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Evaluation of the Relationship between Insulin, Vitamin D Levels and Dietary Habits in Adults with Normal Weight and Obesity

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ABSTRACT

Background: Obesity and insulin resistance has been associated with vitamin D deficiency. Many studies have shown that vitamin D deficiency is associated with increased body weight, impaired glucose tolerance, insulin resistance, early onset of Type 2 diabetes mellitus (T2DM), coronary heart disease, mood disorders, and high blood pressure.

Methods: The study was carried out with a total of 170 subjects, including 121 females and 49 males, aged between 19-65. Individuals' characteristics, general dietary habits, anthropometric measurements, biochemical parameters, physical activity and mood status were evaluated by the researcher.

Results: A total of 170 people with a mean age of 34.96±9.61 years participated in this study. Of the total participants, 121 were females. Individuals with a body mass index (BMI) of ≥25 had higher blood glucose (mg/dL), insulin (uU/mL), Homa-IR (mg/dL), and HbA1-C (%) levels and lower plasma vitamin D (ng/mL) level compared to those with a BMI of <25. It was shown that as the risk of eating disorders increased, insulin and Homa-IR values of the individuals increased too in direct proportion and that Homa-IR values were higher in individuals with a higher risk of depression in direct proportion.

Conclusion: Regarding any body weight management, the people should be evaluated and followed up in terms of insulin and vitamin D levels, dietary habits and mood disorders.

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Introduction

Obesity is defined as an excessive and abnormal increase in body fat enough to impair health. In a broader sense, it is the increase and growth of fat cells due to the imbalance between the energy intake and the energy spent (1). However, in recent years, the focus is on the region and distribution of fat in the body rather than its total amount in the body, and the region and distribution of fat in the body are associated with the morbidity and mortality of diseases (2).

The accumulation of excess fat around the abdominal area and internal organs leads to insulin resistance. Insulin resistance is the most important factor in the emergence of type 2 diabetes mellitus (T2DM), hypertension, dyslipidemia, and coronary artery diseases caused by obesity (3). It is defined as the decreased ability of tissues to respond to insulin. Insulin inhibits lipolysis through stimulation by several mechanisms, including increased uptake of lipoproteins and lipogenesis circulating in adipocytes due to the deposit of triglycerides in adipose tissue (4). While this situation results in a vicious circle between insulin resistance and obesity, it also explains the relationship between obesity and dyslipidemia (5).

Recently, obesity and insulin resistance has been associated with vitamin D deficiency (6). Many studies have shown that vitamin D deficiency is associated with increased body weight, impaired glucose tolerance, insulin resistance, early onset of T2DM, coronary heart disease, mood disorders, and high blood pressure (6-8). One study centered especially on the presence of a bidirectional relationship between vitamin D and obesity, and found that each unit increase in BMI caused a 1.15% decrease in 25(OH)D_3 level (9).

In addition to all these metabolic diseases, epidemiological studies have proved that obesity also causes various mental disorders, and researchers have concluded that there is a causal relationship between them (10, 11). Various mood changes, such as stress, anxiety, and depression, affect the hypothalamic centers and change the eating behavior, and therefore, an interaction develops between the current mental state and the choice, amount, and frequency of food, independent of physiological needs (12, 13). On the other hand, several studies suggested important associations between vitamin D deficiency and many types of mood disorders, including especially major depression and seasonal affective disorder (14, 15).

Materials and Methods

The study was carried out with a total of 170 people, including 121 females and 49 males, aged between 19-65, who presented to a private clinic between December 2019 and February 2020 and accepted to participate in the study voluntarily. The 'Informed Consent Form' was read to the individuals participating in the study, and they were asked if they wanted to participate in the study, and those who wanted to participate voluntarily were included in the study. The study was approved by the Başkent University Clinical Research Ethics Committee (date: December 11, 2019, issue: KA19/378) (protocol number KA19/123).

To determine the personal characteristics and general dietary habits of the individuals participating in the study, a questionnaire containing multiple choice and/or open-ended questions was administered through face to face interviews. The questionnaire form administered aimed to collect information about the general characteristics (age, gender, etc.) of individuals and their diseases diagnosed by a physician.

