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The effect of vitamin D level on body composition and metabolic parameters in adults with different body mass index

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Abstract

The aim of this study was to describe the relationship between serum 25 (OH) vitamin D and anthropometric and metabolic parameters in adult patients with different BMI. The cross-sectional study was conducted between November 2018 and May 2019 with 224 participants. Body weight, height and blood pressure of the individuals included in the study were recorded. Body composition was evaluated by bioelectrical impedance (BIA) on a Tanita BC 420 MA analyzer (Tanita Inc., Japan). Serum 25 (OH) D, fasting insulin level, fasting blood glucose, HDL-cholesterol and triglycerides were measured. Insulin resistance index was calculated (HOMA-IR). Statistical analysis was performed on an IBM SPSS Statistics 22 (Chicago, IL) for the Windows platform. The mean age of the 224 participants (176 females, 48 males) was 36.6 ± 7.9. 36 (16%) of the participants had normal BMI, 67 (29.9%) were overweight and 121 (54%) had obesity. Women had higher levels of fat, fat percentage, LDL-C, and BMI than men. FPG, LDL-C, and HOMA-IR were lower in patients with normal BMI, but differences between high BMI categories were significant only in fasting plasma glucose. Vitamin D was inversely and weakly associated with most of the parameters. It showed a significant correlation between vitamin D and more parameters in males than females. Serum vitamin D was negatively correlated with weight and HDL-C only in obese subjects, whereas it was negatively correlated with age and SBP in subjects with normal BMI. In overweight participants, vitamin D did not correlate with any of the other parameters. Vitamin D deficiency and insufficient are very common in patients with poor metabolic health, although the relationship at individual level is not always present. Therefore, vitamin D supplementation should be considered as a therapeutic option in all subjects who are overweight, obesity and metabolic disorders.

Keywords: Body mass index, vitamin d, metabolic parameter

Introduction

Vitamin D; is a group of sterols that regulate calcium and phosphorus metabolism, are among the fat-soluble vitamins and are hormones and hormone precursors produced in the body unlike other vitamins [1, 2].

Vitamin D insuffiency and insuffiency have become a serious global health problem in the last decade [3, 4]. The relationship between vitamin D status and the different features of metabolic syndrome and the associated cardiovascular risk has been the subject of many studies. Negative correlations of serum vitamin D levels with different metabolic parameters have been studied extensively. There are many publications that correlate serum 25 [OH] D levels with serum lipids [5-7], blood pressure [8, 9], glycemic control, or insulin resistance [10]. However, the results are variable and even contradictory. For example, a cross-sectional study reported that vitamin D was an important independent inverse predictor of total cholesterol, LDL-C and triglycerides in hyperlipidemic patients [6], while another identified a separate association for men and women [5]. In a cross-sectional study, in patients with SBP with systolic blood pressure (SBP) above 130 mm Hg, SBP found higher vitamin D levels than those below 130 mm Hg [8], while randomization analysis with genetic data proved the opposite [9]. In a study of patients with Type 2 DM, it showed that insulin resistance increased as vitamin D level decreased and as a result, glycemic control deteriorated [10]. Few studies have correlated serum vitamin D levels with bioelectrical body impedance analysis (BIA) and combined laboratory metabolic data [11].

The aim of this study was to describe the correlation of serum 25 (OH) D levels with anthropometric and metabolic parameters and BIA complex in men and women with different BMI.

Materials and Methods

This is a cross-sectional observational study. It was approved by the responsible ethical authorities and was made in accordance with ethical standards and the Helsinki Declaration. This study was conducted in accordance with the ethical guidelines stated in the Helsinki Declaration and with an approval from Firat University Medical Faculty Ethics Committee (19.07.2018, Approval number: 06) Each participant signed the informed consent form before any procedure. Participants came from the general population of

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the city. Participants were evaluated by the dietician about diet counseling and weight management. Participants were composed of individuals between 18 and 60 years old who were willing to participate in the study. The age range was chosen to avoid the additional confounding effect of age-related sarcopenia on body composition. Exclusion criteria were other severe or chronic diseases or drugs known to induce body weight, immobilization, and morbid obesity. 600 patients were presented and 224 subjects were approved to participate - 48 males (21.4%) and 176 (78.5%) women.

