Original Article

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Association of Obesity with Vitamin-D Deficiency and Anaemia: A Cross-sectional Study

Internal Medicine Section

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ABSTRACT

Introduction: Obesity is a growing health concern, especially in developing countries like India. Overweight and obesity are considered risk factors for numerous diseases, including micronutrient deficiencies. However, there is a lack of data on the association between vitamin-D status and anaemia in obesity. Therefore, this study was conducted in an urban setting where obesity is more prevalent.

Aim: To investigate the association between increased Body Mass Index (BMI) and vitamin-D deficiency and anaemia.

Materials and Methods: This cross-sectional observational study included 62 healthy overweight or obese adults from Ramaiah Medical College and Hospitals in Bengaluru, South India, from December 2021 to February 2022. Anthropometric measurements were taken, and blood investigations were conducted to estimate vitamin-D levels and haemoglobin levels. Pearson's chi-square test was used to determine associations between the two groups.

Results: The study included (62) healthy adults, of whom 28 subjects (45.1%) were classified as obese (BMI ≥25 kg/m^2) and 34 subjects (54.9%) were classified as overweight (BMI 23-24.9 kg/m^2). There were 22 males and 40 females, with a mean age of 48.5 years. Vitamin-D deficiency was observed in 50 patients (80.6%). The prevalence of vitamin-D deficiency was higher in the obese group (n=23, 82.1%) compared to the overweight group (n=27, 79.4%), although this difference was not statistically significant. Anaemia was present in 14 patients (22.6%). Overweight males were more likely to be anaemic. Anaemia was observed more frequently in elderly overweight and obese patients and was statistically significant (p-value=0.039).

Conclusion: Vitamin-D deficiency and anaemia were seen as common problems in apparently healthy individuals with high BMI. This is a health concern that needs to be addressed, and early screening and appropriate treatment can help improve the quality of life.

Keywords: Haemoglobin, Hypertension, Nutrition, Obesity, Screening

INTRODUCTION

The prevalence of obesity is increasing in India and ranges from 13-50% in urban areas [1]. Obesity is an established risk factor for diabetes, hypertension, and cardiovascular disorders. Once considered a problem only in high-income countries, overweight and obesity are now dramatically on the rise in low and middle-income countries, particularly in urban settings. Obesity has become a prime concern faced by many individuals these days due to changes in lifestyle, stressful working conditions, and increased consumption of foods with low nutritional value. As physicians, our interactions with patients having obesity have increased, making it important to study the various consequences of obesity.

Vitamin-D has gained more importance in recent years. It has a proven role in the homeostasis of calcium and phosphorus. Vitamin-D deficiency has been implicated in various metabolic disorders, including diabetes, as an immunomodulator, in various malignancies, cognitive dysfunctions, depression, and others. There is consistent association in the published literature between obesity and lower serum 25-hydroxyvitamin-D (25D) concentrations [2-5]. One of the endocrine derangements seen in obesity is hyperparathyroidism, believed to be secondary to low Vitamin-D [2]. In a large study among Bangladeshi overweight and obese adults, Vitamin-D deficiency was seen in 72.6% [3].

Obesity, being an inflammatory state, also has varied effects on haematological parameters. It has been linked to iron deficiency. Obesity results in increased cytokines like Interleukin-6 (IL-6), leading to increased expression of hepcidin and subsequent reduced absorption of iron. Hepcidin may be directly secreted by adipocytes. Obesity is also associated with leucocytosis and increased platelet count [6]. The association between obesity and anaemia is a subject of debate. There are many studies on anaemia in obesity among school children, adolescents, and women [7-9]. However, very few studies have focused on vitamin-D deficiency and anaemia in obesity among adults. In this study, authors hypothesise that obese individuals are more likely to be anaemic and vitamin-D deficient. The aim of this study was to investigate the association between increased BMI and vitamin-D deficiency and anaemia.

MATERIALS AND METHODS

This was a cross-sectional observational study conducted at Ramaiah Medical College and Hospitals, Bengaluru, Karnataka, India between December 2021 and February 2022. The study was approved by the Institutional Ethics Committee (IEC) (MS Ramaiah Medical College) (ref no.: MSRMC/EC/AP-05/02-2021).