Participants' body weight measurements were taken with a precise weighing scale. Height, waist, and hip circumference measurements were taken by the researcher with a non-stretch tape measure. Based on the measurements, body mass index value (BMI=[Body Weight (kg)/Height (m^2)]) was calculated. Using a non-stretch tape measure, the waist circumference of the individuals was measured through the line passing between the lower rib bone and the iliac crest, and the hip circumference was measured at the widest circumference of the hip with the hip circumference parallel to the floor.

The waist/hip ratio was calculated using the "waist circumference (cm)/hip circumference (cm)" formula. BMI, waist circumference, and waist/hip ratios were evaluated according to the classification of the World Health Organization (16, 17). Besides, the body composition of the participants (body fat (kg), body fat (%), lean tissue mass (kg), and body water (mL)) were measured with the Bioelectrical Impedance Analysis device (Tanita Mc 780MA), and the values were recorded in the questionnaire form by the researcher. Glucose (fasting), insulin (fasting), HbA1c (%), Homa-IR, and serum vitamin D levels of the participants were measured in a private health institution, and then the values were assessed by the researchers.

The individuals participating in the study were also administered for food frequency questionnaire aiming to collect information about the consumption frequency of milk and milk products, meat, eggs, legumes, vegetables, fruit, bread, cereals, fat, sugar, and sweet drinks. To determine the frequency of consumption, 8 options, including every meal, every day, once-twice a week, three-four times a week, 5-6 times a week, one in a fortnight, and once a month, were defined. This scale was developed and Turkish validity and reliability study was carried out by Rakıcıoglu *et al.* (18). The data obtained were analyzed on BEBIS (Nutrition Information System) software package.

The Eating Attitude Test (EAT) scale that was developed by Garner (19) and its Turkish validity and reliability study was carried out by Savaş (20) was administered to measure the eating disorders of the participants. It was consisted of 40 items and had a 6-point Likert type rating scale. Individuals who got 30 points or more from the EAT were considered at risk for eating attitudes and behaviors. The International Physical Activity Questionnaire-Short Form (IPAQ-SF) that was developed by Booth (21) was used to determine the physical activity levels of individuals. The Turkish validity and reliability of the scale was carried out by Öztürk (22).

The IPAQ-SF was consisted of 7 questions. The total score was obtained by summing the duration (minutes) and frequency (days) of walking, moderate activity, and vigorous activity. The sitting score (sedentary behavior level) was calculated separately. In the evaluation of all activities, doing each activity at least 10 minutes at a time was taken as the criterion. The minute, day, and MET value (multiples of resting oxygen consumption) were multiplied to obtain a score as "MET-minute/ week". The MET value obtained was analyzed in 3 categories. These categories included the following: 1st category: inactive (<600 MET-min/week), 2nd category: minimum active (600<- <3000 MET- min/ week), and 3rd category: very active (>3000 MET-min/week).

The Boratav Depression Screening Scale (Bordepta) that was developed by Boratav (23) was used to investigate the depression. The Turkish validity and reliability study of the scale was conducted by Tasdelen (24). Bordepta is a screening test with appropriate sensitivity and specificity percentages. The scale consisted 16 items, and each item was responded with "Yes" or "No". Ten of the items were assigned 1 point for "yes" response (items 1, 4, 5, 7, 8, 9, 11, 14, 15, and 16), while 6 of them were inversed and assigned 1 point for "no" response (items 2, 3, 6, 10, 12 and 13). The lowest and highest scores that could be obtained from the scale were 0 and 16, respectively. The median value of the sample was used as the cut-off point to create new comparison groups or to transform continuous data into categorical data.

The data obtained from the questionnaires were evaluated on the SPSS software package (Statistic Package for Social Sciences, version 21.0, Chicago, IL, USA). In the analysis of quantitative data, the fit of variables to normal distribution was analyzed using the Kolmogorov-Smirnov test, and non-parametric tests were used for data that did not fit to normal distribution. Mann-Whitney U test was used for the statistical significance test between two independent groups, and the Kruskal-Wallis test was employed for the statistical significance test between three or more independent groups.

Dunn-Bonferroni test was used in the case of a statistically significant difference between three or more independent groups (Dunn-Bonferroni test is also known as Bonferroni correction). The Chi-Square test, which is used to test the difference between the observed and expected frequency values of the data, was also employed to analyze qualitatively expressed categorical variables. The relationship between variables was analyzed using the Spearman Rho correlation test. $p<0.05$ was considered statistically significant.