Devices Used in Transactions

After the medical history of the participants, anthropometric measurements were performed. Body weight was measured up to the nearest 0.1 kg on a calibrated digital scale (Tanita BC 420 MA, Tanita Inc., Japan) in lightweight garments without shoes.

Body height was recorded in the upright position without shoes up to the nearest 0.5 cm. BMI of the participants was calculated. After resting for 15 minutes, the blood pressure was measured twice with an aneroid sphygmomanometer in the sitting position, and the mean value was recorded. Body composition was recorded with a leg-to-leg 50 kHz bioelectrical impedance analyzer (Tanita BC 420 MA, Tanita Inc., Japan) according to the manufacturer's instructions and the predictive formula included in this device. The accuracy of the initial calibration is ± 2% for impedance measurement and ± 0.2 kg for body weight [12].

Blood samples were taken between 8:00 and 10:00 in the morning after fasting overnight.

Routine blood biochemistry (total cholesterol and HDL direct, triglycerides) was performed on a Cobas Integra 400+ analyzer. Fasting plasma glucose was determined by hexokinase method.

In addition, HDL-cholesterol ratios of LDL-cholesterol were measured by Serum 25- (OH) -Vitamin D and insulin electrochemiluminescent detection (ECLIA method on the Elecsys 2010 analyzer, Roche Diagnostics, Switzerland). The inter-assay error for 25 (OH) D, evaluated as coefficients of variation (CV%), was 1.7 - 7.8%, correlated with liquid chromatography / mass spectrometry (LC-MS / MS), characterized by Pearson r = 0.894. The in-test error for serum insulin as described by the manufacturer was CV 1.7% - 1.9%. Subjects with serum 25 (OH) D <12.0 ng / mL were defined as vitamin D deficiency, those with 12-25 ng / mL were inadequate, and those with ≥ 20 ng / mL were normal [13]. Insulin resistance was calculated by the HOMA-IR [HOMA: fasting insulin (μu / ml) x fasting plasma glucose (mg / dl) / 405] equation [14].

The criteria for inclusion in our study were; Patients aged 18-60 years who were referred to the internal nutrition outpatient clinic for healthy nutrition without known chronic diseases were referred to the dietician.

Exclusion criteria; Persons who were younger than 18 years, had no communication and psychological and neurological diseases, had a history of chronic illness, and those who refused to participate in the study were not included in the study.

Statistical Analysis

Data obtained from the study were analyzed with SPSS 22.0 program, error checks, tables and statistical analysis. Descriptive data were given as percentages and mean ±. For statistical analysis of data, Chi-square test (and / or Fisher's exact test) was used for categorical data analysis, Kolmogorov-Smirnow test was used for distribution of numerical data. The correlation between the two numerical data was evaluated by Pearson correlation analysis. p <0.05 was considered statistically significant.

Results

The mean age of the 224 participants (176 females, 48 males) was 36.6 ± 7.9. 36 (16%) of the participants had normal BMI, 67 (29.9%) were overweight, and 121 (54%) had obesity. SBP exceeded 140 mm Hg in 23.5% of participants and DBP exceeded 90 mm Hg in 29.5%. 171 (76.3%) of the participants had normal fasting glycemia and 49 (21.8%) had impaired fasting glucose. LDL-C was <130 mg / dl in 72 (32.1%) of the study population, and more than 130mg / dl in 152 (67.8%). <50 in 130 (58%) of the HDL-C participants Triglycerides were found to be high in 161 (71.8%) of the participants. , exceeded. The anthropometric, body composition and laboratory data of the participants are summarized in Table 1 by gender. Women had higher levels of fat, fat percentage, LDL-C, and BMI than men.

