Original Article

Vitamin D deficiency and insufficiency in Egyptian bariatric patients

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ABSTRACT

Background: Obesity is currently a pandemic that continues to increase all over the world. Nutritional disorders are among the obesity-related adverse events, with vitamin D insufficiency or deficiency being the most frequently encountered one. The aim of the current study was to assess the prevalence of reduced vitamin D levels in Egyptian patients with obesity who were candidates for bariatric surgery and to assess the relation between these levels and the patients' characteristics.

Patients and Methods: This is a retrospective study that included patients with obesity who were recruited for bariatric surgery. The patient's medical files were screened for demographic and clinical data, including data regarding vitamin D status.

Results: This study included 426 patients who were eligible for the study. The patients' vitamin D levels ranged from 4 to 50 ng/ml, with a mean of 30.2±13.7 ng/ml. A statistically significant lower mean vitamin D levels were shown in females (*P=0.006*), patients with extreme obesity (*P=0.021*), diabetes mellitus (*P=0.014*), and polycystic ovary syndrome (*P=0.016*). Patients with depression also showed lower mean levels of vitamin D, with marginal statistical significance (*P=0.056*).

Conclusion: This study confirms the high prevalence of abnormally low vitamin D levels in patients with obesity who were candidates for bariatric surgery. The study highlighted differences based on sex and revealed connections between low vitamin D levels and conditions like type 2 diabetes mellitus, polycystic ovary syndrome, depression, and eligibility for bypass surgeries.

Key Words: Bariatric surgery, obesity, vitamin D.

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INTRODUCTION

Obesity is currently a pandemic that continues to increase all over the world. It is associated with several consequences that impact human health, including an eventual increase in mortality rates[1]. Nutritional disorders are among the obesity-related adverse events, with vitamin D insufficiency or deficiency the most frequently encountered one[2–4]. Several reports and meta-analyses of studies have shown the impact of obesity on vitamin D levels[5–7].

The association between obesity and vitamin D is likely bidirectional. On the one hand, individuals with obesity may exhibit lower circulating levels of vitamin D due to its sequestration in adipose tissue and reduced sunlight exposure associated with limited mobility. On the other hand, vitamin D deficiency could contribute to the development or exacerbation of obesity through its potential impact on adipocyte function, inflammation, and insulin resistance[8].

Bariatric surgery is currently the most definitive treatment for obesity, with sustained weight loss and resolution of obesity-related complications[9,10]. However, it is associated with postoperative complications, which include nutritional deficiencies in the long term, including vitamin D insufficiency or deficiency as the most prevalent one[11–14], especially in procedures with a malabsorptive component[15].

Vitamin D deficiency not only affects the musculoskeletal system but has also been associated with other morbidities such as cardiovascular disease, metabolic syndrome, respiratory infections, and cancer[16]. Therefore, assessment of its prevalence, particularly in a vulnerable population such as patients with obesity, is crucial to planning strategies for treatment and preventing further deficiency due to bariatric surgery.

The aim of the current study was to assess the prevalence of reduced vitamin D levels in Egyptian patients with obesity who were candidates for bariatric surgery and to

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assess the relation between these levels and the patient's characteristics.

PATIENTS AND METHODS:

This is a retrospective study that included the prospectively registered data of patients with obesity who were recruited for bariatric surgery at our institution and other bariatric centers from January 2017 to the end of 2022. The study was conducted after obtaining the approval of the regional Research Ethics Committee. The guidelines of the Declaration of Helsinki were followed.

The patient's eligibility for bariatric surgery was assessed after a thorough examination by a multidisciplinary team. The institutional protocol for patients 'management and selection of the appropriate bariatric procedure as per the guidelines provided by the international medical and surgical societies[17–19], considering patients' characteristics. An informed written consent was obtained from each patient before the surgery.

The surgical procedures performed were sleeve gastrectomy (SG), Roux-en-Y gastric bypass (RYGB), and one anastomosis gastric bypass (OAGB). In brief, after the routine preoperative workup, the bariatric procedure was performed laparoscopically under general anesthesia. The surgery began with pneumoperitoneum induction, as established. Gastric resection and the sleeve were created over a 36 Fr bougie, beginning from His angle and continuing until 3–4 cm proximal to the pylorus. After sleeve creation, gastric bypass was performed in patients undergoing RYGB and OAGB. For RYGB, the Treitz ligament was identified, and a biliopancreatic limb (BPL) was created at a length of 45 cm and then side-to-side anastomosed to the gastric pouch. A 120-cm alimentary limb was performed, and then a 4.5-cm side-to-side jejuno-jejunal anastomosis was done with the BPL. In patients undergoing OAGB, the BPL was fashioned at a 200 cm length, and a side-to-side gastrojejunal anastomosis was done at a 3 cm length. The BPL was vertically formulated to be ante-colic and isoperistaltic.

