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Prevalence of vitamin D deficiency in adults presenting for bariatric surgery in Lebanon

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Abstract

Background: Vitamin D deficiency is common among obese patients presenting for bariatric surgery in Europe and North America. The prevalence of vitamin D deficiency in this patient population in Lebanon and the Middle East has not been studied.
Objectives: The aim of this study was to determine the rate of vitamin D deficiency in a cohort of patients presenting for bariatric surgery in Lebanon.
Setting: American University of Beirut Medical Center, Beirut, Lebanon.
Methods: Data was extracted from a prospective database of patients presenting for bariatric surgery at the American University of Beirut Medical Center from July 2011 until June 2014. The prevalence of vitamin D deficiency was determined using established cut-offs followed by analysis of the relationship between low vitamin D and certain patient characteristics.
Results: More than two thirds of all patients (68.9%) were vitamin D deficient ($\leq$19.9 ng/mL), whereas 22.6% had insufficient levels (20-29.9 ng/mL) and only 8.6 % had sufficient levels ($\geq$30 ng/mL). Vitamin D levels were inversely associated with BMI $>$50 kg/m^2. Low vitamin D levels were also correlated with younger age, male gender, lack of physical exercise, and nonsunny season. No association was shown between 25-hydroxyvitamin D deficiency and type 2 diabetes mellitus, cardiovascular disease, osteoarticular disease, hypertension, or depression.
Conclusion: Vitamin D deficiency is prevalent among patients with Class II or Class III obesity presenting for bariatric surgery in Lebanon. These findings emphasize the need for careful attention when evaluating patients before bariatric surgery and the importance of providing patients with adequate supplementation. (Surg Obes Relat Dis 2016;12:405–411.) © 2016 American Society for Metabolic and Bariatric Surgery. All rights reserved.

Keywords: Vitamin D; Vitamin D deficiency; Bariatric surgery; Weight loss

Obesity is one of the most prevalent health problems today [1]. According to the World Health Organization (WHO), > 1.9 billion adults, aged 18 years and older, were overweight (body mass index [BMI] $\geq$25 kg/m^2) in 2014. Of these, > 600 million were obese (BMI $\geq$30 kg/m^2) [2]. In the Middle East, the prevalence of obesity has exceeded that of Western countries, reaching 40%–50% [3,4]. Along with the ever-growing number of obese patients, there has been an evident rise in the numbers of bariatric surgical procedures worldwide. Bariatric surgery is the only effective treatment for class III obesity and for class II obesity in the presence of significant co-morbidity [5]. However, many nutritional deficiencies, present in patients with class II or III obesity before surgical intervention, are often not corrected and may even be aggravated postoperatively. Such an example is vitamin

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25-hydroxyvitamin D (25 OHD) deficiency, which is prevalent in 21% to 90 % of obese individuals at baseline [5–10].

The rate of vitamin D deficiency in patients with class II or III obesity presenting for bariatric surgery has been well documented in Europe and North America. To the best of the authors' knowledge, this has not been studied in the Middle East. The goal of the present study was to evaluate the prevalence of vitamin D deficiency in adult patients presenting for bariatric surgery. Secondarily, the study aimed to identify certain characteristics that might be associated with hypovitaminosis D in this population.

Materials and methods

The study was approved by the Institutional Review Board at the American University of Beirut. Patients' data were collected from consecutive patients presenting for bariatric surgery consultation at the American University of Beirut Medical Center (AUBMC) from July 2011 until June 2014. The data was collected prospectively and included demographic characteristics (age, gender, country of residence), anthropomorphic information (weight, height, BMI), medical history and laboratory results of serum 25 OHD. Inclusion criteria were defined as patients between the ages of 18 and 65 years with a BMI $\geq$35 kg/m^2 and with serum 25 OHD levels obtained at the AUBMC Clinical Laboratory. Patients who had already undergone a previous bariatric procedure that bypasses part of the intestinal tract (gastric bypass or biliopancreatic diversion) or were presenting after bariatric surgical complications from another facility were excluded. It was believed that such procedures or complications might have a significant impact on vitamin D absorption; therefore, such patients were excluded from the study. Patients who had prior restrictive bariatric operations, such as gastric banding or gastroplasty, and were presenting for revisional surgery or consultation were not excluded, because there is no clear data that gastric restriction has significant impact on 25 OHD absorption. Patients who did not have serum 25 OHD levels recorded or had the blood tests done at institutions other than AUBMC were excluded. Presence of comorbidities was assessed according to patients' self-reports on initial assessment, medication usage, and sometimes laboratory tests, whereas lifestyle habits were based solely on patients' self-reports. Patients were considered to exercise if they reported performing at least 30 minutes of vigorous intensity aerobic physical activity per week.

