Original Article Ann Med Res 2023;30(6):650–656

Current issue list available at AnnMedRes

Annals of Medical Research

journal page: www.annalsmedres.org

# The association between vitamin D and body mass index and influential factors

Cetin Ergul[a], Mehmet Gundogdu[a], Emine Esra Ergul[b,*]

[a]*Erzincan Binali Yıldırım University, Mengücek Gazi Training and Research Hospital, Department of Internal Medicine, Erzincan, Türkiye*
[b]*Erzincan Binali Yıldırım University, Mengücek Gazi Training and Research Hospital, Department of Physical Medicine and Rehabilitation, Erzincan, Türkiye*

ARTICLE INFO

**Keywords:**
Body mass index
Vitamin D
Physical activity

Received: Jan 03, 2023
Accepted: Jun 12, 2023
Available Online: 23.06.2023

DOI:
10.5455/annalsmedres.2022.12.387

**Abstract**

**Aim:** A critical health problem that affects people all around the world is vitamin D deficiency. Fundamentally, obesity and vitamin D deficiency are acknowledged as major global public health problem. In this study, we examined the connection between low vitamin D levels and Body Mass Index (BMI), as well as the association between demographic factors and vitamin D.

**Materials and Methods:** 207 participants who were 18 years old or older and had ever been diagnosed with a chronic disease were included in the study. The participants filled out a questionnaire to analyze their demographic characteristics and physical activity levels. As well as evaluating the body mass index, serum vitamin D levels were tested.

**Results:** It was reported that among the study participants, there was a substantial positive association between levels of physical activity and vitamin D levels. Vitamin D levels were found to be significantly negatively correlated with participant weight and BMI. Increasing weight and BMI lead to a reduction in vitamin D levels. It was demonstrated that gender, body mass index, physical activity level, marital status, vitamin D-containing food consumption state and consumption amount, vitamin D supplementation state, ways of going to work, daily exposure to sunlight, seasonal exposure to sunlight affects vitamin D levels.

**Conclusion:** The study group was found to have very high levels of vitamin D insufficiency and deficiency, and there was a strong association between 25-hydroxy vitamin D3 (25(OH)D3) serum level and physical activity level and BMI.

Copyright © 2023 The author(s) - Available online at www.annalsmedres.org. This is an Open Access article distributed under the terms of Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License.

## Introduction

Numerous studies have demonstrated that vitamin D insufficiency is a global health problem that affects populations globally. Vitamin D deficiency was found to be 51.8% in Turkey [1]. In obese patients, the ratio of adipose tissue is high. Vitamin D has a higher affinity for adipose tissue than other tissues as vitamin D is included in a liposolubl vitamin group. Therefore, vitamin D has a decreased bioavailability. Because of hepatosteatosis, which inhibits the liver's capacity to synthesize 25-hydroxyvitamin D3, vitamin D levels in obese individuals may also be lower [2].

Many scientific studies have recently been conducted in order to demonstrate the cause and effect association between vitamin D deficiency and obesity [3-5]. Scientific research on the connection between vitamin D deficiency and obesity has become more prevalent as a result of the identification of 25(OH)D3 deficiency in obese people [6]. According to some research, metabolic syndrome and obesity may have a hidden cause that is vitamin D deficiency. Reduced insulin secretion, an increase in adipose tissue, and a disorder of the lipid profile are the results that were discovered [5].

Currently, we can state more definitely that vitamin D and obesity are interrelated. There are two different hypotheses regarding this issue. The first point of view is that obesity is likely to cause vitamin D deficiency. Considering the second viewpoint, vitamin D deficiency may be the cause of obesity and prevent weight loss [7]. There are findings showing that obesity causes vitamin D deficiency. Studies have revealed that adipose tissues absorb vitamin D and that with weight loss, adipose tissues release the previously stored vitamin D into the blood circulation in the early stages of weight loss [8]. There is evidence from

*Corresponding author:
*Email address:* esrayilmaz50@hotmail.com (Emine Esra Ergul)

several studies that a vitamin D deficiency leads to obesity. These studies revealed that the level of Vitamin D in serum is invertedly proportional to the Homeostatic Model of Assessment –Insulin Resistance (HOMA-IR). It has been demonstrated that reaching the optimal level of vitamin D in obese individuals may lead to weight loss by increasing insulin sensitivity [9, 10].