After surgery, the patients were provided with standardized postoperative care, including medications, supplementation, a diet regimen, and a follow-up visit schedule.

The patient's medical files were screened for demographic and clinical data, including data regarding vitamin D status. Vitamin D sufficiency was considered when levels were above 30 ng/ml, insufficiency when levels ranged from 20 to 30 ng/ml, and deficiency when levels were less than 20 ng/ml[20]. Patients with incomplete data were excluded from the study.

Sample size

The sample size required for this study was calculated using G*Power 3.1.9.4, with a power of 95% and a total confidence interval width of 10±5%. Based on a 48.7% vitamin D deficiency rate in patients with obesity as retrieved from the largest study, which included 232 patients with obesity assessed for bariatric surgery[21], a minimum of 402 patients were required for the current study.

Study outcomes

The study outcomes of this study were the status of vitamin D levels in patients who were candidates for bariatric surgery and the potential associations with patients' characteristics.

Statistical analysis

The obtained data were analyzed using Jamovi statistical software of the R package (Jamovi, Version 2.3.28; Computer Software, Sydney, Australia). The numerical data was presented as a range and mean±SD and compared using an independent t test or an analysis of variance test, as appropriate. Categorical data were expressed as a number and percentage and compared using the χ^2 or Fisher's exact test accordingly. A Pearson correlation test was used to assess the correlation between vitamin D levels and the patients' numerical data. *P values* less than 0.05 were considered significant.

RESULTS:

This study included 426 patients who were eligible for the study. The patients' ages ranged from 18 to 66 years, with a mean of 37.2±11.7 years. There was a female predominance (n=311, 73%). The study patients had a mean weight of 126±22.9 kg and a mean BMI of 45.5±6.58 kg/m^2. Categorizing the patients according to the obesity grade revealed that 56 (13.1%) patients were of moderate obesity (with a BMI of 35 to <40 kg/m2), 272 (63.8%) patients were of severe obesity (with a BMI of 40 to <50 kg/m2), and 98 (23%) patients were of extreme obesity (with a BMI of ≥50 kg/m^2) (Table 1).

The patients' vitamin D levels ranged from 4 to 50 ng/ml, with a mean of 30.2±13.7 ng/ml. Vitamin D sufficiency was found in 255 (59.9%) patients, insufficiency in 42 (9.9%) patients, and deficiency in 129 (30.3%) patients (Table 1).

The patients' associated medical complications were hypertension (n=125, 29.3%), osteoarthritis/back pain (n=85, 20%), gastroesophageal reflux disease (n=82, 19.2%), type 2 diabetes mellitus (T2DM; n=78, 18.3%), dyslipidemia (n=57, 13.4%), bronchial asthma (n=37, 8.7%), hypothyroidism (n=31, 7.3%), polycystic ovary syndrome (PCOS) (n=22, 5.2%), hernia (n=14, 3.3%), depression (n=14, 3.3%), obstructive sleep apnea (n=13, 3.1%), ischemic heart disease (n=11, 2.6%), and hyperparathyroidism (n=4, 0.9%).

The surgeries performed were predominantly SG (n=324, 76.1%). OAGB and RYGB were performed in 52 (12.2%) and 40 (9.4%) patients, respectively. The surgeries were primary in the majority of patients (n=409, 96%) and revisional in 17 (4%) patients (Table 1).

Variation of vitamin D according to the patient's characteristics

No statistically significant differences among the different age groups in the mean vitamin D levels (P=0.863). Sex-based differences in vitamin D levels were shown, with females showing a statistically significant lower mean level (29.1±14.0 vs. 33.2±12.4 ng/ml in males, *P=0.006*) (Table 2).

In terms of BMI categories, the lowest mean levels were shown in the group with extreme obesity (26.4±16.0 ng/ml, compared to a mean of 31.4±13.3 ng/ml in patients with moderate obesity and 31.4±12.6 ng/ml in patients with severe obesity). The difference was statistically significant (*P=0.021*) (Table 2).