Vitamin D measurement and definitions of deficiency, insufficiency, and sufficiency

When 25 OHD is bound to vitamin D-binding protein, it has a half-life of > 2 weeks and is a clinically accurate indicator of vitamin D status [1]. In the present study, 25 OHD levels were categorized as deficient (<20 ng/mL), insufficient (between 20 and 29.9 ng/mL), and sufficient ($\geq$ 30 ng/mL), based on Holick's classification [11,12]. Roche total binding protein assay with electrochemiluminescence detection was used for measurement of vitamin D status. This assay is specific for both D2 and D3 forms of 25 OHD and has an analytical measuring range of 3.00–70.0 ng/mL. Values below the limit of detection are reported as <3.00 ng/mL. Values above the measuring range are reported as >70.0 ng/mL. The functional sensitivity was determined to be 4.01 ng/mL.

Statistical analysis

Analysis was conducted using SPSS (Statistical Package for Social Sciences), version 22 (SPSS, Armonk, NY). Blood sampling season was defined as sunny (April through September) or nonsunny (October through March). Once prevalence of vitamin D deficiency, insufficiency, and sufficiency was obtained, univariate analyses to assess the association with different variables were carried out using χ^2 tests or Student's *t* test, as appropriate. Moreover, multivariate logistic regression analyses were carried out to identity the variables associated with vitamin D deficiency, whereby factors found to be significant at the univariate level or those of clinical significance were included. Odds ratio (OR) and 95% CI were reported. The level of statistical significance was set at a *P* value <.05.

Results

A total of 840 patients presented for bariatric surgical consultation between July 2011 and June 2014. Of the 840 patients at baseline, 257 met the inclusion criteria and constituted the study's cohort. Most patients were excluded because of the lack of 25 OHD levels (49%) or because the measurement of 25 OHD levels was done at other facilities (20.4%). The baseline characteristics of the cohort are summarized in Table 1. Twenty-one patients (8.2%) had previous gastric banding, and 1 patient had a previous vertical banded gastroplasty. Most patients (79.8%) were Lebanese, with a mean age of 39.7 years (±12.3 yr) and a mean body mass index of 43.1 kg/m^2 (±7.0). The study population was equally distributed between men and women (50.20% versus 49.80% respectively). The mean serum 25 OHD was 16.5 ng/mL (±9.6). More than two thirds of all patients (68.9%) were vitamin D deficient, whereas 22.6% had insufficient levels and only 8.6% had sufficient levels.

Univariate analysis

Vitamin D deficiency is clinically more relevant than insufficiency [13]. Thus, the primary aim of the present study was to determine the prevalence and risk factors

Table 1
Baseline characteristics of the study population

Variables			Mean (±SD)	Frequency (%)
Total sample			N = 257	
Demographic characteristics	Age (years)		39.7 (±12.3)	
	Gender	Male		50.20
		Female		49.80
	Country	Lebanon		79.80
		Iraq		9.70
		Others		10.50
	Month of assessment	Sunny		51.80
		Nonsunny		48.20
	Body mass index (kg/m^2)		43.1 (±7.0)	
		35.0–40.0		40.50
		40.01–45.0		28.00
		45.01–50.0		17.10
		>50		14.40
Lifestyle	Smoking			35.80
	Alcohol intake			37.40
	Physical exercise	No		81.70
		Yes		18.30
Co-morbidities	Diabetes			31.50
	Hypertension			31.90
	Dyslipidemia			26.50
	Depression			16.70
	Cardiovascular disease			2.30
	Osteoarticular disease	Single joint disease		38.90
		Multiple joint disease		25.30
Previous surgeries	Restrictive bariatric surgery			8.90
	Cholecystectomy			12.50
Obesity	Family history of obesity			74.00
	Obesity since (years)		20.6 (±13.5)	
	Previous maximal weight loss (kg)		16.2 (±11.1)	
Vitamin D	25 OHD (ng/mL)		16.5 (±9.6)	
	25 OHD categories	Deficiency (≤ 19.9 ng/mL)		68.90
		Insufficiency (20-29.9 ng/mL)		22.60
		Sufficient (≥30 ng/mL)		8.60

25 OHD = vitamin 25-hydroxyvitamin D

associated with vitamin D deficiency. Therefore, patients with insufficient and sufficient levels were combined in 1 group (n = 80). Univariate analysis was conducted to study the association between all the collected variables and the prevalence of vitamin D deficiency (Table 2). Vitamin D deficiency was found to be significantly associated with BMI, age, physical exercise, and hypertension.

