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The Effect of Weight Loss on Serum Vitamin D Levels in Obese Women with Vitamin D Deficiency

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ABSTRACT

Today, the simultaneous increase of obesity and vitamin D deficiency is estimated to affect over one billion people in the world. An association between vitamin D deficiency and obesity is well known, but the mechanisms are not totally clear yet. This study was designed to investigate the effect of weight loss on serum vitamin D levels in obese women. ***Methods:*** *The study has been performed on 44 obese women who were admitted to the in TEV Sultanbeyli State Hospital Nutrition and Dietetics Clinic between the dates October 2016 and April 2017. In the first meeting, the demographic features and dietary habits were interrogated with a questionnaire form; 3-day food consumption records were taken; body compositions were determined with anthropometric measurements and the biochemical parameters were analyzed. After the first meeting, a specific weight loss diet program was generated, and nutritional education was given to the subjects.* ***Results:*** *The correlation between vitamin D and BMI values after the study showed a positive correlation (r=0.52) in the 5-10% weight loss group and a negative correlation (r=-0.52) in the >10% weight loss group. But this relationship was not found to be statistically significant because the total number of subjects was low (p>0.05).* ***Conclusions:*** *This study shows that there may be a higher rise in vitamin D levels in patients with larger volumes of body fat loss. Therefore, there is a need for prospective studies with larger numbers of subjects.*

Keywords: Vitamin D deficiency, Obesity, Weight loss, Biochemical findings, Women

INTRODUCTION

Vitamin D is a fat-soluble vitamin which is naturally produced by the body with sunlight exposure and it also is a secondary steroid hormone [1-4]. Vitamin D comes from two sources; exogeneous (food) and endogenous (metabolic), contrary to other vitamins [5,6]. The D_2 form of vitamin D (ergocalciferol) is usually supplied from plants, especially mushrooms; Vitamin D_3 form (cholecalciferol) is usually synthesized by animals [2,4-7]. D_2 and D_3 vitamins are metabolized similarly [8]. Vitamin D_3 is also synthesized endogenously in the skin following exposure to UV-B irradiation and about 80-90% of vitamin D required by human body is synthesized [1,9]. Two hydroxyl groups must be added to vitamin D is converted into biologically active form (1α $25(OH)_2$-D_3, calcitriol). The first hydroxylation to produce 25 hydroxyvitamin D (25(OH)D, calcidiol) takes place in the liver. The second hydroxylation occurs when 25(OH)-D is converted to 1,25 dihydroxy vitamin D ($1,25(OH)_2$-D) by 1α-hydroxylase enzyme in the kidney [10].

The main function of vitamin D is to preserve calcium and phosphorus homeostasis in the circulation by increasing the absorption of calcium in the bowel and stimulating the absorption in the distal renal tubules to reduce calcium excretion and mobilizing bone minerals together with parathyroid hormone (PTH) and fibroblast growth factor (FGF-23) [1,11,12].

Vitamin D has more effects than simply maintaining calcium and phosphorus levels in the body [3,13]. The $1,25(OH)_2D$ directly or indirectly controls more than 200 genes which are responsible for cellular storage, differentiation, apoptosis and angiogenesis [11,14].

The Vitamin D receptor (VDR) is already present in many cells (lung, heart, skin, T and B lymphocytes, monocytes). It has also been shown that 25(OH)-D can be turned into $1,25(OH)_2D$ by 1-α hydroxylase enzyme in tissues other than the kidneys (such as lung, skin, colon, pancreas, and immune cells) [15]. Recent studies have shown that vitamin

D is active in adipocytes and that enzymes which metabolize the VDR and vitamin D are released from adipocytes [10]. For this reason, researches linking these two in recent years have become widespread [16,17]. Although most of the studies are cross-sectional, some studies point out to obesity as a risk factor on vitamin D level development [16,18]. Many observational studies have revealed the relation of obesity with low 25(OH)D serum concentration [19-21]. At present day it is assumed that the comorbid increase in obesity and vitamin D deficiency is affecting over 1 billion people around the world [22]. Low serum vitamin D concentrations at different rates is widespread nowadays depending on age, race, increase in adipose tissue, geographical features, and other factors [23]. In a meta-analysis of 15 studies (among 3867 obese and 9342 healthy people), in which the relation between obesity and vitamin D was analyzed, vitamin D deficiency prevalence has been found to be higher in the obese group compared to the control group (independent from geographical variables) [24]. According to latest evidence from a meta-analysis, there is a weak but inverse correlation between 25(OH)D and BMI (P=0.005) and there has been shown a 4% increase in 25(OH)D level for each 10% decrease in BMI [25].

