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ORIGINAL ARTICLE – OPEN ACCESS

Evaluation of Obesity with Vitamin D Levels and Related Parameters

Aybike Gizem Kayacan[1], Neslihan Sürmeli[2], Mehtap Ünlü Söğüt[1], Elanur Yılmaz[3]

ABSTRACT

Objective: This study aimed to investigate the relationship between vitamin D levels, biochemical findings, and body analysis data of adult individuals, and effects of seasonal vitamin D level differences on these relationships.

Materials and Methods: In this retrospective study, medical records of 159 individuals who applied to Samsun Büyük Anadolu Hospital Nutrition and Dietary Polyclinic were examined. The serum 25(OH)D levels were defined as <10 ng/ml vitamin D deficiency; 10–20 ng/ml vitamin D insufficiency; and >20 ng/ml normal vitamin D level. Vitamin D levels were also divided into two according to seasons: summer and winter.

Results: Of the 159 participants included in the study, 42 were overweight and 94 were obese. Vitamin D deficiency was found in 21.4% and vitamin D insufficiency was found in 35.2% of the patients. Winter vitamin D levels were significantly lower than summer vitamin D levels. Vitamin D levels decreased with increasing body fat mass and percentage, abdominal fat mass and percentage. Individuals with vitamin D deficiency had higher body mass index than individuals with vitamin D insufficiency. Vitamin B12 levels of individuals with vitamin D deficiency were found to be significantly lower. Aspartate aminotransferase levels of individuals with vitamin D deficiency were higher than individuals with vitamin D insufficiency.

Conclusion: Vitamin D deficiency and insufficiency varies according to sunbathing times in summer and winter season and it is quite common in obese patients. Strategies should be developed to prevent and control obesity and to combat the inadequacy of vitamin D nutritional status.

Keywords: Adiposity, body mass index, vitamin D, obesity

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[1]Nutrition and Dietetics, Ondokuz Mayıs University, Faculty of Health Sciences, Samsun, Turkey
[2]Nutrition and Dietetics, Yüzüncü Yıl University, Vocational Health High School, Van, Turkey
[3]Department of Nutrition and Dietetics, Büyük Anadolu Hospital, Samsun, Turkey

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Correspondence Aybike Gizem Kayacan, Department of Nutrition and Dietetics, Ondokuz Mayıs University, Faculty of Health Sciences, Samsun, Turkey
Phone: +90 536 734 87 41
e.mail: aybike.kayacan@omu.edu.tr

INTRODUCTION

Obesity is defined as the most common metabolic disorder in the world; and according to World Health Organization (WHO) data, there are approximately 600 million obese people worldwide. It is estimated that this figure will double by 2030 (1). Vitamin D (calciferol) is a hormone, mainly defined by its role as regulator of phosphate and calcium homeostasis (2). In vitamin D deficiency, serum levels of calcium and phosphorus are normal; and 24-h urinary calcium excretion and 25(OH)D levels, primary circulatory form of vitamin D in the blood, is lowered (3). Evidence pointing to obesity increasing the risk of vitamin D deficiency has been consistently reported in all age groups and in different population groups (4). While some studies have shown that body mass index (BMI) and obesity are directly related to circulating vitamin D-binding proteins, and 25(OH)D levels may be lower in obesity (5, 6), there are studies that do not support this opinion (7).

There is an inverse correlation between adiposity and serum 25(OH)D concentration (8, 9). High adiposity has been shown to induce vitamin D deficiency by decreasing circulating concentrations of 25(OH)D. One of the hypotheses explaining this situation is that the adipose tissue in obese individuals prevents exposure to solar ultraviolet radiation, which is indispensable for the synthesis of vitamin D3 from the skin (4). Another hypothesis is that the production of active vitamin D metabolite (1,25(OH)2D) in adipose tissue is increased, and it is claimed that it applies negative feedback control on hepatic synthesis of 25(OH)D (10). Vitamin D also has antiadipogenic properties (11). It stimulates apoptosis of adipocytes through an intracellular increase in ionized calcium, increased energy consumption, activation of sympathetic nervous system to increase dietary thermogenesis, and fat oxidation (12).