Results

Table 1 presents data regarding the general characteristics, health conditions, and dietary habits of the participants. Accordingly, a total of 170 individuals, including 121 females (71.2%) and 49 males (28.8%) participated in the study. The mean age of the individuals was 34.96±9.61 years. Also, 88.8% of the participants had chronic diseases, and the most common disorders among the participants were insulin resistance (41.1%), vitamin deficiency (72.2%), high cholesterol (31.1%), and obesity (11.3%).

The evaluation of the data by gender regarding the anthropometric measurements of the individuals participating in the study was presented in Table 2. Accordingly, the mean BMI of females was 25.72±5.9 kg/m^2, 21.5% were slightly overweight, and 11.6% had first degree obesity. The mean BMI of males was 28.79±4.2 kg/m^2, 49.0% were slightly overweight, and 20.4% were determined to be first degree obese. The mean waist circumference of females was 83.98±15.6 cm, 50.4% of them were classified as normal, and 33.8% of them were found to be at high-risk.

The mean waist circumference of males was 100.81±13.77 cm, 26.5% of them were classified as normal, and 44.9% of them had a high-risk waist

Table 1: The general characteristics, health conditions, and dietary habits of the participants.

	Participants (n:170)	
	n	**%**
Gender		
Women	121	71.2
Man	49	28.8
Age (year), $\bar{X} \pm SD$	34.96±9.61	
Chronic diseases		
Yes	151	88.8
No	19	11.2
Type of disease*		
Insulin resistance	62	41.1
Diabetes	10	6.6
Obesity	17	11.3
Vitamin deficiency	109	72.2
High cholesterol	47	31.1
Hypothyroidism	15	9.9
Hypertension	6	4.0
Iron deficiency	16	10.6
Polycystic ovary syndrome	15	9.9
Other diseases (Asthma, Vertigo)	2	1.4

*Percentage Calculation Mode for Multiple Select Type Questions.

Table 2: The evaluation of data on anthropometric measurements of the participants by gender.

	Women (n=121)		Men (n=49)	
	n	%	n	%
BMI (kg/m^2)				
<18.5, underweight	3	2.5	0	0
18.5-24.99, normal	69	57.0	8	16.3
25.0-29.99, overweight	26	21.5	24	49.0
30.0-34.99, Obesity class I	14	11.6	10	20.4
35.0-39.99,Obesity class II	9	7.6	7	14.3
BMI, $\bar{X}$±*SD*	25.72±5.9		28.79±4.2	
Waist circumference (cm)				
Normal (man <94, woman <80)	61	50.4	13	26.5
Risk (man ≥94, woman ≥80)	23	19.0	14	28.6
High risk (man ≥102, woman ≥88)	37	30.6	22	44.9
Waist circumference, $\bar{X}$±SD	83.98±15.6		100.81±13.77	
Waist/Hip ratio (cm)				
Normal (man <0.90, woman <0.85)	82	67.8	12	24.5
Risk (man ≥0.90, woman ≥0.85)	39	32.2	37	75.5
Waist/Hip ratio, $\bar{X}$±SD	0.81±0.06		0.94±0.05	
Body fat (%), $\bar{X}$±SD	29.77±7.2		23.97±5.83	
Fat tissue (kg), $\bar{X}$±SD	21.66±10.0		22.63±8.9	
Lean body mass (kg), $\bar{X}$±SD	47.91±6.94		68.52±8.7	
Body water (mL), $\bar{X}$±SD	33.98±4.6		48.41±7.38	

Table 3: Energy and macronutrient intake of the participants according to their BMI values.