Table 1. The descriptive statistics of the participants are shown according to sex

Variable	Total (N = 224)			Men (N = 48)		Women (N = 176)	
	Mean	SD	Min – Max	Mean	SD	Mean	SD
Age (years)	35.6	7.9	18-48	32.9	8.8	36.4	7.6
Weight (kg)	82.5	18.3	39.9-157.4	88.8	23.2	80.7	16.4
Height (cm)*	164.6	8.4	144-188	176	7.2	161.5	5.5
BMI (kg/m2)	30.5	6.3	15.2-48	28.6	6.6	31	6.1
SBP (mmHg)	120	11.2	90-141	117.9	13.6	120.6	10.5
DBP (mmHg)	70.8	7.6	50-84	70.6	8.8	70.8	7.2
Serum 25(OH)D (ng/mL)	17.6	10.3	0.5-59.3	18.1	7.9	17.4	10.9
Fasting glucose (mg/dl)	91.3	13	64-148	92	9.1	91.1	13.9
Triglycerides (mg/dl)	218.1	39.5	165-320	221.3	40.7	217.2	39.1
LDL-C (mg/dl)	151.3	33.8	100-202	150.3	39	151.6	32.4
HDL-C (mg/dl)	49.5	10.1	28-71	49.2	9.6	49.5	10.3
Insulin (mIU/L)	15.3	10.2	1-101	15.7	10.4	15.2	10.2
HOMA–IR index	3.5	2.7	0.2-29.9	3.5	2.4	3.4	2.8
ALT(μ/L) *	21.5	14	6-99	30.1	15.6	19.1	12.6
Fat(kg) *	28.9	12.7	1.6-77.6	22	14.6	30.7	11.4
Fat(%)*	33.6	10.1	3.9-50.7	22.6	9.3	36.6	8.1
Lean mass *	53.6	9.7	35.7-90.2	66.8	10.4	50	5.5
Liquid mass*	38.2	7.1	24.1-64.5	47.3	7.6	35.7	4.5

* p<0.001 for the difference between men and women

The anthropometric, body composition and laboratory data of the participants are summarized in Table 2 according to BMI. FPG, LDL-C, and HOMA-IR were lower in patients with normal BMI, but differences between high BMI categories were significant only in fasting plasma glucose. The same upper-case letter in the horizontal line represents no significant difference, while different letters suggest significant differences between BMI subgroups ($p \leq 0.05$). The bold letters highlight the presence of statistical significance.

Table 2. The descriptive statistics of the participants according to their BMI is shown.

Variable	Grup 1 (normal weight) (n=36)		Grup 2 (overweight) (n=67)		Grup 3: (obese) (n=121)		p*	p**
	mean	std	mean	std	mean	std		
Age (years)	31.97	8.35	34.57	8.68	37.40	7.01	**0.001**	1-2:0.322 1-3:**0.001** 2-3:0.053
Weight (kg)	57 .75	10 .95	76 .41	8 .27	93 .26	15 .20	**<0.001**	1-2:**<0.001** 1-3:**<0.001** 2-3:**<0.001**
Height (cm)	167 .06	9 .42	165 .75	7 .87	163 .36	8 .24	**0.031**	1-2:1.00 1-3:0.062 2-3:0.186
BMI (kg/m2)	20 .68	3 .04	27 .87	1 .27	34 .88	4 .36	**<0.001**	1-2:**<0.001** 1-3:**<0.001** 2-3:**<0.001**
SBP (mmHg)	120 .06	9 .50	120 .58	12 .85	119 .74	10 .91	0.889	1-2:1.00 1-3:1.00 2-3:1.00
DBP (mmHg)	71 .81	8 .01	71 .21	7 .39	70 .29	7 .62	0.507	1-2:1.00 1-3:0.887 2-3:1.00
Serum 25(OH) D (ng/mL) (ng/mL)	18.55	(4.20-38.50)	16.50	(2.00-57.70)	15.20	(2.10 -59.30)	0.453	1-2:1.00 1-3:1.00 2-3:1.00
Fasting glucose (mg/dl)	85 .86	12 .86	90 .19	10 .54	93 .54	13 .85	**0.005**	1-2:0.308 1-3:**0.005** 2-3:0.263
Triglycerides (mg/dl)	218 .83	38 .69	212 .61	34 .46	221 .04	42 .34	0.375	1-2:1.00 1-3:1.00 2-3:0.490
LDL-C (mg/dl)	143 .08	33 .052	154 .73	35 .188	152 .02	33 .286	0.241	1-2:0.291 1-3:0.497 2-3:1.00
HDL-C (mg/dl)	48 .47	9 .638	49 .24	10 .475	49 .99	10 .223	0.709	1-2:1.00 1-3:1.00 2-3:1.00
Insulin (mIU/L)	15.30	(1.00-28.00)	14.50	(2.00-34.80)	14.30	(2.88-101.01)	0.691	1-2:1.00 1-3:0.847 2-3:0.251
HOMA–IR	2.95	(0.20-5.10)	3.08	(0.43-7.30)	3.03	(0.54-29.92)	0.537	1-2:1.00 1-3:0.240 2-3:0.145
ALT(µ/L)	19 .36	16 .09	19 .19	9 .44	23 .40	15 .33	0.088	1-2:1.00 1-3:0.387 2-3:0.147