It is not yet clear whether or not the reason why serum vitamin D concentration of obese individuals is lower than that of non-obese people is because of increase in the uptake of vitamin D in adipose tissues, differences in intake of supplementary powders or diets, less exposure to sunlight, reduction in skin biosynthesis, genetic variations or some other internal factors related to obesity. Even the level of sensitiveness of serum concentration changes with weight loss has not been clearly defined [9]. Vitamin D has some anti-adipogenic features and limited number of studies have proven that vitamin D might reinforce weight loss and metabolic processes [26,27]. But the interaction between vitamin D and increase in body fat percentage, i.e., obesity, is controversial and complex. Whichever causes the other is not yet clarified [28]. The effect of vitamin D deficiency on obesity as a cause or result is still a debated issue [24].

There are mainly four mechanisms which are used to explain the low level of vitamin D in the case of obesity. These are; the lower rate of sunlight exposure among obese people, the reduction of 25(OH)D by negative feedback stemming from increased 1,25(OH)D_2, the uptake of vitamin D in adipose tissues and the volumetric dilution of low 25(OH)D concentration [17].

This study aims to look at the effect of weight loss on serum vitamin D level in obese women with vitamin D deficiency. In our country, there are no studies on the relationship between obesity and vitamin D deficiency among adults. Thus, the present paper will contribute to scientific literature in this regard.

MATERIALS AND METHODS

This study has been carried out between October 2016 and April 2017 on obese (BMI $\geq$ 30 kg/m^2) premenopausal women with vitamin D deficiency aged between 18 and 49 years, who have applied to Tacirler Eğitim Vakfı (TEV) Sultanbeyli State Hospital Policlinic of Nutrition and Dietetics for weight loss. Throughout the study, a total number of 103 subjects who complied with the study criteria (those who had chronic illnesses; postmenopausal subjects; pregnant or breastfeeding subjects; those using medicines such as meth morphine etc. or vitamin/mineral supplements were excluded from the study) was reached. However, the study was completed with 44 subjects because of incompliance with the diet or lack of follow-ups.

The subjects' sociodemographic features, dietary habits, anthropometric measurements (height, weight, body mass index (BMI), hip and waist circumference, body composition (body fat mass in kg, body water content in kg) and biochemical parameter measurements (FBG, insulin, phosphorus (P), calcium (Ca), vitamin D, parathyroid hormone (PTH) and physical activity features was analyzed through face-to-face interview method. At the beginning of the study, 3-day food consumption records were taken from individuals.

During the first interview a regular weight loss program (0.5-1.0 kg/week) was established. Subjects were supposed to take 15-20% of their energy from proteins, 20-30% from fats and 50-60% from carbohydrates following balanced diet requirements. The study was based on weight loss of at least 5% of the subject's initial body weight, and the data on subjects who lost weight over 5% were repeated (anthropometric and blood tests).

Statistical analyses

Our findings were given in tables as arithmetic mean and standard deviation. Difference between groups were assessed with ANOVA and Mann-Whitney U test. Correlations between variables were assessed using Pearson's coefficient of correlation. In all cases, $p<0.05$ was considered significant. All data were analyzed using 15.0 version of SPSS (Statistical Package for Social Sciences) program.

This study has been approved on 12 May 2016 by Acıbadem University Medical Research Assessment Board with resolution number 2016-8/13.

RESULTS

It was found that 68.2% of individuals were aged between 19 and 30 years and 31.8% were between 31 and 50 years of age. 54.5% of subjects were primary school graduate, 81.6% housewives, 93.2% married, and 88.6% preferred modest religious clothing covering most of the body.