Obesity and vitamin D deficiency are among the most serious public health problems in the world and in our country. This study aims to reveal the factors affecting serum vitamin D levels in individuals aged 18 years and older without malignancy, coronary artery disease, chronic renal failure, liver disease, diabetes mellitus (DM) and thyroid disease.

## Materials and Methods

In this cross-sectional study, all patients who applied to the outpatient clinic between October 2018 and March 2019, and meet the inclusion criteria were included in the study. Participants with known malignancy, coronary artery disease, chronic renal failure, diabetes mellitus, liver disease, and thyroid disease were not included in the study. Since all patients were included, no sample size calculation was made. All participants offered full informed consent, and the study was accorded the go-ahead by the local ethics committee (Erzincan Binali Yıldırım University Clinical Research Ethics Committee, Date: 26.09.2018 Decision no: 31/04). The Declaration of Helsinki's principles were respected on performing of all procedures.

The primary measurement is vitamin D and BMI. A questionnaire form was applied to evaluate the physical activities and general characteristics of the participants by measuring their serum vitamin D levels and BMI. In the questionnaire form; participants' age, gender, occupation, way of going to work, educational status, marital status, smoking status, whether they take vitamin D and calcium supplements, daily consumption rates of foods containing vitamin D, sunlight exposure hours intervals and hours, their current body weight and height, their regular physical activity status, their pregnancy status, the amount of weight they gained during pregnancy and their anthropometric measurements were recorded by questioning. Weight and height measurements of participants; weight and height meter (SECA, Seca GmbH&Co.KG.Germany). Body mass indexes were recorded by dividing the weight by the meters square of the height [Body mass index BMI (kg/m$^2$) = Body weight (kg)/ Height$^2$ (m$^2$)].

Serum vitamin D, blood samples taken into EDTA tube were examined using Agilent Technologies 6460 Triple Quad LC/MS device, with HPLC (high-performance liquid chromatography) and MS (Mass spectrometry) methods. Reference values for vitamin D were evaluated according to the device, and vitamin D above 20 ng/ml was accepted as adequacy.

Physical activity registration form was used to calculate the daily energy (kcal) expenditures of individuals [11]. Physical activities were categorized by considering the physical activity coefficients. (sleeping, lying down, sitting activities, standing activities, brisk walking, cycling, etc. activities, activities such as dancing, etc., activities such as football-basketball, etc.) and the time spent is a total of 24 hours (1440 minutes). The activity factors are1.0 for rest/sleep/lying down, 1.5 for very light activity (Sitting, painting, laboratory, sewing, knitting, ironing, cooking, tabletop play, playing a musical instrument, watching TV), 2.5 for light activity (slow walking, carpentry work, restaurant work, house cleaning, child care, sports such as table tennis, golf), 5 for moderate activity (walking, field work, carrying loads, cycling, skiing, tennis, dancing), 7 for heavy activity (uphill load carrying, climbing, digging by hand, construction work, sports such as basketball, football). It has been paid attention that the time spent is 24 hours in total. The physical activity factor (PAR) was found by multiplying the time spent in physical activity (hours) by the physical activity factor coefficient.

*Statistical analysis*

Descriptive statistics of the data were obtained by using the IBM SPSS 20 (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp.) package program. Number and percentile distributions were used for summarizing categorical variables and mean±standard deviation or median (minimum-maximum) value was used when summarizing continuous variables. Probability sampling method (Simple Random Sampling) was used. The analysis of categorical variables was conducted using the Pearson Chi-square test, but the p value could not be presented because the expected value was below 5 in some cells. When the percentage of cells with an expected value of less than 5 is 25% or less, a Monte Carlo simulation is performed and the p value is presented. Correlation analysis was applied while examining the association between continuous variables. The Kolmogorov-Smirnov test was used to determine whether continuous variables had a normal distribution. When comparing independent groups, Mann Whitney U test was utilized for 2 groups, and Kruskal Wallis test was utilized for 3 or more groups. $P<0.05$ was considered significant in the study.