Examining various associated medical conditions, patients with T2DM and PCOS showed statistically significantly lower mean levels compared to those without (26.8±15.5 vs. 31.0±13.1 ng/ml, *P=0.014* for T2DM and 23.4±14.5 vs. 30.6±13.5 ng/ml, *P=0.016* for PCOS). Patients with depression also showed lower mean levels of vitamin D compared to those without (23.4±16.1 vs. 30.5±13.5 ng/ml) with marginal statistical significance (*P=0.056*) (Table 2).

Other associated medical conditions, including hypertension, dyslipidemia, gastroesophageal reflux disease, hiatus hernia, BA, obstructive sleep apnea, ischemic heart disease, osteoarthritis/back pain, hypothyroidism, and hyperparathyroidism, not show statistically significant differences in vitamin D levels (*P>0.05*) (Table 2).

The vitamin D levels showed no statistically significant difference among patients according to the type of surgery (primary or revisional, *P=0.214*), but there was a statistically significant difference according to the surgical procedure (*P<0.001*), with the lowest levels in candidates for SG (27.7±13.39 ng/ml) (Table 2).

In the correlation analysis, vitamin D levels showed a statistically significant negative correlation with the patients' BMI (r=-0.17, *P<0.001*) (Fig. 1). No statistically significant correlation was shown with the patients' age (r=-0.06, *P=0.224*) or weight (r=-0.08, *P=0.096*).

Table 1: Demographic and clinical data of the included patients (N=426)

Characteristic		Mean±SD, range
Age (years)		37.2±11.7, 18–66
Weight (kg)		126±22.9, 85–230
BMI (kg/m^2)		45.5±6.58, 35.1–81.2
Vitamin D levels (ng/ml)		30.2±13.7, 4–50
		n (%)
Sex		
Female	311 (73)	
Male	115 (27)	
Obesity grade		
Moderate obesity (35 to <40)	56 (13.1)	
Severe obesity (40 to <50)	272 (63.8)	
Extreme obesity (≥50)	98 (23)	
Vitamin D status		
Sufficiency	255 (59.9)	
Insufficiency	42 (9.9)	
Deficiency	129 (30.3)	
Medical complications		
Hypertension	125 (29.3)	
Osteoarthritis/back pain	85 (20)	
GERD	82 (19.2)	

Type 2 diabetes mellitus	78 (18.3)
Dyslipidemia	57 (13.4)
Bronchial asthma	37 (8.7)
Hypothyroidism	31 (7.3)
PCO	22 (5.2)
Hernia	14 (3.3)
Depression	14 (3.3)
OSA	13 (3.1)
IHD	11 (2.6)
Hyperparathyroidism	4 (0.9)
Performed surgeries	
SG	324 (76.1)
OAGB	92 (21.6)
RYGB	10 (2.3)
Surgery type	
Primary	409 (96)
Revisional	17 (4)

GERD, gastroesophageal reflux disease; IHD, ischemic heart disease; OAGB, one anastomosis gastric bypass; OSA, obstructive sleep apnea; RYGB, Roux-en-Y gastric bypass; SG, sleeve gastrectomy.

Table 2: Comparison of the vitamin D levels according to the patients' characteristics (N=426)

Characteristic	Group	*N*	Vitamin D levels (mean±SD)	*P* value
Age group	≤35 years	183	30.4±13.1	0.863
	35–55 years	207	29.9±14.0	
	>55 years	36	31.1±15.0	
BMI Category	Moderate obesity	56	31.4±13.3	0.021*
	Severe obesity	272	31.4±12.6	
	Extreme obesity	98	26.4±16.0	
Surgery type	Primary	409	30.4±13.7	0.214
	Revisional	17	26.2±12.3	
Surgical procedure	RYGB	40	34.1±8.43	<0.001*
	OAGB	52	35.5±14.74	
	SG	324	27.7±13.39	
Sex	Female	311	29.1±14.0	0.006*
	Male	115	33.2±12.4	
DM	No	348	31.0±13.1	0.014*
	Yes	78	26.8±15.5	
Hypertension	No	301	30.8±13.5	0.180
	Yes	125	28.8±13.9	
Dyslipidemia	No	369	29.9±13.8	0.300
	Yes	57	32.0±12.9	
GERD	No	344	30.5±13.6	0.315
	Yes	82	28.9±14.0	
Hiatus hernia	No	412	30.2±13.6	0.635
	Yes	14	31.9±14.8	
BA	No	389	30.3±13.5	0.678
	Yes	37	29.3±15.3	