*multiple comparison p value, **binary comparison p value

Correlation analysis of serum vitamin D by anthropometric and metabolic parameters according to age and sex.

Correlation coefficients that correlate Spearman's vitamin D levels with anthropometric and metabolic parameters are shown in Table 3 as a whole in the group and separately for men and women. Vitamin D was inversely and poorly associated with most of the parameters. It showed a significant correlation between vitamin D and more parameters in males than females.

Table 3. The Spearman's correlation coefficients between serum 25(OH)D and the anthropometric and metabolic parameters are shown according to sex

Independent variable	Total group (N=264)		Men (n=109)		Women (n=155)	
Age (years)	r=0.062	p= 0.373	r= -0.324	**p= 0.025**	r=0.156	**p= 0.039**
Weight (kg)	r=0.115	p= 0.086	r= -0.296	**p= -0.041**	r= -0.079	p= 0.298
Height (cm)	r= -0.031	p= 0.660	r= -0.299	**p= 0.039**	r=-0.011	p= 0.881
BMI (kg/m2)	r= - 0.083	p= 0.215	r=- 0.205	p= 0.162	r=- 0.055	p= 0.471
SBP (mmHg)	r=0.014	p= 0.835	r=0.051	p= 0.731	r=0.008	p= 0.131
DBP (mmHg)	r=0.049	p= 0.470	r=0.325	**p= 0.024**	r=-0.016	p= 0.830
Fasting glucose (mg/dl)	r= -0.039	p= 0.561	r= -0.152	p= 0.303	r= -0.025	p= 0.738
Triglycerides (mg/dl)	r=0.092	p= 0.168	r= -0.009	p= 0.954	r=0.113	p= 0.136
LDL-C (mg/dl)	r=0.068	p= 0.309	r=0.027	p= 0.858	r=0.080	p= 0.289
HDL-C (mg/dl)	r=0.095	p= 0.158	r=0.092	p= 0.533	r= -0.129	p= 0.088
Insulin (mIU/L)	r= -0.081	p= 0.234	r= 0.131	p= 0.376	r= -0.123	p= 0.103
HOMA–IR index	r= -0.084	p= 0.211	r= 0.107	p= 0.468	r= -0.118	p= 0.118
ALT(µ/L)	r=0.013	p= 0.851	r= -0.106	p= 0.475	r=0.032	p= 0.677

The correlation coefficients of Spearman's vitamin D levels and anthropometric and metabolic parameters are shown in Table 4 by BMI category. By dividing the entire study group into 3 BMI categories, most of the variables lost their association with vitamin D levels. Serum vitamin D was negatively correlated only with weight and HDL-C in obese subjects, whereas it was negatively correlated with age and SBP in subjects with normal BMI. In overweight participants, vitamin D did not correlate with any of the other parameters.