The pre-and post-intervention body weight of individuals (88.91 ± 11.02 kg - 80.45 ± 10.7 kg) and changes in BMI (36.16 ± 5.01 kg/m^2 to 32.72 ± 4.85 kg/m^2) were statistically significant ($p<0.05$). The average waist circumference of the individuals was 104.45 ± 9.1 cm before the study and 96.5 ± 8.34 cm after the study. This decrease was also found statistically significant ($p<0.05$).

Table 1 Comparison of some anthropometric measurements of individuals with weight loss of 5-10% and over 10% after intervention

Anthropometric Measurements	Weight Loss 5-10%		t - p	Weight Loss > 10%		t - p
	Before Intervention	After Intervention		Before Intervention	After Intervention	
	$\bar{x}$ ± SD	$\bar{x}$ ± SD		$\bar{x}$ ± SD	$\bar{x}$ ± SD	
Body weight (kg)	89.38 ± 11.78	82.32 ± 11.3	t=24.91 p=0.001*	87.99 ± 9.7	76.83 ± 8.66	t=18.64 p=0.001*
BMI (kg/m^2)	36.29 ± 5.58	33.43 ± 5.33	t=24.34 p=0.001*	35.9 ± 3.85	31.36 ± 3.54	t=20.08 p=0.001*
Waist circ. (cm)	103.52 ± 8.08	96.69 ± 7.78	t=9.27 p=0.001*	106.27 ± 10.88	96.13 ± 9.61	t=7.06 p=0.001*
Hip circ. (cm)	120.62 ± 9.89	113.48 ± 8.86	t=15.91 p=0.001*	117.4 ± 6.81	108.6 ± 6.56	t=11.34 p=0.001*
Waist hip ratio	0.87 ± 0.06	0.87 ± 0.07	t=0.71 p= 0.479	0.88 ± 0.07	0.86 ± 0.07	t=1.70 p=0.111
Body fat mass (kg)	38.3 ± 8.24	33.0 ± 8.11	t=31.93 p=0.001*	37.17 ± 7.33	29.02 ± 6.31	t=4.75 p=0.001*
Body fat (%)	42.44 ± 3.61	39.57 ± 4.23	t=11.32 p=0.001*	41.89 ± 3.94	37.4 ± 4.09	t=10.73 p=0.001*
Body water (kg)	37.32 ± 2.93	36.1 ± 2.6	t=6.95 p=0.001*	37.13 ± 2.54	35.01 ± 2.4	t=10.99 p=0.001*
Body water (%)	42.04 ± 2.58	44.22 ± 3.12	t=11.59 p=0.001*	42.41 ± 2.65	45.83 ± 3.01	t=11.70 p=0.001*
*p<0.05 Level of significance						

The individuals were grouped into two according to the change in body weight, those who lost between 5-10% and those who lost >10%. The comparison of the groups after study, decrease in body weight, BMI, waist circumference, hip circumference, body fat mass, body fat (% and kg) values were statistically significant in both groups ($p<0.05$). The difference in waist-hip ratio in both groups is not statistically significant ($p>0.05$) (Table 1).

When the pre- and post-treatment values of groups with weight loss of 5-10% and >10% were compared, the decrease in insulin and HOMA-IR values were statistically significant ($p<0.05$). In addition, the difference in serum vitamin D and phosphorus levels of individuals who lost more than 10% of body weight was also significant ($p<0.05$) (Table 2).

Table 2 Comparison of intervention biochemical findings and weight loss percentages of individuals