Energy and Nutrients	BMI<25				BMI≥25				*p* value*
	Median	IQR[#]	Min	Max	Median	IQR[#]	Min	Max	
Energy (kcal)	1610.91	373.28	1075.47	2244.98	1808.46	473.14	889.63	2558.74	0.002*
Carbohydrate (g)	117.59	34.86	56.10	199.72	129.53	48.22	48.72	196.27	0.084
Carbohydrate (TE%)	29.00	5.00	20.00	48.00	29.00	4.50	10.00	40.00	0.817
Protein (g)	60.00	10.26	44.39	82.41	68.26	16.39	38.17	102.34	0.001*
Protein (TE%)	15.00	3.00	11.00	20.00	15.00	3.00	12.00	25.00	0.144
Fat (g)	100.92	31.51	48.31	147.91	122.72	32.99	42.87	165.29	0.006*
Fat (TE%)	55.00	5.00	39.00	63.00	55.00	4.00	43.00	72.00	0.432
Monounsaturated fatty acid(%)	50.17	14.35	19.28	80.81	53.36	13.85	16.80	78.20	0.066
Polyunsaturated fatty acid (%)	10.26	3.81	6.26	20.55	11.42	5.06	3.82	28.21	0.050*
Saturated fatty acid (%)	32.47	10.32	18.52	50.28	39.00	12.07	15.53	57.47	0.001*
Fiber (g)	20.50	6.23	8.97	28.64	22.64	8.04	10.27	35.93	0.047*

*p<0.05, [#]IQR: Inter Quantile Range, BMI: Body mass index, Min: Minimum, Max: Maximum.

circumference measurement. Besides, the waist/hip ratio of females was 0.81±0.06 cm, 67.8% was classified as normal, and 32.2% were risky. The males had a mean waist/hip ratio of 0.94±0.05 cm, and 75.5% had a risky waist/hip ratio. In the study, while the mean fat percentage of females was 29.77%, this ratio was 23.97% in males. The mean lean tissue mass and body water values of the females were 47.91±6.94 kg and 33.98±4.6 mL, respectively. These values were 68.52±8.7 kg and 48.41±7.38 mL in males, respectively.

Table 3 shows individuals' energy and macronutrient intakes with daily diet according to their body mass index. Accordingly, individuals with a BMI of ≥25 had higher intakes of energy (kcal), protein (g), fat (g), polyunsaturated fatty acid (%), saturated fatty acid (%), and fiber (g) compared to individuals with a BMI of <25 (p<0.05).

Table 4, on the other hand, presents the micronutrient intakes of individuals in their daily diet according to their BMI and the evaluation of these intakes according to the Dietary Reference Intake Levels (DRI). Individuals with a BMI value of ≥25 were found to have higher daily intakes of vitamin A, thiamine, riboflavin, niacin, pyridoxine, folate, and vitamin B12, as well as sodium, calcium,

Table 4: Micronutrient intake of the participants and the evaluation of Dietary Reference Intake (DRI) levels.

Micro Nutrients	BMI<25					BMI≥25					*p* value
	Median	IQR	Min	Max	DRI (%)	Median	IQR	Min	Max	DRI (%)	
Vitamins											
Vitamin A (mcg)	1126.56	290.28	548.90	1513.01	140.82	1185.47	336.29	329.02	1474.47	148.18	0.048*
Vitamin E (mg)	14.21	4.11	7.89	25.59	94.73	14.47	3.86	5.17	25.25	96.46	0.768
Thiamine (mg)	0.75	0.21	0.45	1.04	65.21	0.83	0.26	0.44	1.31	72.17	0.022*
Riboflavin (mg)	1.41	0.45	0.84	2.15	117.5	1.61	0.44	0.87	2.52	134.16	0.001*
Niacin (mg)	12.67	3.62	7.01	18.53	84.46	13.86	4.19	6.83	23.73	92.40	0.006*
Pyridoxine (mg)	1.19	0.24	0.75	1.76	91.53	1.31	0.44	0.78	2.41	100.76	0.003*
Folate (mcg)	130.13	38.39	71.54	178.48	32.53	145.30	46.11	64.48	220.77	36.32	0.002*
Vitamin B12 (mcg)	3.80	1.38	2.00	6.85	158.33	4.28	1.07	1.40	7.13	178.33	0.035*
Vitamin C (mg)	108.75	49.96	35.03	171.57	131.81	115.96	55.42	4.30	194.42	140.85	0.734
Minerals											
Sodium (mg)	1919.76	513.01	793.37	2876.66	127.98	2155.40	623.85	864.45	3577.56	143.69	0.003*
Potassium (mg)	2484.34	738.89	1389.90	3313.26	81.16	2657.42	890.29	1192.75	4252.24	88.58	0.146
Calsium (mg)	850.13	301.64	411.04	1353.31	85.01	967.90	281.28	441.57	1697.30	96.79	0.011*
Magnesium (mg)	314.84	69.77	190.54	410.58	85.09	348.92	99.28	182.87	569.27	94.30	0.007*
Iron (mg)	11.03	2.35	6.50	14.29	84.84	11.83	2.73	6.43	18.59	91.00	0.029*
Zinc (mg)	11.06	2.25	7.66	15.13	116.42	12.20	2.81	7.69	20.00	128.42	0.001*