Table 4. The Spearman's correlation coefficients between serum 25(OH)D and the anthropometric and body composition parameters are shown according to BMI

Independent variable	Normal weight (N=)	Overweight (n=)	Obesity (n=)
Age (years)	-0.992 / **0.002**	-0.060 / 0.992	0.165 / 0.070
Weight (kg)	-0.063 / 0.714	0.007 / 0.957	-0.195 / **0.032**
Height (cm)	0.145 / 0.400	0.044 / 0.722	-0.118 / 0.198
BMI (kg/m^2)	-0.060 / 0.992	-0.060 / 0.992	-0.060 / 0.992
SBP (mmHg)	-0.352 / **0.035**	0.116 / 0.349	0.034 / 0.713
DBP (mmHg)	-0.069 / 0.689	-0.006 / 0.964	0.102 / 0.265
Serum 25(OH) D (ng/mL)			
Fasting glucose (mg/dl)	0.032 / 0.854	0.012 / 0.920	-0.066 / 0.471
Triglycerides (mg/dl)	-0.050 / 0.773	0.338 / 0.005	0.023 / 0.800
LDL-C (mg/dl)	-0.107 / 0.534	0.22 / 0.326	0.095 / 0.302
HDL-C (mg/dl)	0.048 / 0.783	0.029 / 0.813	-0.187 / **0.040**
Insulin (mIU/L)	-0.037 / 0.829	-0.186 / 0.132	-0.062 / 0.501
HOMA–IR index	-0.021 / 0.903	-0.186 / 0.133	-0.072 / 0.432
ALT(µ/L)	0.026 / 0.880	0.004 / 0.976	0.012 / 0.894
TSH	-0.007 / 0.967	-0.075 / 0.549	0.054 / 0.559

Discussion

In this cross-sectional observation study, we investigated the correlation between serum 25 (OH) vitamin D levels and anthropometric and metabolic parameters. Vitamin D was inversely and weakly associated with most of the parameters. It showed a significant correlation between vitamin D and more parameters (Weight (kg), Height (cm) and DBP (mmHg)) in men than women. When we formed sub-groups according to BMI categories, a significant negative correlation was found between vitamin D levels and Weight (kg) and HDL-C levels in the obesity group compared to the normal weight and overweight groups.

Serum vitamin D and lipids

The relationship between vitamin D deficiency and lipids has been determined in some cross-sectional studies in large population samples. In a study conducted in China, serum 25 (OH) D levels were positively correlated with triglycerides (β coefficient = -0.24), LDL-C (β coefficient = -0.34), and inverse and total cholesterol, TC (β coefficient = 0.35).). In the study conducted in obese children, a positive correlation was found between HDL and serum 25 (OH) D concentration, while a negative correlation was found between triglyceride (TG) [15]. In elderly people, low vitamin D levels were associated with high HbA1c and low HDL [16]. In a meta-analysis with specific reference to the effect of vitamin D on lipids, all cross-sectional studies have shown that serum 25 (OH) D is negatively associated with LDL-C and positively associated with HDL-C [7]. There is a uniform study agreement on the negative relationship between serum 25 (OH) D and triglycerides.

Serum vitamin D and blood pressure

The relationship between blood pressure and serum vitamin D is also a matter of debate in the literature. In cross-sectional studies, 25 (OH) D is more correlated with systolic blood pressure (SBP) than diastolic blood pressure (DBP) [8]. Interventional studies with vitamin D supplementation have reported decreased or no effect not only in SBP [17] but also in both SBP and DBP [18] [19, 20]. In our study, we recorded the positive correlation of serum 25 (OH) D with DBP in the male group. In multivariate regression analysis, only SBP showed a borderline relationship with vitamin D status. A number of publications have attempted to examine the nature of the relationship between vitamin D and high blood pressure [9, 21]. One of these meta-analyzes showed that high 25 (OH) D concentrations in phenotypic assays were associated with decreased SBP (%0.12 mm Hg per 10% increase, p = 0.003) and low hypertension rate, but not with decreased DBP (0.02 mm Hg, p = 0.37) [9].