Multivariate analysis

After multivariate adjustment, 25 OHD deficiency was significantly associated with a younger age (mean age: 37.4 ± 11.5 years versus 44.7 ± 12.6 years, $P < .0001$), male gender ($P = .04$), lack of physical exercise ($P = .01$), a BMI >50 kg/m^2 (OR = 4.68; CI: 1.50–14.58, $P = .008$), and month of assessment (Table 3). Each 1 kg/m^2 increase in BMI above 50 kg/m^2 increased the odds of 25 OHD deficiency by 4.68 times compared with those with a BMI between 35–40 kg/m^2 (Table 3). In univariate analysis, no significant association was found between nonsunny months (October–March) and 25 OHD deficiency. However, after multivariate adjustment and controlling for confounding factors, nonsunny months were found to be significantly associated with 25 OHD deficiency (OR = 1.96, $P = .03$), as clinically suspected. Presence of hypertension was not found to be associated with 25 OHD deficiency.

Discussion

Vitamin D is 1 of the 4 liposoluble vitamins required for optimal health and is important for maintaining calcium homeostasis and bone mineralization [14]. Research during the past 20 years has revealed other roles for vitamin D, including an inverse correlation with overall mortality, diabetes, hypertension, cardiovascular diseases, frequency of fractures, some infections, and breast and colon cancers [1,4,8–10,15–22]. The major source of vitamin D for most humans is sun exposure and, to a lesser extent, dietary intake. Even so, most people consume little vitamin D through their natural diets [20,21].

The study shows an overall prevalence of vitamin D deficiency of 68.9% among patients with class II or

Table 2
Univariate analysis: all variables and the prevalence of vitamin D deficiency

Variables			25 OHD < 20 ng/mL (%)	25 OHD ≥ 20 ng/mL (%)	*P* value
Total sample			n = 177	n = 80	
Demographic characteristics	Age (years)	Mean (±SD)	37.4 (±11.5)	44.7 (±12.6)	<.0001
	Gender	Male	53.7	42.5	.1
		Female	46.3	57.5	
	Country	Lebanon	79.1	81.3	.71
		Iraq	10.7	7.5	
		Others	10.2	11.3	
	Month of assessment	Sunny	49.2	57.5	.22
		Nonsunny	50.8	42.5	
	Body mass index (kg/m^2)	Mean (±SD)	43.9 (±7.6)	41.4 (±5.0)	.009
		35.0-40.0	36.2	50.0	
		40.01–45.0	29.9	23.8	
		45.01–50.0	15.8	20.0	
		> 50	18.1	6.3	
Lifestyle	Smoking		37.3	32.5	.46
	Alcohol intake		36.2	40.0	.56
	Physical exercise	No	85.9	72.5	.01
		Yes	14.1	27.5	
Co-morbidities	Diabetes		28.8	37.5	.17
	Hypertension		27.7	41.3	.03
	Dyslipidemia		23.7	32.5	.14
	Depression		14.7	21.3	.19
	Cardiovascular disease		2.3	2.5	1
	Osteoarticular disease	Single joint disease	39.0	38.8	.43
		Multiple joint disease	23.2	30.0	
Previous surgeries	Restrictive bariatric surgery		9.0	8.8	.94
	Cholecystectomy		10.7	16.3	.22
Obesity	Family history of obesity		73.7	74.7	.87
	Obesity since (years)	Mean (±SD)	19.5 (±12.8)	23.1 (±14.8)	.06
	Previous maximal weight loss (kg)	Mean (±SD)	17.0 (±11.5)	14.4 (±10.1)	.09

25 OHD = vitamin 25-hydroxyvitamin D

III obesity presenting for bariatric surgery in Lebanon. Insufficiency was present among 22.6%, and only 8.6% had sufficient vitamin D levels. These results are in accordance with the findings from previous studies of morbidly obese patients in Europe and the United States, summarized in Table 4. Prevalence of 25 OHD deficiency in the aforementioned studies ranged between 60% and 96%. Two studies conducted in a Spanish morbidly obese population reported a prevalence of vitamin D deficiency similar to the present study (67.7% and 71.3% versus 68.9% in the present study) [5,23]. Both Spain and Lebanon have borders on the Mediterranean and have similarities in weather, dietary habits, and medium skin pigmentation. Lebanon lies in Zone 2 of ultraviolet (UV) radiation, in which there is not sufficient UV radiation during at least 1 month of the year and the degree of skin pigmentation is considered intermediate between light and dark [24].