*$p<0.05$; IQR: Inter Quantile Range, DRI: Dietary Reference Intake, BMI: Body mass index, Min: Minimum, Max: Maximum.

Table 5: The evaluation of the biochemical findings, eating attitudes, physical activity levels and mood according to their BMI values.

	BMI<25			BMI≥25			*p* value
	Median	Min	Max	Median	Min	Max	
Glucose (mg/dL)	80.00	72.00	98.00	89.00	73.00	209.00	0.001*
Insulin (uU/mL)	9.30	4.49	15.70	12.40	5.80	22.10	0.001*
HOMA-IR (mg/dL)	1.80	0.82	3.10	2.76	1.39	6.90	0.001*
HbA1-C (%)	5.00	4.20	5.80	6.30	4.80	9.40	0.001*
Vitamin D (ng/mL)	18.20	6.87	34.10	13.40	6.70	48.00	0.001*
	n	%		n	%		
EAT							0.622
<30	80	98.8		86	96.6		
≥30	1	1.2		3	3.4		
IPAQ							0.760
Inactive	28	34.6		34	38.2		
Minimum active	52	64.2		53	59.6		
Active	1	1.2		2	2.2		
Bordepta							0.163
<5	38	46.9		32	36.0		
≥5	43	53.1		57	64.0		

*$p<0.05$. BMI: Body mass index, Min: Minimum, Max: Maximum, EAT: Eating Attitude Test, IPAQ: International Physical Activity Questionnaire.

magnesium, iron, and zinc compared to individuals with a BMI value of <25 ($p<0.05$). Also, there was insufficient folate intake in both groups.

Table 5 demonstrates the evaluation of the biochemical findings, eating attitudes, physical activity levels and moods of the individuals participating in the study according to their BMI groups. Accordingly, blood glucose (mg/dL), insulin (uU/mL), Homa-IR (mg/dL), and HbA1-C (%) levels were found to be higher in individuals with a BMI value of ≥25 compared to individuals with a BMI value of <25 ($p<0.05$). The plasma vitamin D (ng/mL) levels of the individuals with a BMI value of ≥25 were found to be lower than those with a BMI value of <25 ($p<0.05$).

On the other hand; 1.2% of the individuals in the BMI<25 group and 3.4% of the individuals in the BMI≥25 group had an eating attitude score of 30 points or above, which indicated a risk for eating disorders. Also, 34.6% of individuals in the BMI<25 group were found to be inactive and 64.2% were minimum active, while 38.2% of the individuals in the BMI≥25 group were inactive and 59.6% were minimum active. Besides, 53.1% of the individuals in the BMI<25 group and 64.0% of the individuals in the BMI≥25 group had Bordepta scores of 5 points or above, which indicated a risk of mood disorders. The differences between eating attitudes, physical activity levels, and moods according to BMI groups were not found statistically significant ($p>0.05$).

Discussion

According to the report published by the World Health Organization, 39% of individuals aged 18 or over were overweight and 13% were obese (24). The prevalence of obesity across Europe was about 22.0% in females and 15.0% in males. In Turkey, this value is 41.0% in females and 20.5% in males (25, 26). Obesity is the most important risk factor leading to insulin resistance. Insulin secretion in individuals with obesity can increase up to three times compared to normal individuals (27).

Weight loss or gain is associated with an increase or decrease in insulin sensitivity, and abdominal obesity, which occurs especially with an increase in body fat in the waist region, and is stated to be the main risk factor in the formation of insulin resistance (28). The most important biochemical parameters examined in the follow-up of obesity and insulin resistance are fasting blood glucose, insulin, HbA1c, and Homa-IR values. In this study, it was observed that as the body mass index increased, fasting blood glucose, fasting insulin, HbA1c, and Homa-IR levels also increased significantly.