Serum vitamin D and glycemia

Type 2 diabetes is the most common metabolic disease in the adult population. Although it is generally known as middle and advanced ages, it has started to be seen at a younger age in recent years. Vitamin D is known to play a role in Type 2 DM related and glycemic control. There is a need for vitamin D in the absorption of calcium, which plays a role in the regulation of insulin secretion in pancreatic beta cells. Vitamin D regulates insulin secretion from pancreatic beta cells. Vitamin D deficiency was associated with insulin resistance [22, 23]. There was no correlation between plasma insulin and HOMA-IR index and vitamin D levels in the study population.

Additional findings

The inverse relationship of body fat percentage to serum vitamin D is not surprising, as it is parallel to increased body weight and decreased vitamin D level. Since the analysis of body composition is more accurate in estimating obesity than measuring only body weight, the correlation coefficients with vitamin D are higher in kilograms for% of body fat. Therefore, BIA may be a more sensitive tool for screening subjects at risk for vitamin D deficiency.

All this evidence should be carefully evaluated. The relationship between vitamin D (fat-soluble vitamin) and metabolic parameters can be interpreted in both directions. Obesity leading to low vitamin D levels or low levels of vitamin D leading to obesity [24, 25]. However, forming subgroups according to BMI probably caused statistical loss due to the small sample size. However, BMI was included in the multivariate model as a baseline variable. Other researchers also reported that there was no direct relationship with BMI [26].

Our study was not designed to investigate the causal relationship between vitamin D and metabolic parameters. However, it is worth mentioning that vitamin D is involved in regulating energy balance. The active metabolite can regulate different cellular processes such as cell proliferation, differentiation and apoptosis [27].

The major advantage of our study is that it combines data from different research methods (BIA, anthropometry, and assessment of metabolic health, thus making a complex definition of the relationship between vitamin D and obesity and metabolic status. The major disadvantage is limited sample size and It prevents the statistical significance of certain sub-groups.

Our data weakly support the hypothesis that the association of vitamin D levels with various metabolic parameters such as lipids, fasting plasma glucose and blood pressure in some population samples. Whether this relationship is causal or low vitamin D cannot be answered by this study alone with metabolic parameters. Low levels of vitamin D seem to be appropriate for predicting the risk of increased lipid levels and body fat percentage, thus contributing to simple measurements of overweight and obesity.

Conclusion

In conclusion, although the relationship at individual level is not always present, vitamin D deficiency and deficiency are very common in patients with poor metabolic health. Therefore, vitamin D supplementation can be considered as a therapeutic option in all subjects who are overweight, obesity and metabolic disorders.

Conflict of interests
We declare that we have no conflict of interest.

Financial Disclosure
This study received no financial support.

Ethical approval
This study was conducted in accordance with the ethical guidelines stated in the Helsinki Declaration and with an approval from Firat University Medical Faculty Ethics Committee (19.07.2018, Approval number: 06).