Inclusion criteria: All individuals aged 18 years or older with a BMI of 23 kg/m^2 or higher (according to the consensus guidelines for the Asian population [10]) who were attending the hospital for routine executive health check-ups. Patients with diabetes and hypertension under treatment were also included. Sixty-two patients who met the inclusion criteria were enrolled in the study.

Exclusion criteria: Patients who had recently received any vitamin supplements, individuals with chronic liver or kidney disease, and those on medications that affect bone metabolism were excluded. Additionally, individuals with recent major surgery, a history of blood loss, pregnant or lactating females were also excluded from the study.

Sample size: Based on a study by Kannan U and Achuthan A, it was observed that the correlation between Body Mass Index (BMI) and haemoglobin level was r=-0.27 for BMI >23 kg/m^2, r=0.171

for BMI 18.5-23 kg/m^2, and r=0.965 for BMI <18.5 kg/m^2 [7]. For the present study, expecting similar results with 80% power, 95% confidence level, and considering a population correlation coefficient of r=0.58, a minimum of 56 subjects were required. This was calculated using nMaster 2.0 software developed by CMC Vellore to calculate sample size. Final sample size was 62 patients.

After obtaining written informed consent, relevant medical history including dietary history was recorded. Anthropometric measurements were taken. Height was measured using a wall-mounted stadiometer, weight was measured using calibrated electronic weighing scales, and BMI was calculated as weight in kilograms divided by height in meters squared. According to the consensus guidelines for Asian Indians, a BMI of 23 to 24.9 kg/m^2 was considered overweight and a BMI of 25 kg/m^2 or higher was considered obese [10]. Only overweight or obese individuals were included in the study.

Vitamin-D levels were measured using the Chemiluminescence immunoassay method. Individuals with Vitamin-D levels <30 ng/mL were considered deficient [11]. Individuals with and without Vitamin-D deficiency were compared. Complete haemogram was measured using the automated method with the Beckman Coulter DxH 800 USA machine. According to the World Health Organisation (WHO) criteria, females with haemoglobin levels <12 g/dL and males with haemoglobin levels <13 g/dL were considered anaemic [12].

STATISTICAL ANALYSIS

All quantitative variables such as age, weight, height, etc., were expressed using descriptive statistics like mean and standard deviation. All qualitative or categorical variables were analysed using frequency and percentage. Pearson's chi-square test was used to find associations between the two groups. A p-value of <0.05 was considered significant. All statistical analyses were performed using Microsoft Excel and Statistical Package for the Social Sciences (SPSS) software version 18.0 (IBM SPSS Statistics, Somers NY, USA).

RESULTS

In this study, 62 adults with a high BMI presenting to a tertiary care urban hospital for a general health check-up were included. Among them, 28 subjects (45.1%) were obese with a BMI of ≥25 kg/m^2, and the remaining 34 (54.9%) were overweight (BMI 23-24.9 kg/m^2). There were 22 males and 40 females with a mean age of 48.565±12.35 years [Table/Fig-1].

Variables	Mean±Standard deviation
Age (years)	48.565±12.35
Weight (kg)	69.383±8.984
Height (m)	1.648±0.726
Body Mass Index (BMI) (kg/m^2)	25.476±2.684
Haemolobin (g/dL)	12.831±1.904
Vitamin-D level (ng/mL)	23.357±14.890

[Table/Fig-1]: Baseline characteristics of the study.

The average Vitamin-D levels were 23.3±14.890 ng/mL. Vitamin-D deficiency was observed in 50 (80.6%) patients. Among them, 29 (46.8%) subjects had Vitamin-D deficiency (<20 ng/mL), and 21 (33.8%) had Vitamin-D insufficiency (20-30 ng/mL) according to the Clinical Practice Guidelines of the Endocrine Society, 2011 [11]. Anaemia was present in 14 (22.6%) patients.