Absorption of vitamin B12 requires a medium filament protein (IF), a specific transport protein secreted by gastric parietal cells. The vitamin B12-IF complex binds to the specific ileal cell surface receptor on the ileal mucosa where it is separated and dispersed in the B12 portal circulation. This is a calcium-dependent process. Calcium absorption is dependent on vitamin D3. Accordingly, vitamin D deficiency may inhibit important calcium-dependent processes such as vitamin B12 absorption (Fig. 1) (13).

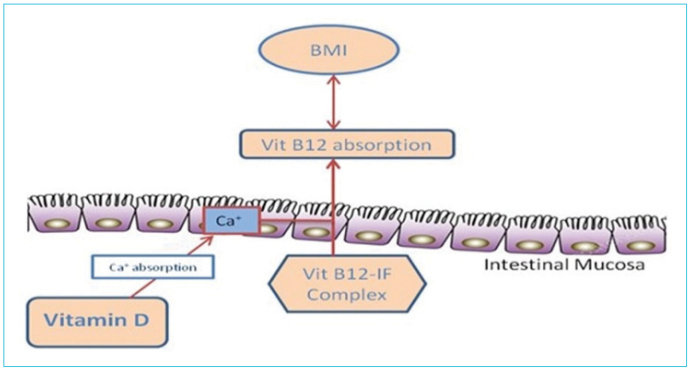

Figure 1. Vitamin B12 uptake: dependence and influence of vitamin D, vitamin D receptor and calcium

BMI: Body mass index; Vit: Vitamin; Ca^{+}: Calcium; IF: Intrinsic factor

Although Turkey is geographically situated to have an adequate sunny climate, sunlight is not benefited enough because of several reasons. This study was carried out in Samsun, one of Turkey's relatively sunny provinces. The aim was to investigate the effects of vitamin D levels on obesity, related biochemical results, and body analysis data. It also aimed to investigate the effects of seasonal differences on vitamin D levels.

MATERIALS and METHODS

In this retrospective case control study, 159 individuals (115 female and 44 male) who applied to Samsun Büyük Anadolu Hospital Nutrition and Dietary Polyclinic between 01.09.2016 and 01.09.2017 were included. Individuals who were older than 18 years of age, did not have bariatric surgery, and did not take any vitamin D supplementation were included. Among these individuals, those who applied between 01.09.2016 and 28.02.2017 were classified as winter and those who applied between 01.03.2017 and 31.08.2017 were classified as summer group. At the beginning of the study, ethics committee approval was obtained from Ondokuz Mayıs University Clinical Research Ethics Committee with the number B.30.2.ODM.0.20.08/1433.

Body analysis data evaluated in the study included weight, BMI, body fat mass, body fat percentage, abdominal fat mass, and abdominal fat percentage. Body composition was obtained from the results of bioelectrical impedance analysis (TARTI, TANITA BC-418).

BMI was calculated by dividing the weight by the square of height. According to the WHO criteria, individuals were classified into four groups: BMI <18.50 is lean; BMI 18.5–24.9 is normal, BMI 25.0–29.9 is overweight; and BMI >30.0 is obese (14). Clinical and metabolic data include fasting blood glucose (FBG), HbA1c, insulin, triglyceride, total cholesterol, LDL-cholesterol, HDL-cholesterol, alanine aminotransferase (ALT), aspartate aminotransferase (AST), and vitamin B12. The serum 25(OH)D levels <10 ng/ml was classified as vitamin D deficiency; 10–20 ng/ml was classified as vitamin D insufficiency; and >20 ng/ml was classified as normal vitamin D level (10).