References

1. Fidan F, Alkan BM, Tosun A. Çağın Pandemisi: D vitamini eksikliği ve yetersizliği. Turk J Osteoporos. 2014;20:71-4.
2. Wacker M, Holick M. Vitamin D-effects on skeletal and extraskeletal health and the need for supplementation. Nutrients. 2013;5:111-48.
3. Hilger J, Friedel A, Herr R, et al. A systematic review of vitamin D status in populations worldwide. Br J Nutr. 2014;111:23–45.
4. Palacios C, Gonzalez L. Is vitamin D deficiency a major global public health problem? J Steroid Biochem Mol Biol. 2014;144:138–45.
5. Wang Y, Si S, Liu J, et al. The associations of serum lipids with vitamin D status. PLoS One. 2016;11:e0165157.
6. Glueck CJ, Jetty V, Rothschild M, et al. Associations between serum 25-hydroxyvitamin D and lipids, lipoprotein cholesterols, and homocysteine. N Am J Med Sci. 2016;8:284–90.
7. Jorde R, Grimnes G. Vitamin D and metabolic health with special reference to the effect of vitamin D on serum lipids. Prog Lipid Res. 2011;50:303–12.
8. Nayak SB, Ramnanansingh TG. Evaluation of vitamin D relationship with type 2 diabetes and systolic blood pressure. BMJ Open Diab Res Care. 2016;4:e000285.
9. Vimaleswaran KS, Cavadino A, Berry DJ, et al. Association of vitamin D status with arterial blood pressure and hypertension risk: a mendelian randomisation study. Lancet Diabetes Endocrinol. 2014;2:719–29.
10. Onalan E, Gozel N. Prevalence of vitamin D deficiency in patients with type 2 diabetes and its relationship with glycemic control. Journal of Turgut Ozal Medical Center. 2019;26: 222-5.
11. Vilarrasa N, Maravall J, Estepa A, et al. Low 25-hydroxyvitamin D concentrations in obese women: their clinical significance and relationship with anthropometric and body composition variables. J Endocrinol Invest. 2007 Sep;30:653-8.
12. Tanita. Tanita Corp. Tokyo, Japan: 2005. Body composition analyzer BC-420MA - Instruction manual.
13. Stivelman E, Retnakaran R. Role of Vitamin D in the Pathophysiology and Treatment of Type 2 Diabetes. Curr Diab Rev 2012;8:42-47.
14. Yenigün M. Insulin direnci ve ölcüm metodları. In: Altuntas Y, ed, Her yonuyle diabetes mellitus: Istanbul, 2nd Ed, Nobel Tıp Kitapevi. 2001:839-52.
15. Kim M, Na W, Sohn C. Correlation between vitamin D and cardiovascular disease predictors in overweight and obese Koreans. J Clin Biochem Nutr, 2013;52:167-71.
16. Kashi Z, Saeedian Fs, Akha O, et al. Vitamin D deficiency prevalence in summer compared to winter in a city with high humidity and a sultry climate. Endocrinol Pol. 2011;62:249-51.
17. Qi D, Nie X, Cai J. The effect of vitamin D supplementation on hypertension in non-CKD populations: A systemic review and meta-analysis. Int J Cardiol. 2017;227:177–86.
18. Nasri H, Behradmanesh S, Ahmadi A, et al. Impact of oral vitamin D (cholecalciferol) replacement therapy on blood pressure in type 2 diabetes patients; a randomized, double-blind, placebo controlled clinical trial. J Nephropathol. 2014;3:29–33.
19. Beveridge LA, Struthers AD, Khan F, et al. Effect of vitamin D supplementation on blood pressure: A systematic review and meta-analysis incorporating individual patient data. JAMA Intern Med. 2015;175:745–54.
20. Kampmann U, Mosekilde L, Juhl C, et al. Effects of 12 weeks high dose vitamin D3 treatment on insulin sensitivity, beta cell function, and metabolic markers in patients with type 2 diabetes and vitamin D insufficiency a double-blind, randomized, placebo-controlled trial. Metabolism. 2014;63:1115–24.
21. Kunutsor SK, Burgess S, Munroe PB, et al. Vitamin D and high blood pressure: causal association or epiphenomenon? Eur J Epidemiol. 2014;29:1–14.
22. Talaei A, Mohamadi M, Adgi Z. The effect of vitamin D on insulin resistance in patients with type 2 diabetes. Diabetol Metab Syndr. 2013;5:8.
23. Nada A. Correlation between vitamin D3 and fasting plasma glucose, a1c and serum lipids in non-diabetic subjects. Zagazig University Med. J., 2013;19:1-5.
24. Tamer G, Mesci B, Tamer I, et al. Is vitamin D deficiency an independent risk factor for obesity and abdominal obesity in women? Endokrynol Pol. 2012;63:196–201.
25. Rodríguez-Rodríguez E, Navia-Lombán B, López-Sobaler AM, et al. Associations between abdominal fat and body mass index on vitamin D status in a group of Spanish schoolchildren. Eur J Clin Nutr. 2010;64:461–67.
26. Miñambres I, Sánchez-Hernández J, Sánchez-Quesada JL, et al. The association of hypo-vitaminosis D with the metabolic syndrome is independent of the degree of obesity. ISRN Endocrinol. 2012:691803.
27. Soares MJ, Pathak K, Calton EK. Calcium and vitamin D in the regulation of energy balance: where do we stand? Int J Mol Sci. 2014;15:4938–45.