Table 3
Multivariate analysis for risk factors of vitamin D deficiency

Variables	Adjusted OR (95%CI)	*P* value
Age (years)	.95 (.92–.97)	<.0001
BMI 35.0–40.0 (Reference)	Reference	Reference
BMI 40.1–45.0	1.85 (.90–3.81)	.10
BMI 45.1–50.0	1.11 (.50–2.47)	.81
BMI > 50	4.68 (1.50–14.58)	.008
Physical exercise	.39 (.19–.83)	.01
Alcohol intake	.78 (.42–1.46)	.45
Hypertension	.69 (.36–1.33)	.27
Gender Male	Reference	Reference
Female	.52 (.28–.98)	.04
Month of assessment Sunny	Reference	Reference
Nonsunny	1.96 (1.07–3.61)	.03

BMI = body mass index; CI = confidence interval; OR = odds ratio

Although the above studies used the same definition of vitamin D deficiency (<20 ng/mL), there was variability among 25 OHD deficiency prevalence that may have been due to factors such as the type of assay used, differences in climate and sun exposure, intake of supplements, and food supplementation programs [10,25]. For instance, intake of vitamin D in North America is higher than Europe due to food supplement policies and a higher tendency to take vitamin D supplements in the United States [25].

To the best of the authors' knowledge, there have not been any studies in the Middle East region that assessed vitamin D status in prebariatric surgery patients. However, many population-based studies in this region have found a correlation between increased BMI and adiposity and low vitamin D levels. In a study by Gannagé-Yared et al.,

Table 4
Published vitamin D studies among obese patients in the United States and Europe

Study	Population	Prevalence of vitamin D deficiency (%)*	Association present with vitamin D deficiency	No association with vitamin D deficiency
Violeta Moizé et al. [5]	Spain	67.7		
Fish et al. [6]	USA	84		Preoperative BMI
Damms-Machado et al. [7]	Germany	83		
Ducloux et al. [8]	France	96	Ethnicity, BMI, calcium & phosphate levels, season	PTH (weak correlation)
Grace et al. [10]	UK	90	Ethnicity, DMII, CAD, OSA, Depression	Severe functional impairment
Van der Schueren et al. [25]	USA	65		BMI, ethnicity
de Luis et al. [23]	Spain	71.3	BMI	
Carlin et al. [36]	USA	60		
Bellia et al. [39]	Italy			Systemic inflammation and body adiposity
Stein et al. [47]	USA	65		Race, sunlight, VD intake, PTH
Goldner et al. [48]	USA	61	Calcium, VD intake, sunlight exposure	
Present study	Lebanon	68.9	Age, male gender, lack of physical exercise, nonsunny season, BMI >50 kg/m^2	Obesity-related co-morbidities, alcohol intake

BMI = body mass index; CAD = coronary artery disease; DMII = diabetes mellitus type II; OSA = obstructive sleep apnea; PTH = parathyroid hormone; VD = vitamin D. *Vitamin D Deficiency Defined as 25 OHD <20 ng/ml

among 251 Lebanese osteoporotic women, it was shown that 84.9% had 25 OHD levels $<$ 30 ng/mL and that vitamin D levels were negatively correlated with BMI [16]. Another study in Iran among 259 healthy adolescents [26] and 4 other studies in Saudi Arabia [27–30] also reported a correlation between BMI and low vitamin D levels. On the other hand, a study done among adolescent females in Kuwait showed no significant association between 25 OHD and BMI before and after controlling for confounders [31]. In the present study, vitamin D levels were inversely associated with BMI. This relationship was best seen in the multivariate analysis with a BMI >50 kg/m^2 (OR = 4.68; CI 1.50–14.58, P = .008). These results are consistent with findings of other studies in North America, Europe, and the Middle East [3,5,6,16,23,26–30,32–39].