OSA	No	413	30.1±13.6	0.548
	Yes	13	32.5±15.3	
PCOS	No	404	30.6±13.5	0.016*
	Yes	22	23.4±14.5	
IHD	No	415	30.3±13.7	0.404
	Yes	11	26.8±13.0	
Osteoarthritis/back pain	No	341	30.0±13.5	0.433
	Yes	85	31.3±13.7	
Depression	No	412	30.5±13.5	0.056
	Yes	14	23.4±16.1	
Hypothyroidism	No	395	30.2±13.7	0.954
	Yes	31	30.4±13.8	
Hyperparathyroidism	No	422	30.2±13.7	0.738
	Yes	4	32.5±14.4	

GERD, gastroesophageal reflux disease; IHD, ischemic heart disease; OAGB, one anastomosis gastric bypass; OSA, obstructive sleep apnea; PCOS, polycystic ovary syndrome; RYGB, Roux-en-Y gastric bypass; SG, sleeve gastrectomy.

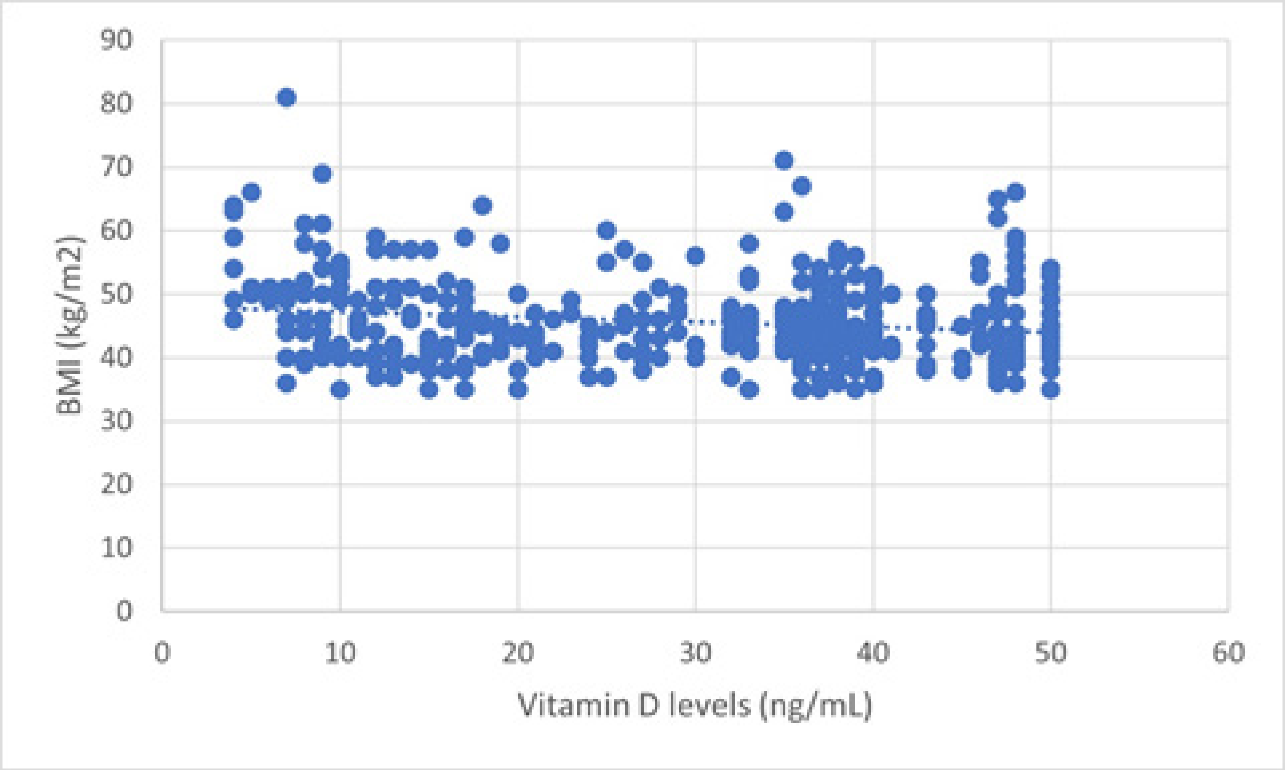

Fig. 1: Correlation between BMI and vitamin D levels.

