liter; P < 0.0001) in both Caucasian and African-American adults.
We found that out of 70 patients, 18 had anaemia and 52 had not. 14 patients had age <60 years and 4 had >60 years. There were 10 males and 8 females. 13 had hypertension and 5 had not. 12 had diabetes and 6 had not. 9 were obese and 9 were overweight. Vashi PG et al.[15] investigated the relationship between serum 25-hydroxy-vitamin D [25(OH)D] and BMI in cancer. Serum 25(OH)D was measured at presentation to the hospital. The cohort was divided into 4 BMI groups (underweight: <18.5, normal weight: 18.5-24.9, overweight: 25-29.9, and obese: >30.0 kg/m^2). Mean 25(OH)D was compared across the 4 BMI groups. 303 were males and 435 females. Mean age at diagnosis was 55.6 years. The mean BMI was 27.9 kg/m^2 and mean serum 25(OH)D was 21.9 ng/ml. Most common cancers were lung (134), breast (131), colorectal (97), pancreas (86) and prostate (45). Obese patients had significantly lower serum 25(OH)D levels (17.9 ng/ml) as compared to normal weight (24.6 ng/ml) and overweight (22.8 ng/ml) patients; p < 0.001. After adjusting for age, every 1 kg/m^2 increase in BMI was significantly associated with 0.42 ng/ml decline in serum 25(OH)D levels.
We found that out of 18 anaemic patients, 11 had vitamin-D (<30 ng/mL) and 7 had vitamin-D (>30 ng/mL). Qin Y et al.[16] in their study 1,537 women aged 20 years and above were included. Subjects were classified by body mass index (BMI) categories as underweight, normal weight, overweight and obese according to the Chinese standard. Central obesity was defined as a waist circumference ≥ 80 cm. Anemia was defined as hemoglobin concentration < 12 g/dl. Prevalence ratios (PRs) of the relationship between anemia and BMI or waist circumference were calculated using Poisson regression. Overall, 31.1% of the Chinese women were anemic. The prevalence of overweight, obesity and central obesity was 34.2%, 5.8% and 36.2%, respectively. The obese group had the highest concentrations of hemoglobin compared with other BMI groups. After adjustment for confounders, overweight and obese women had a lower PR for anemia (PR: 0.72, 95% CI: 0.62-0.89; PR: 0.59, 95% CI: 0.43-0.79). Central obesity was inversely associated with anemia.

LIMITATIONS OF THE STUDY

- Small sample size (n=70) limits the generalizability of the findings.
- Cross-sectional design prevents the establishment of causality.
- Single-centre study may introduce selection bias.
- Potential confounding variables (like sun exposure, diet, physical activity) were not controlled or adjusted for.
- Vitamin D assay technique and cut-off levels may vary across laboratories, affecting result consistency.
- Lack of longitudinal follow-up prevents analysis of long-term outcomes.

CONCLUSION

Authors found that individuals with high BMI, despite appearing healthy, were often found to have common issues of vitamin D deficiency and anaemia. This study found a significant association between vitamin D deficiency and lower haemoglobin levels, suggesting a potential link between vitamin D status and anaemia in overweight and obese adults. Anaemia was also associated with older age, diabetes, and hypertension. However, no significant association was found between BMI and anaemia or between vitamin D status (using a 30 ng/mL cut-off) and anaemia. These findings highlight the need for routine screening of vitamin D and haemoglobin levels in individuals with metabolic comorbidities. This health issue requires attention, and early screening along with suitable treatment can enhance quality of life.

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