The mechanisms underlying vitamin D deficiency in patients with class II or III obesity are still not well understood [37]. Vitamin D sequestration in excess adipose tissues leading to decreased bioavailability of this vitamin and lower sun exposure were considered key factors behind vitamin D deficiency in patients with class II or III obesity. Moreover, those individuals usually have a more sedentary lifestyle, tend to spend less time outside, and tend to be overdressed [1,10,23,40]. Other theories relate to fatty liver disease, commonly found in obesity, and the influence of the disruption of liver activity on vitamin D synthesis [41]. People with class II or III obesity were shown to synthesize a lower amount of vitamin D3 than normal-weight individuals when exposed to the same amount of UV light [1].

In addition, vitamin D deficiency was found to be correlated with younger age (adjusted OR = .95, CI .92–.97, $P < .0001$), male gender ($OR_{females}$ = .52, CI .28–.98, P = .04), lack of physical exercise ($OR_{physical\ activity}$ = .39, P = .01), and nonsunny season ($OR_{nonsunny\ months}$ = 1.96, CI 1.96–3.61, P = .03).

It is well known that elderly people are more susceptible to developing vitamin D deficiency due to several risk factors: decreased dietary intake, diminished sunlight exposure, reduced skin thickness, impaired intestinal absorption, and impaired hydroxylation in the liver and kidneys [42]. However, in this study and to the authors' surprise, the mean age for patients with 25 OHD <20 ng/mL was 37.4 years versus 44.7 years in those with 25-OHD ≥ 20 ng/mL. There is not a good explanation for this observation, but it is possible that older patients are more likely to have sought medical attention and may have received supplementation from medical practitioners or through media awareness. A significant limitation to the present study, because of its retrospective nature, is the lack of documentation of vitamin D supplement intake because this was not initially included in the database.

Even though men were more physically active than women (60% versus 40%, respectively) and likely had more sun exposure because many women are veiled or conservatively dressed, men were more vitamin D deficient than women. In the literature, some studies reported on similar findings showing lower vitamin D levels in men. A cross-sectional study from Norway among 2,026 patients with a BMI of 40 kg/m^2 or more, or 35 kg/m^2 or more and experiencing obesity-related health conditions showed that male patients had a higher rate of vitamin D deficiency (56% versus 47%) [43]. Similarly, another study of 2,126 persons with varying degrees of being overweight or obese showed that the prevalence of vitamin D deficiency was as high as 32% among women and 46% among men [44]. This might be due to the increased awareness of the importance of this vitamin among women in this population leading them to take more supplements than men.

It is important to note that living in a country with plenty of sunshine doesn't guarantee getting enough sun exposure. Studies from Gulf countries such as the United Arab Emirates registered the lowest vitamin D levels in summer [3]. In addition, many studies in Saudi Arabia have shown that vitamin D levels are generally lower than the rest of the world, despite its sunny climate throughout the year, due to the high prevalence of obesity and to climatic and cultural reasons that decrease sun exposure in this population [27–30].

Lack of physical exercise was significantly associated with vitamin D deficiency among the present bariatric surgery population ($P = .01$). Patients with poor outdoor physical activity may have less UVB rays exposure resulting in low vitamin D levels [45]. In addition, there is a growing body of evidence that 25 OHD deficiency is associated with a decline in muscle function and performance, which can be improved by adequate supplementation especially in the elderly population [46].

Despite the correlation between a variety of obesity comorbidities and vitamin D deficiency reported in the literature, this study showed no statistically significant association between 25 OHD deficiency and type 2 diabetes mellitus, cardiovascular disease, osteoarticular disease, hypertension, or depression.

Study limitations

The present study lacked data regarding dietary history and intake of vitamin D and calcium supplements, which might have led to an underestimation of vitamin D deficiency among patients with class II or III obesity. In addition, no community-based nonobese group was available as control to compare the results. Despite these limitations, the present findings provide insight into prevalence and risk factors for vitamin D deficiency in patients before bariatric surgery.

Conclusion

This is the first study in the Middle East to assess the prevalence of vitamin D deficiency in a cohort of bariatric surgery candidates with class II or III obesity. Deficiency of 25 OHD was shown to be very common among this population with more than two thirds of patients being deficient. Age, gender, physical exercise, lack of sun-exposure, and increased BMI were found to be significantly associated with vitamin D deficiency. This highlights the need for screening of nutritional deficiencies among those patients, as well as the need for interventional studies and clinical trials to determine the optimal dose of vitamin D supplementation before and after the surgery.

Disclosures

The authors have no commercial associations that might be a conflict of interest in relation to this article.

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