Statistical Analysis

The data obtained from the patient results were transferred to the computer environment; and 21.0 version of Statistical Package for Social Studies program was used for statistics. The conformity of the measurable values to the normal distribution was analyzed by the Kolmogorov–Smirnov test. Levene's test was used for homogeneity. Pearson chi-square analysis was used to compare categorical variables between groups. Student's t test was used to compare the continuous variables between the two groups, while comparisons between more than two groups were used in the case of normal distribution and variance homogeneous ANOVA, otherwise Kruskal–Wallis tests were used. Dunn's post-hoc tests were carried out on each pair of groups. The statistical significance limit was set at $p<0.05$.

Table 1. Main characteristics of participants

	Min.	Max.	Mean±SD
Age	18	85	34.4±12.8
Weight (kg)	24.3	159.6	86.5±21.4
Height (m)	1.4	1.87	1.6±0.08
BMI (kg/m^2)	14.6	63.9	32.3± 7.7
Body fat percentage (%)	13.7	59.5	35.3±8.8
Body fat mass (kg)	6.8	91.8	31.7±13.8
Abdominal fat percentage (%)	10.4	61.3	33.2±8.2
Abdominal fat mass (kg)	2.3	37.1	15.7±6.4

Min.: Minimum; Max.: Maximum; BMI: Body mass index; SD: Standard deviation

Table 2. Distribution of vitamin D levels according to season and gender

Groups →	Season				Sex			
Vitamin D level ↓	Summer		Winter		Women		Men	
	n	%	n	%	n	%	n	%
Deficiency	10	12.7	24	30.0	28	24.3	n=6	13.6
Insufficiency	30	38.0	26	32.5	44	38.3	12	27.3
Normal	39	49.4	30	37.5	43	37.4	26	59.1
	p=0.027*				p=0.044*			

*p<0.05

RESULTS

Table 1 presents main characteristics of age, weight, height, BMI, body fat percentage, body fat mass, abdominal fat percentage, and abdominal fat mass. A total of 159 individuals were included in the study. Among them, 115 (72.3%) were female and 44 (27.7%) were male. When the BMI values of the individuals were examined, it was determined that 1 subject was lean (0.6%), 22 subjects were normal weight (13.8%), 42 subjects were overweight (26.4%), and 94 subjects were obese (59.1%).

Table 2 presents the assessment of vitamin D levels of individuals by season and sex. Vitamin D deficiency was found in 21.4% (n=34) of the individuals, and vitamin D insufficiency was found in 35.2% (n=56) of the subjects. When this is examined in terms of seasons, in winter, vitamin D deficiency was found in 30%

Table 3. Distribution of vitamin D level classifications according to BMI values

	Vitamin D level						p
	Deficiency[a]		Insufficiency[a]		Normal		
BMI	n	%	n	%	n	%	
Lean	0	0	1	100	0	0	0.696
Normal	3	13.6	8	36.4	11	50.0	
Lean	0	0	1	100	0	0	0.744
Overweight	6	14.3	18	42.9	18	42.9	
Lean	0	0	1	100	0	0	0.842
Obese	25	26.6	29	30.9	40	42.6	
Normal	3	13.6	8	36.4	11	50.0	0.643
Overweight	6	14.3	18	42.9	18	42.9	
Normal	3	13.6	8	36.4	11	50.0	0.313
Obese	25	26.6	29	30.9	40	42.6	
Overweight	6	14.3	18	42.9	18	42.9	0.467
Obez	25	26.6	29	30.9	40	42.6	

BMI: Body mass index; a: Between deficient and insufficient group p<0.05

(n=24) of the individuals and vitamin D insufficiency was found in 32.5% (n=26). In summer, vitamin D deficiency was found in 12.7% (n=10) of individuals and vitamin D insufficiency was observed in 38% (n=30) of individuals. It was found that summer vitamin D levels were significantly higher than winter vitamin D levels (p<0.05).

Individuals were divided into four groups according to BMI: lean, normal, overweight, and obese. Vitamin D levels were evaluated between two groups and between multiple groups. Evaluation of vitamin D levels according to BMI values is given in Table 3. No significant difference in vitamin D levels was observed between normal, overweight, and obese individuals (p>0.05). However, the mean BMI of individuals with deficient vitamin D levels was found to be significantly higher than the BMI of those with insufficient vitamin D levels (p=0.047).