Various scientific studies have shown a correlation between increasing BMI and decreasing serum 25(OH)D_3 concentration (29, 30). In a genetic study conducted on 42,024 people in North America and Europe, genetic evidence revealed that high BMI caused low vitamin D levels, and it was concluded that each unit increase in BMI caused 1.15% decrease in 25(OH)D_3 level. The examination of vitamin D level of the participants in the current study indicated that individuals with a BMI value of ≥25 had lower vitamin D levels compared to individuals with a BMI value of <25.

According to DRI, a nutrition plan should be created in both healthy individuals and individuals with insulin resistance to meet 45-65% of energy from carbohydrates, 10-35% from proteins, and 20-35% from fat (31). In this study, the proportions of the daily energy intake of the participants from carbohydrate, protein, and fat were 29.0%, 15.0%, and 55.0%, respectively. According to the data, it can be seen that the ratio of total energy from proteins is appropriate for the recommended value range, but the ratio from carbohydrates is low, and the ratio from fats is high.

A dietary pattern with high fat content is thought to increase inflammation and cause insulin resistance (32). A decrease in the intake of saturated fatty acids in the diet leads to a decrease in fasting and fullness insulin levels, while a high saturated fat intake above the recommended level can lead to insulin resistance (33). In this study, it was determined that individuals with a BMI value of ≥25 had higher consumption of saturated fatty acids than individuals with a BMI value of <25.

Obesity, which is a global problem in terms of public health, is also considered as a psychosomatic disease by some researchers (34). In a study conducted on this subject, it was determined that mood, anxiety, and eating disorders were seen at a higher rate in individuals with obesity compared to healthy individuals (35). In a study investigating the relationship between eating attitudes and social appearance anxiety among university students, there was a significant relationship between eating attitude score and BMI and that BMI increased as the eating attitude score increased (36). In this study, although it was not statistically significant, individuals in the BMI≥25 group had higher risk for eating disorders compared to individuals in the BMI<25 group.

It is thought that there is a causal relationship between obesity and various mental disorders (37). Petry *et al.* (38) revealed that as BMI increased, the likelihood of mood disorders, anxiety disorders, and personality disorders also increased. A population-based study investigated mood disorders of adult individuals and found that depressive symptoms were much higher in females who were slightly overweight and obese compared to females who were slightly overweight and non-obese (39). In the present study, 53.1% of the participants whose Bordepta score was 5 points or more, which indicated a risk for mood disorders, were in the BMI <25 group, whereas 64.0% of them were in the BMI≥25 group.

On the other hand, impaired glycemic control also affects individuals psychosocially. It has been reported that depressive symptoms are more common in people who do not have a good glycemic control (39, 40). Accordingly, impaired glycemic control, insulin resistance or diabetes can trigger mood disorders, as well as affecting various hormones that have an effect on mood; for example, serotonin affects food selection, leptin affects corticosterone inflammatory mechanisms, and plasma affects glucose regulation and insulin resistance (40). In the current study, it was determined that as individuals' risk for eating disorder increased, insulin and Homa-

IR values increased in direct proportion and that Homa-IR values were higher in individuals with higher risk of depression in direct proportion.

Conclusion

The present study showed that in body weight management, individuals should be evaluated and followed up in terms of insulin and vitamin D levels, dietary habits, and mood disorders. To provide clearer recommendations, the results of this study should be supported by more comprehensive studies with larger samples.

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Conflict of Interest

None declared.