Biochemical Findings	Weight Loss 5-10%		t - p	Weight Loss >%10		t - p
	Before Intervention	After Intervention		Before Intervention	After Intervention	
	$\bar{x}$ ± SD	$\bar{x}$ ± SD		$\bar{x}$ ± SD	$\bar{x}$ ± SD	
Insülin (uU/mL)	12.9 ± 4.19	10.4 ± 4.26	t= 5.50, p=0.001*	15.34 ± 6.77	11.01 ± 5.37	t=4.89, p=0.001*
FBG (mg/dL)	94.72 ± 8.66	94 ± 8.22	t=0.35, p=0.725	98.4 ± 12.73	95.6 ± 7.29	t=0.83, p=0.420
HOMA-IR	3.02 ± 1.07	2.44 ± 4.19	t=4.34, p=0.001*	3.79 ± 1.86	2.65 ± 1.48	t=3.73, p=0.002*
Vitamin D (ng/mL)	9 ± 5.46	8.08 ± 4.58	t=1.64, p=0.111	8.17 ± 3.45	6.51 ± 2.95	t=3.31, p=0.005*
PTH (pg/mL)**	63.47 ± 34.37	59.47 ± 31.73	p=0.189	64.34 ± 39.29	59.36 ± 30.03	p=0.208
Phosphorus (mg/dL)	3.3 ± 0.56	3.39 ± 0.5	t=1.16, p=0.255	3.28 ± 0.42	3.53 ± 0.46	t=2.61, p=0.020*
Calcium (mg/dL)	9.45 ± 0.54	9.42 ± 0.54	t=0.31, p=0.757	9.47 ± 0.35	9.62 ± 0.43	t=1.55, p=0.143
* Level of significance p<0.05; ** Mann-Whitney U Test						

A statistically significant correlation (r=0.52) was found between serum vitamin D and BMI values in patients with 5-10% weight loss after the study (p=0.04). There was a negative correlation (r=-0.39) between serum vitamin D and BMI values in patients with more than 10% weight. However, this relation was not considered statistically significant (p=0.157) (Figure 1). This is due to the number of individuals in this group being 15.

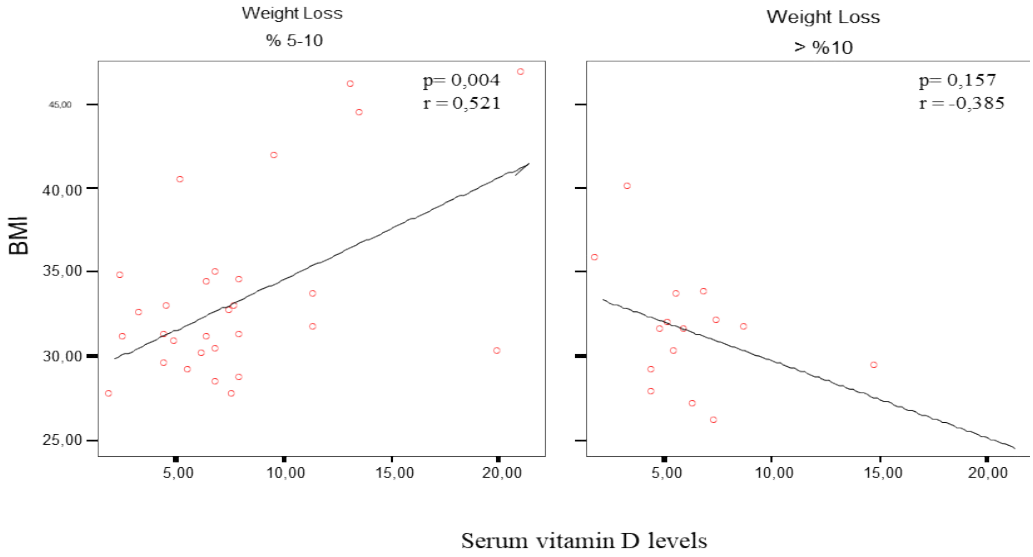

Figure 1 Correlation between serum Vitamin D levels and BMI values

DISCUSSION

Number of epidemiological studies proving the relation between Obesity and vitamin D is continuously increasing. An important study related to this issue is claiming that there is an adverse relation between body fat ratio and 25(OH) D concentration and that there is an independent relation between low serum level 25(OH)D and increased BMI and body fat mass [29]. Similarly, Rajakumar, et al. have found out that serum 25(OH)D level has inverse relation with BMI, total body fat percentage, visceral fat tissue and subcutaneous fat tissue [30].

Another study comparing obese and healthy overweight individuals has found out that vitamin D deficiency and obesity are interrelated and that, according to vitamin D deficiency, obese individuals are under 3.36 relative risk compared to normal weight individuals [31]. The study by Abdelkarem, et al. on obese women vitamin D levels were found to be inadequate in 59.6% of obese women, 19.3% were moderate inadequate and 21.3% were found adequate [32].