No significant difference was observed between vitamin D level and body weight. However, body weight of individuals with deficient vitamin D levels was found to be significantly higher than individuals with normal vitamin D levels (p<0.05). A statistically significant difference was observed between vitamin D levels with body fat percentage and body fat mass (p<0.05). It was found that vitamin D levels were lower in individuals with high body fat percentage and body fat mass. This significant difference was found to be caused by individuals with vitamin D deficiency (serum 25(OH)D level <10 ng/ml). The body fat percentage and body fat mass of individuals with vitamin D deficiency were found to be higher than those with normal vitamin D levels. A similar relationship was observed for abdominal fat percentage and abdominal fat mass. Vitamin D levels were lower in individuals with high abdominal fat mass and abdominal fat mass (p<0.05) (Table 4).

There was no significant relationship between vitamin D levels and FBG, AST, ALT, total cholesterol, LDL-cholesterol, HDL-cholesterol, triglyceride, insulin, and HbA1c levels (p>0.05). The AST levels were found to be higher in vitamin D deficient group than vitamin D insufficient group (p<0.05). There was a significant relationship between vitamin D levels and vitamin B12 levels (p<0.05). Vitamin B12 levels of individuals with normal vitamin D levels were found to be significantly higher compared to those with deficient and insufficient levels of vitamin D (Table 5).

Table 4. Distribution of vitamin D level classifications according to body analysis data

Body analysis data	Vitamin D level (ng/ml)	Median	Minimum	Maximum	p
Weight (kg)	Deficient[a]	90.0	23.8	59.5	
	Insufficient	84.1	14.3	53.5	0.060
	Normal[a]	84.0	13.7	48.4	
Body fat percentage (%)	Deficient[a,b]	39.9	23.8	59.5	
	Insufficient[b]	35.3	14.3	53.5	0.004*
	Normal[a]	33.6	13.7	48.4	
Body fat mass (kg)	Deficient[a,b]	37.1	14.6	91.8	
	Insufficient[b]	30.6	6.8	78.0	0.009*
	Normal[a]	26.3	9.2	56.6	
Abdominal fat percentage (%)	Deficient[a]	35.6	19.7	54.7	
	Insufficient	33.4	10.4	61.3	0.049*
	Normal[a]	31.5	14.0	47.1	
Abdominal fat mass (kg)	Deficient[a]	16.6	6.1	37.1	
	Insufficient	15.1	2.3	28.5	0.025*
	Normal[a]	14.2	3.7	27.4	

SD: Standard deviation; *p<0.05; a: Between deficient and normal group p<0.05; b: Between deficient and insufficient group p<0.05

Table 5. Distribution of vitamin D level classifications according to biochemical results

Biochemical results	Vitamin D level (ng/ml)	Median	Minimum	Maximum	p
FBG (mg/dL)	Deficient	100.0	75.0	161.0	
	Insufficient	75.0	83.0	157.0	0.169
	Normal	97.0	80.0	202.0	
AST (U/L)	Deficient[a]	17.0	9.0	96.0	
	Insufficient[a]	9.0	9.0	33.0	0.057
	Normal	17.0	10.0	60.0	
ALT (U/L)	Deficient	19.0	6.0	79.0	
	Insufficient	6.0	5.0	71.0	0.426
	Normal	17.0	6.0	82.7	
Total Cholesterol (mg/dL)	Deficient	188.5	106.0	297.0	
	Insufficient	106.0	116.0	280.0	0.289
	Normal	177.0	28.0	322.0	
LDL-Cholesterol (mg/dL)	Deficient	96.3	45.0	194.2	
	Insufficient	45.0	53.2	157.0	0.216
	Normal	99.6	39.0	198.8	
HDL-Cholesterol (mg/dL)	Deficient	44.0	24.0	73.0	
	Insufficient	24.0	27.0	78.0	0.359
	Normal	47.0	27.0	106.0	
Triglycerides (mg/dL)	Deficient	112.0	50.0	782.0	
	Insufficient	50.0	40.0	341.0	0.426
	Normal	107.0	28.4	389.0	
Insulin (µU/Ml)	Deficient	12.6	3.4	37.5	
	Insufficient	3.4	2.7	41.8	0.487
	Normal	9.8	3.3	47.1	
HbA1c (%)	Deficient	5.7	4.7	9.9	
	Insufficient	4.7	4.1	7.3	0.131
	Normal	5.5	4.0	11.9	
Vitamin B12 (pg/mL)	Deficient[b]	334.1	129.5	1299.0	
	Insufficient[c]	364.0	116.3	642.6	0.010*
	Normal[b,c]	386.8	186,6	1604.0	