As shown in [Table/Fig-2], the patients with Vitamin-D deficiency were analysed and there was no statistically significant difference with respect to age, gender, and dietary habits. The presence of Vitamin-D deficiency was higher in obese individuals (23, 82.1%) compared to overweight individuals (27, 79.4%), though not statistically significant. Patients with a history of hypertension were found to have a lower incidence of Vitamin-D deficiency compared to non hypertensives. However, no difference was observed in patients with or without diabetes.

Parameters		Vitamin-D deficiency		Total	Pearson Chi-square	p-value
		Yes (n%)	No (n%)			
Gender	Male	17 (77.3)	5 (22.7)	22	0.248	0.618
	Female	33 (82.5)	7 (17.5)	40		
Age (years)	Age <60	40 (83.3)	8 (16.7)	48	0.984	0.321
	Age >60	10 (71.4)	4 (28.6)	14		
Diet	Pure vegetarian	20 (90.9)	2 (9.1)	22	2.302	0.129
	Mixed diet	30 (75)	10 (25)	40		
Hypertension	Yes	20 (69)	9 (31)	29	4.762	0.029
	No	30 (90.9)	3 (9.1)	33		
Diabetes	Yes	15 (71.4)	6 (28.6)	21	1.728	0.189
	No	35 (85.4)	6 (14.6)	41		
BMI	Obese	23 (82.1)	5 (17.9)	28	0.073	0.786
	Overweight	27 (79.4)	7 (20.6)	34		

[Table/Fig-2]: Association of socio-demographic parameters, diabetes, hypertension, and BMI with Vitamin-D deficiency.

Anaemia was observed in 14 (22.5%) of the apparently healthy individuals in this study, which was high for an urban setting. Overweight males were more affected, though not statistically significant. Anaemia was observed more in elderly (>60 years) overweight and obese patients, and it was statistically significant (p-value=0.039). Additionally, it was observed that anaemia was more common in diabetics (p-value=0.006) and hypertensives (p-value=0.007) [Table/Fig-3].

There was no significant association between vitamin-D deficiency and anaemia among the study participants (p-value=0.82) [Table/Fig-4].

Parameters		Anaemia		Total	Pearson Chi-square	p-value
		Yes (n%)	No (n%)			
Gender	Male	5 (22.7)	17 (77.3)	22	0.001	0.984
	Female	9 (22.5)	31 (77.5)	40		
Age (years)	Age <60	8 (16.7)	40 (83.3)	48	4.253	0.039
	Age >60	6 (42.9)	8 (57.1)	14		
Diet	Pure vegetarian	3 (13.6)	19 (86.4)	22	1.56	0.212
	Mixed diet	11 (27.5)	29 (72.5)	40		
Hypertension	Yes	11 (37.9)	18 (62.1)	29	7.344	0.007
	No	3 (9.1)	30 (90.9)	33		
Diabetes	Yes	9 (42.9)	12 (57.1)	21	7.468	0.006
	No	5 (12.2)	36 (87.8)	41		
BMI	Obese	5 (17.9)	23 (82.1)	28	0.652	0.42
	Overweight	9 (26.5)	25 (73.5)	34		

[Table/Fig-3]: Association of sociodemographic parameters, diabetes, hypertension, and BMI with anaemia.
*Pearson Chi-square

Vitamin-D	Anaemia		Total	p-value
	Yes	No		
Vitamin-D (<30 ng/mL)	11 (22%)	39 (78%)	50	0.82
Vitamin-D (>30 ng/mL)	3 (25%)	9 (75%)	12	
Total	14	48	62	

[Table/Fig-4]: Association between Vit D deficiency and anaemia in the study participants.
*Pearson Chi-square

DISCUSSION

Obesity, anaemia, and vitamin-D deficiency are important health problems. Vitamin-D deficiency and anaemia were commonly

observed in individuals with high BMI; however, there was no statistically significant difference between the overweight and obese groups.

In this study, vitamin-D deficiency was observed in 50 (80.6%) of apparently healthy South Indian urban patients with overweight and obesity. This could be due to sedentary and indoor jobs, leading to reduced exposure to sunlight among urban populations. According to a recent review, hospital-based studies in different parts of India and different population subsets showed a prevalence of vitamin-D deficiency ranging from 37-99% [13].