DISCUSSION

Reduced vitamin D levels are one of the most frequently occurring micronutrient deficiencies in people with obesity[14,21–27]. The current study conducted on an Egyptian cohort with obesity demonstrated that vitamin D insufficiency and deficiency were found in 9.9 and 30.3% of the patients, respectively, denoting abnormally low levels in 40.2% of the patients. This prevalence lies within the range reported in the literature, with abnormally low vitamin D levels found in 21.1–100% of patients with obesity[14,28–32]. Variations in the prevalence of vitamin D levels among studies could be attributed to the different geographical locations, cutoff values defining the low levels, used methods for measurement, and the BMI of the included patients, with some studies including patients with a BMI of 25.5 kg/m^2 and others including those with a BMI equal to or higher than 40 kg/m^2.

Other aspects of the association between obesity and low vitamin D levels were demonstrated in this study, including the lowest levels of vitamin D observed in patients with extreme obesity and a significant negative association between vitamin D levels and BMI. In line with our findings, Ong *et al*.[30] found the patients with the highest BMI had the lowest vitamin D levels. Other studies showed a significant negative association between vitamin D levels and BMI[33–36]. Interestingly, Vimaleswaran *et al*.[8] reported that a 1.15% reduction in vitamin D levels occurred for each unit increase in BMI. Additionally, Stein *et al*.[26] demonstrated that each unit increase in BMI was associated with a reduction of vitamin D levels by 1.3 nmol/l.

This study showed that there was a sex-based difference in vitamin D levels, with females showing a statistically significant lower mean value. Similar findings were reported by the study of Ong *et al*.[30], which was conducted in Singapore and found a higher burden of vitamin D deficiency in the studied women. One plausible explanation for the sex disparity in vitamin D levels could be related to differences in body composition between males and females. Adipose tissue is known to sequester vitamin D[37], and since females generally have a higher proportion of body fat than males, this may contribute to lower circulating vitamin D levels. Moreover, lifestyle factors such as sun exposure and dietary habits may differ between sexes, influencing vitamin D levels. Females, for example, may be more likely to use sunscreen or cover their skin for cultural or cosmetic reasons, potentially limiting their vitamin D synthesis from sunlight.

The present study highlights significantly lower vitamin D levels in patients with T2DM. The inverse association between vitamin D levels and T2DM has been documented in numerous studies[38–41], suggesting a multifaceted interplay between vitamin D, insulin sensitivity, and glucose metabolism. Vitamin D plays a role in pancreatic beta-cell function, insulin synthesis, and the sensitivity of target tissues to insulin[42]. The lower vitamin D levels observed in patients with T2DM in this study highlight the importance of considering vitamin D status as a potential modifiable risk factor in the management and prevention of diabetes.

In this study, patients with PCOS also showed significantly lower vitamin D levels. The findings of this study align with existing literature that suggests a potential link between these two conditions[43]. Several mechanisms may contribute to the observed lower vitamin D levels in individuals with PCOS. Insulin resistance, a common feature of PCOS, has been associated with impaired vitamin D metabolism[34,42–45]. Additionally, hormonal imbalances characteristic of PCOS, such as elevated levels of androgens, could influence vitamin D synthesis and metabolism[43].

The revelation of significantly lower vitamin D levels in patients with depression, as highlighted in the present study, adds a compelling dimension to the growing body of research examining the potential link between vitamin D and depression[46,47].

In this context, a bidirectional nature of the relationship between vitamin D and depression has been proposed. One hypothesis is that vitamin D, known for its role in neuroprotection and neurotransmitter regulation, may influence mood and emotional well-being[46]. Conversely, individuals with depression may be more likely to adopt sedentary behaviors, have limited outdoor activities, and experience changes in dietary habits, all of which could contribute to lower vitamin D levels.

Finally, this study showed significantly lower vitamin D levels in candidates for SG. This appears related to the patients' selection criteria, where patients with preoperative nutritional deficiencies are less likely to be chosen for malabsorptive surgery.

The present study's prevalence of vitamin D insufficiency and deficiency among individuals with obesity echoes previous research, yet this study, to the best of our knowledge, included the largest cohort compared to other studies investigating the same issue. Several limitations are acknowledged. These include the retrospective design and the absence of data regarding vitamin D supplementation in the included patients. However, our study offers unique insights into vitamin D variations according to patients' characteristics. Further longitudinal studies, including assessments of the impact of vitamin D levels on postoperative outcomes and the benefits of vitamin D supplementation on complications associated with obesity, are warranted.

CONCLUSION

This study confirms the high prevalence of abnormally low vitamin D levels in patients with obesity who were candidates for bariatric surgery. The study highlighted differences based on sex and revealed connections between low vitamin D levels and conditions like T2DM, PCOS, depression, and eligibility for bypass surgeries.

CONFLICT OF INTEREST

There are no conflicts of interest.

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