FBG: Fasting blood glucose; AST: Aspartate aminotransferase; ALT: Alanine aminotransferase; SD: Standard deviation; *p<0.05 a between deficient and insufficient group p<0.05; b: Between deficient and normal group p<0.05; c: Between insufficient and normal group p<0.05

DISCUSSION

Because the main source of vitamin D is sunlight, the most important reason for the vitamin D deficiency or insufficiency is that sunlight is not sufficiently utilized (15). In this study, vitamin D levels in winter were significantly lower than vitamin D levels in summer. This situation shows the importance of sunbathing in vitamin D deficiency. The study conducted by Hekimsoy et al. reported the prevalence of vitamin D deficiency as 13.8% and insufficiency as 74.9% in the Aegean Region of Turkey (16). A recent study conducted in Ankara province of Turkey reported the vitamin D deficiency rate as 51.8% and vitamin D insufficiency rate as 20.7% (17). In the data obtained from our study, the rate of vitamin D deficiency was found to be 21.4%, and the rate of insufficiency and normal vitamin D levels were 35.2% and 43.4%, respectively. These differences may be caused by many factors such as the place of living, nutritional status, vitamin and mineral levels, cultural habits, existing diseases, seasonal differences, anthropometric body measurements, and age differences.

Over the last decade, the number of studies on the relationship between vitamin D deficiency and anthropometric measurements has increased. A meta-analysis investigating the relationship between obesity and vitamin D deficiency in different age groups reported that vitamin D level is associated with obesity, regardless of age or latitude (8). It was concluded that vitamin D synthesis in obese individuals was decreased compared to that in non-obese individuals (18). A study with young female individuals reported an inverse relationship between body weight and vitamin D levels. It

was determined that the mean weight of individuals with vitamin D deficiency was higher (19). Studies have shown a positive relationship between weight loss and serum 25(OH)D concentrations (20, 21). In our study, 26.6% of obese individuals had deficient vitamin D, while 30.9% had insufficient vitamin D levels. There was no significant difference between lean, normal, overweight, and obese individuals and their vitamin D levels. However, when compared to the BMI of individuals with deficient and insufficient levels of vitamin D, the BMIs of individuals with vitamin D deficiency were significantly higher.

In a study evaluating the supplementation of vitamin D on obesity complications and fat distribution in patients with low plasma 25(OH)D levels, 7000 IU vitamin D supplementation were given to 52 individuals with BMI >30 kg/m^2 for 26 weeks. Body composition, subcutaneous (SAT) and visceral adipose tissue (VAT), and intrahepatic (IHL) and intramyocellular lipids were evaluated. Although plasma 25(OH)D levels increased at the end of treatment, no changes were observed in body fat, SAT, VAT, IHL, blood pressure markers (20). The theory of increased adiposity decreases serum 25(OH)D levels, and weight loss through diet or bariatric surgery increases in serum 25(OH)D levels was put forward (10). In a study in women, elevated serum 25(OH)D levels were associated with a smaller adipocyte size (22). In this study, body fat percentage, body fat mass, abdominal fat percentage, and abdominal fat mass were found to be higher in individuals with deficient or insufficient levels of vitamin D than individuals with normal vitamin D levels.