In this study vitamin D level was insufficient in 93.2% of individuals and this level has increased to 97.7% after the study. Among individuals who lost between 5-10% of body weight, the level of vitamin D decreased in 65.5% of subjects and increased in 34.5%. Among those who lost more than 10% of body weight the level of vitamin D has decreased in 80% of individuals and increased in 20% of them. Vitamin D differentiation among groups according to weight loss is not considered statistically significant ($p>0.05$).

One mechanism believed to have an effect on obesity and low vitamin D level is the decrease in bioavailability. This means increase in body fat and decrease in serum 25(OH)D level. Decrease in body weight may cause increase of 25(OH)D concentration in peripheral tissues [33]. This study was based on the hypothesis that the loss in body weight may increase serum vitamin D in human body and major differences in anthropometric measurements were obtained after diet programs. According to BMI classification (I, II, III degree obese) differences in average body weight and BMI values before and after the study were found to be statistically significant in both groups ($p<0.05$).

Significant reductions in weight, waist circumference and hip circumference after a 12-week diet program were found for overweight or obese women aged between 19 to 64 years, and these values were found to be statistically significant. ($p<0.05$) [34]. According to another study carried out on Saudi women by Al-Daghri, et al. it was shown that there was a relation between vitamin D level and insulin sensitivity [35]. Insulin sensitivity in women with vitamin D deficiency has been lower than those with sufficient vitamin D levels. This may show that vitamin D may

play a role on insulin metabolism [32].

Tzotzas, et al. found that 25(OH)D levels had a negative correlation with body weight, BMI, waist circumference and body fat mass percentage in their study on obese and control group of women [36]. After a 20-week low calorie diet, a 10% decrease in BMI lead to a decrease in HOMA index and lipid levels and an increase in 25(OH)D levels. In this study, while 63.6% of the individuals had insulin resistance initially, this ratio decreased to 40.9% at the end of the study. In addition, all the individuals who has insulin resistance (100%) had a high-risk waist circumference, and this ratio dropped to 83.3% after the study. However, the difference was not statistically significant ($p>0.05$). Taking into account that all individuals in our study had vitamin D deficiencies, we can assume that our results match the literature findings.

Mason and et al. have divided 439 postmenopausal, overweight, and obese women into four random groups and followed them up for 12 months. 1st group: diet treatment (1200 - 2000 kcal/day; >30% of daily energy taken from fats), 2nd group: exercise, 3rd group: exercise and diet, 4th group: control group. The mean increase in serum 25(OH) levels of women who lost 5-10%, 5-9.9%, 10-14%, and 15% of body weight were 2.1, 2.7, 3.3 and 7.7 ng/mL respectively. The amount of body fat loss (kg) was found to be significantly related to the increase in serum 25(OH) D level [9].

In this study, there was a negative correlation ($r=-0.026$) between the amount of body fat loss and PTH level after the study. A negative correlation ($r=0,145$) between the amount of body fat loss and vitamin D was also determined. This means that, as the amount of fat loss increases, PTH and vitamin D levels also increase. But the above numbers are not considered statistically significant, possibly because of low number of subjects.

Another small-scale study has found out that after a 20-week diet in 26 women there has been a decrease in total body weight loss (9,7%) and increase in 25(OH)D level from 15.4 ng/mL to 18.3 ng/mL (+2.9 ng/mL) [36]. Similarly, a study with 43 premenopausal women for 12 weeks revealed a decrease of 11.5% of body weight and an increase of 2.9 ng/mL (from 30.3 ng/mL to 33.2 ng/mL) in 25(OH)D [37]. In another study, a similar increase (31%) in 25(OH) D, a strong correlation between 25(OH)D levels and body weight loss, and a smaller but yet important correlation with fat mass changes were found [38].

CONCLUSION

In this study, there was no significant difference in vitamin D levels according to weight loss rates, and a negative relationship was found between >10% weight loss and vitamin D, that is, BMI level decreased as vitamin D levels increased. However, the relationship was not significant because of the low number of samples. The reason for low turnout may be low education levels of subjects and their failure to adapt to diet programs and not attending regular follow-up. Therefore, there is a need for extensive studies involving more individuals with a higher education level towards obesity and vitamin D association.

DECLARATION

Conflict of Interest

The authors and planners have disclosed no potential conflicts of interest, financial or otherwise.

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