The mean level of 25 (OH) Vitamin-D was 23.357±14.890 ng/mL, which was much lower than the normal range [11]. This finding was similar to another study by Parikh SJ et al., where the average 25 (OH) Vitamin-D levels in obese healthy subjects were 23.5±12.2 ng/mL, significantly lower (p-value <0.0001) than the non obese group (31±14.4 ng/mL) [2]. In another study conducted on overweight and obese Bangladeshi adults, the mean serum 25 (OH) D level was 25.25±11.97 ng/mL [3].

Among those with vitamin-D deficiency, 46.8% had severe deficiency (<20 ng/mL), and 33.8% had insufficiency (20-30 ng/mL), which was slightly higher than that observed in a similar study by Paul AK et al., [3]. Many observational studies and meta-analyses have found an inverse relationship between vitamin-D levels and BMI [2,4]. Various mechanisms have been described in the literature to explain this relationship, including volumetric dilution, sequestration of vitamin-D in adipose tissue, reduced hepatic metabolism due to fatty liver, or reduced sunlight exposure due to a sedentary lifestyle [5,14]. Whether vitamin-D deficiency is a cause or effect of obesity is still not clearly understood [14]. In the present study, vitamin-D deficiency was more prevalent in obese individuals compared to overweight individuals; however, this difference was not statistically significant.

There was no statistically significant difference with respect to gender or age between the two groups. These findings were consistent with other similar studies [2,15]. A study by Poudel N et al., showed a higher incidence of vitamin-D deficiency in individuals aged over 60 years and in females [16]. There was no significant difference in vitamin-D levels among the subjects with or without diabetes. This finding contrasts with another study by Hussain Gilani SY et al., where they concluded that obesity and diabetes were inversely related to vitamin-D levels [17]. A pure vegetarian diet is deficient in vitamin-D and vitamin B12. Hence, the effect of diet on the presence of vitamin-D deficiency and anaemia was considered and studied. However, it was not found to be significant. The presence of diabetes or the type of diet did not significantly affect vitamin-D levels. However, it was observed that vitamin-D deficiency was more prevalent in non hypertensive individuals 30 (90.9%) compared to patients with hypertension 20 (69%). The reason could be that patients with hypertension were more conscious and made changes in their diet and lifestyle.

Anaemia was observed in 14 (22.5%) of the apparently healthy individuals in present study, which was high for an urban setting. This could be due to unhealthy eating habits leading to obesity as well as nutritional deficiencies. In a cross-sectional study by Arshad M et al., the prevalence of anaemia was 9.8% among morbidly obese individuals [18]. In another study by Kannan U and Achuthan A, it was observed that overweight/obesity and increased waist circumference were inversely associated with anaemia [7]. In the present study, overweight males were more affected, though not statistically significant. This finding was comparable to other similar studies [7]. However, some studies have shown that obese individuals are less likely to be anaemic [8]. Anaemia was observed more frequently in elderly patients aged >60 years. This could be due to other factors causing anaemia, which were not further investigated in the study. Anaemia was also significantly more prevalent in individuals with diabetes and hypertensive individuals. This could be explained by the fact that obesity, being a proinflammatory state, is a risk factor for both diabetes and hypertension.

Limitation(s)

The present study had a few limitations. A control group was not included. The results cannot be generalised as it was a single-centre study. Further investigations to evaluate the cause of anaemia were not conducted in this study. Larger randomised studies in the future may help establish the association of obesity with micronutrient deficiencies like vitamin-D, vitamin B12, and iron.

CONCLUSION(S)

This study sheds light on the fact that vitamin-D deficiency and anaemia are common health problems in overweight and obese individuals. The presence of vitamin-D deficiency (80.6%) and anaemia (22.5%) was quite high in this study, which included healthy subjects with high BMI. Anaemia was more prevalent in the elderly with hypertension or diabetes. Hence, screening obese individuals in the community for anaemia and vitamin-D deficiency may help in early diagnosis and management. Obesity, being a modifiable risk factor, can be treated early to prevent many complications. Regardless of vitamin-D estimation, supplementation of vitamin-D may be beneficial in this subset of the population, especially in resource-limited settings.

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