A systematic review by Song et al. reported a 38% reduction in the relative risk of type 2 diabetes mellitus (T2DM) in individuals with higher 25(OH)D plasma concentrations (23). A study with non-obese individuals reported that 25(OH)D levels were associated with fasting plasma glucose, insulin, and HOMA-IR levels (24). A study where 7000 IU of vitamin D supplementation given to obese individuals reported that there was no change in HOMA-IR and lipid levels, despite an increase in vitamin D levels (20). In a study conducted with morbid obese individuals, subjects were divided into three groups according to their vitamin D levels. It was reported that HDL-cholesterol levels were lower and triglyceride levels were higher in vitamin D deficient group (25). In our study, no statistically significant relationship was found between vitamin D levels and fasting plasma glucose, insulin and HbA1c, total cholesterol, HDL-cholesterol, LDL-cholesterol, and triglyceride levels.

Because the conversion of vitamin D3 into 25(OH)D happens in liver, it makes liver an important organ in the synthesis of vitamin D. In a study by Cordeiro et al., the prevalence of high serum 25(OH)D deficiency is reported in obese individuals with liver disease. However, there was no statistically significant correlation of vitamin D levels with AST and ALT levels (26). Liangpunsakul and Chalasani reviewed 6800 patients using big cohort database, and they found unexplained ALT elevation in 308 people. They compared the vitamin D levels of these individuals with the control group of 979 individuals. Even when metabolic syndrome, insulin resistance, and serum triglyceride levels were controlled, patients with high ALT levels had lower vitamin D levels than the control group (27). In a study including 262 patients who applied to an endocrinology clinic, a similar relationship was reported. Regardless of age, gender, triglyceride, and insulin resistance, there was a relationship between non-alcoholic liver disease and vitamin D levels (28). In this study, no statistically significant correlation was found between vitamin D levels and liver enzyme levels such as AST and ALT. However, AST levels were found to be higher in individuals with deficient vitamin D than in insufficient individuals.

In a study of middle-aged women, vitamin D and vitamin B12 levels were reported to be related independent from fat mass of individuals (29). In a study by Rogenhofer et al., a high correlation between vitamin D levels and vitamin B12 levels was reported (30). In this study, vitamin B12 levels were found to be lower in individuals with deficient and insufficient vitamin D levels than those with normal vitamin D levels.

One of the limitations of the study was the low number of the participants. Also, the individuals were taken from the Nutrition and Dietary Polyclinic alone, and the majority of the patients (85.5%) were obese and overweight. In addition, the effect of various factors such as dietary intake, sunbathing time, physical activity, presence of secondary hyperparathyroidism, and the drugs used make it difficult to clearly reveal the causality relationship between obesity and vitamin D deficiency.

CONCLUSIONS

The results of the study show that vitamin D levels decrease as the BMI, body fat mass, and body fat percentage increase. In addition, it was observed that vitamin D levels were significantly lower in the winter season when they were affected by seasonal changes. The fact that 21.4% having vitamin D deficiency and 35.2% having vitamin D insufficiency despite the fact that Turkey is geographically located to have a sunny climate shows that there is a lack of adequate intake and synthesis of vitamin D.

Strategies should be developed to prevent and control obesity and to combat the inadequacy of vitamin D nutritional status. The relationship between vitamin D and chronic diseases, especially obesity, remains unclear; whether deficiency of vitamin D is caused by obesity, or differences in vitamin metabolism causing the development of obesity remains unclear. To increase vitamin D levels to normal, it is important to consume foods rich in vitamin D, such as liver oil, vitamin D-rich fish, oily fish, and egg yolks, also taking vitamin D supplementation when necessary.

Ethics Committee Approval: At the beginning of the study, ethics committee approval was obtained from Ondokuz Mayıs University Clinical Research Ethics Committee with the number B.30.2.ODM.0.20.08/1433.

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Designed the study: AGK, MÜS, NS, EY. Collected the data: AGK, NS, EY. Analyzed the data: AGK, NS. Wrote the paper: AGK, MÜS, NS. All authors have read and approved the final manuscript.

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