References

1 Khamoushi A, Mohammadi Sartang M, Mazloom Z, et al. Dietary diversity and abdominal obesity among female students of Shiraz University of Medical Sciences, Shiraz, Iran. *Int J Nutr Sci*. 2020;5:83-87. DOI:10.30476/IJNS.2020.86935.1074.
2 Shaker-Hosseini R, Ghodrati N. Dietary patterns defined a posteriori or a priori in relation to obesity ındices in Iranian Women. *Int J Nutr Sci*. 2017;2:209-217.
3 Van Gaal LF, Mertens IL, Christophe E. Mechanisms linking obesity with cardiovascular disease. *Nature*. 2006;444:875-80. DOI:10.1038/nature05487. PMID:17167476.
4 Petersen MC, Shulman GI. Mechanisms of insulin action and insulin resistance. *Physiol Rev*. 2018;98:2133-2223. DOI:10.1152/physrev.00063.2017. PMID:30067154.
5 Czech MP. Insulin action and resistance in obesity and type 2 diabetes. *Nat Med*. 2017;23:804-814. DOI:10.1038/nm.4350. PMID:28697184.
6 Pramono A, Jocken JW, Blaak EE. Vitamin D deficiency in the aetiology of obesity-related insulin resistance. *Diabetes Metab Res Rev*. 2019;35:3146. DOI: 10.1002/dmrr.3146. PMID:30801902.
7 Vicka Oktaria MD. Association of vitamin D deficiency with cardiovascular disease risk in children: implications for the Asia Pacific Region. *Asia Pac J Clin Nutr*. 2016;25:8-19. DOI:10.6133/apjcn.122016.s1. PMID:28027627.
8 Khosravi ZS, Kafeshani M, Tavasoli P, et al. Effect of Vitamin D supplementation on weight loss, glycemic indices, and lipid profile in obese and overweight women: A clinical trial study. *Int J Prev Med*. 2018;9:63. DOI:10.4103/ijpvm.IJPVM_329_15. PMID:30123437.
9 Vimaleswaran KS, Berry DJ, Lu C, et al. Causal relationship between obesity and vitamin D status: bi-directional Mendelian randomization analysis of multiple cohorts. *PLoS Med*. 2013;10:1001383. DOI:10.1371/journal.pmed.1001383. PMID:23393431.
10 Rajan TM, Menon V. Psychiatric disorders and obesity: a review of association studies. *J Postgrad Med*. 2017;63:182-90. DOI: 0.4103/jpgm.JPGM_712_16. PMID:28695871.
11 Haghighatdoost F, Kelishadi R, Qorbani M, et al. Family dinner frequency is inversely related to mental disorders and obesity in adolescents: the CASPIAN-III study. *Arch Iran Med*. 2017;20:218-23. PMID:28412825.
12 de Lima RMS, dos Santos Bento LV, Lugon MDMV, et al. Early life stress and the programming of eating behavior and anxiety: Sex-specific relationships with serotonergic activity and hypothalamic neuropeptides. *Behav Brain Res*. 2020;379:112399. DOI:10.1016/j.bbr.2019.112399. PMID:31790781.
13 Leng G, Adan RA, Belot M, et al. The determinants of food choice. *Proc Nutr Soc*. 2017;76:316-327. DOI:10.1017/S002966511600286X. PMID:27903310.
14 Parker GB, Brotchie H, Graham RK. Vitamin D and depression. *J Affect Disord*. 2017;208:56-61. DOI:10.1093/gerona/glx130. PMID:27750060.
15 Casseb GA, Kaster MP, Rodrigues ALS. Potential role of vitamin D for the management of depression and anxiety. *CNS Drugs*. 2019;33:619-637. DOI:10.1007/s40263-019-00640-4. PMID:31093951.
16 World Health Organization. World Health Organization Global database on body mass index. 2010.
17 World Health Organization. Waist circumference and waist-hip ratio: report of a WHO expert consultation. 2011.
18 Rakıcıoğlu N, Acar Tek N, Ayaz A, et al. Yemek ve Besin Fotoğraf Kataloğu Ölçü ve Miktarları. 7'inci baskı, Hacettepe Üniversitesi Yayınları, Ankara, 2017.
19 Garner D, Olmsted M, Bohr Y, et al. The Eating Attitudes Test: Psychometric features. *Psychol Med*. 1982;12:871-8. DOI:10.1017/s0033291700049163. PMID:6961471.
20 Savasir I. Anoreksiya Nevroza Belirtileri Indeksi. *Psikoloji Dergisi*. 1989;7:19-25.

21 Booth M. Assessment of physical activity: an international perspective. *Res Q Exerc Sport.* 2000; 71:114-120. DOI:10.1080/02701367.2000.11082794. PMID:25680021.

22 Öztürk UFM, Savcı FDS, Arıkan FDH. Üniversite öğrencilerinin fiziksel aktivite düzeyleri. *Türk Kardiyol Dern Arfl.* 2006;34:166-72.

23 Boratav C. The Boratav Depression Screening Scale (Bordepta): A Sensitive Scale for Recognizing Depression in Epidemiologic Studies and Primary Health Care. *Turk Psikiyatri Derg.* 2003;14:172-83. PMID:14569468.

24 Taşdelen B, Kanık EA. Sağlık araştırmalarında biyoistatistiksel yöntemlerin doğru kullanımı ve sunumu. *Mersin Üniversitesi Sağlık Bilimleri Dergisi.* 2009;2:1-13.

25 WHO. Obesity and overweight. https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight.

26 Varo JJ, Martínez-González MA, Martínez JA. Obesity prevalence in Europe. *An Sist Sanit Navar.* 2002;25:103. DOI: 10.23938/ASSN.0818. PMID: 12861274.

27 Sağlık Bakanlığı. Türkiye Beslenme Rehberi. https://dosyasb.saglik.gov.tr/Eklenti/10915,tuber-turkiye-beslenme-rehberipdf.pdf. 2015.

28 Solymoss BC, Bourassa MG, Lespérance J, et al. Incidence and clinical characteristics of the metabolic syndrome in patients with coronary artery disease. *Coron Artery Dis.* 2003;14:207-12. DOI:10.1097/01.mca.0000065744.52558.9f. PMID:12702923.

29 Zhang Y, Shi L, Mei H, et al. Inflamed macrophage microvesicles induce insulin resistance in human adipocytes. *Nutr Metab.* 2015;12:21. DOI:10.1186/s12986-015-0016-3.

30 Vanlint S. Vitamin D and obesity. *Nutrients.* 2013;5:949-56. DOI:10.3390/nu5030949. PMID:23519290.

31 Engelsen O, Brustad M, Aksnes L, et al. Daily duration of vitamin D synthesis in human skin with relation to latitude, total ozone, altitude, ground cover, aerosols and cloud thickness. *Photochem Photobiol.* 2005;81:1287-90. DOI:10.1562/2004-11-19-RN-375. PMID:16354110.

32 Institute of Medicine (US) Standing Committee on the Scientific Evaluation of Dietary Reference Intakes. Dietary reference intakes. National Academies Press (US); 1997.

33 Lackey DE, Lazaro RG, Li p, et al. The role of dietary fat in obesity-induced insulin resistance. *Am J Physiol Endocrinol Metab.* 2016;311:989-97. DOI:10.1152/ajpendo.00323.2016. PMID:27802965.

34 Susilowati N, Hanim D, Dewi YLR. Body mass index of schizophrenic patients with combined antipsychotic therapy. *Int J Nutr Sci.* 2020;5:7-12. DOI:10.30476/IJNS.2020.84313.1045.

35 Resch M, Haasz P, Sido Z. Obesity as psychosomatic disease. *European Psychiatry.* 1998;13:315. DOI:10.1016/S0924-9338(99)80652-X.

36 Britz B, Siegfried W, Ziegler A, et al. Rates of psychiatric disorders in a clinical study group of adolescents with extreme obesity and in obese adolescents ascertained via a population based study. *Int J Obes Relat Metab Disord.* 2000;24:1707-14. DOI: 10.1038/sj.ijo.0801449. PMID:11126229.

37 Erdoğan İ, Eryürek S, Ünübol H. Examınatıon Of The Relatıonshıp Between Socıal Appearence Anxıety And Eatıng Attıtude Of Unıversıty Students. *Int J Social Sci.* 2019;2:85-94.

38 Marcus MD, Wildes JE. Obesity: is it a mental disorder? *Int J Eat Disord.* 2009;42:739-53. DOI:10.1002/eat.20725. PMID:19610015.

39 Petry NM, Barry D, Pietrzak RH, et al. Overweight and obesity are associated with psychiatric disorders: results from the National Epidemiologic Survey on Alcohol and Related Conditions. *Psychosom Med.* 2008;70:288-97. DOI: 10.1097/PSY.0b013e3181651651. PMID:18378873.

40 Puhl RM, Brownell KD. Confronting and coping with weight stigma: an investigation of overweight and obese adults. *Obesity.* 2006;14:1802-15. DOI:10.1038/oby.2006.208. PMID:17062811