## Results

The descriptive characteristics of the individuals are summarized in Table 1. Additionally, Vitamin D and calcium supplementation state vitamin D-containing food consumption state, daily and seasonal exposure to sunlight are reported in Table 2. Of the participants, 124 (59.9%) stated that they didn't participate in regular physical activity, 40 (19.3%) stated that they did regular physical activity, 43 (20.8%) sometimes did and sometimes did not. The exercise frequency of the exercisers was 3.03±1.496 days per week, and the average exercise duration was 1.06±0.419 hours. The mean Physical Activity Factor level of the participants was 36.28±6.745.

The mean vitamin D level of the patients was found to be 16.47±9.120 ng/ml. The correlation between the vitamin D levels of the participants and their physical activity level and anthropometric characteristics is presented in Table 3. The participants' vitamin D levels, level of physical activity, and height were found to be positively and significantly correlated with each other. On the other hand, a negative significant association was found between the participants' weight and BMI. Similarly, no significant

**Table 1.** Distribution of descriptive characteristics of the participants in the study.

| Features | Male | | Female | | Total | |
|---|---|---|---|---|---|---|
| | Number | % | Number | % | Number | % |
| Age (year) | | | | | | |
| 19-30 | 21 | 39.6 | 46 | 29.9 | 67 | 32.4 |
| 31-40 | 7 | 13.2 | 32 | 20.8 | 39 | 18.8 |
| 41-50 | 7 | 13.2 | 35 | 22.7 | 42 | 20.3 |
| 51 years and old | 18 | 34.0 | 41 | 26.6 | 59 | 28.5 |
| Gender | | | | | | |
| Female | | | | | 154 | 74.4 |
| Male | | | | | 53 | 25.6 |
| Marital status | | | | | | |
| Married | 33 | 62.3 | 106 | 68.8 | 139 | 67.1 |
| Single | 20 | 37.7 | 48 | 31.2 | 68 | 32.9 |
| Profession | | | | | | |
| Office clerk | 41 | 77.4 | 52 | 33.8 | 93 | 44.9 |
| Field, garden work | 11 | 20.8 | 3 | 1.9 | 14 | 6.8 |
| Housewife | 1 | 1.9 | 99 | 64.3 | 100 | 48.3 |
| Educational status | | | | | | |
| Primary school | 10 | 18.9 | 68 | 44.2 | 78 | 37.7 |
| Middle school | 3 | 5.7 | 19 | 12.3 | 22 | 10.6 |
| High school | 19 | 35.8 | 25 | 16.2 | 44 | 21.3 |
| University | 20 | 37.7 | 38 | 24.7 | 58 | 28.0 |
| Master's/PhD | 1 | 1.9 | 4 | 2.6 | 5 | 2.4 |
| Way of going to work | | | | | | |
| On foot | 10 | 19.2 | 11 | 19.3 | 21 | 19.3 |
| By private vehicle | 16 | 30.8 | 13 | 22.8 | 29 | 26.6 |
| Public transport | 13 | 25.0 | 23 | 40.4 | 36 | 33.0 |
| Sometimes by car, sometimes on foot | 13 | 25.0 | 10 | 17.5 | 23 | 21.1 |
| | Mean±SD | | Mean±SD | | Mean±SD | |
| Age | 41.49±18.196 | | 39.40±13.248 | | 39.93±14.655 | |
| Pregnancy count * | | | 3.0(1-7) | | | |

*presented as the median (minimum-maximum) value. SD: Standard deviation.

correlation was found between Vitamin D levels and age groups when compared according to age groups (p: 0.790). Similarly, no relation was found between age groups and physical activity level (p: 0.094).

It was determined that vitamin D levels and the physical activity levels of the men participating in the study had a higher mean score than the female patients, and the difference between them was statistically significant ($p<0.001$). When marital status and physical activity and vitamin D levels were compared; there was no statistically significant difference between marital status and physical activity levels ($p=0.159$). Otherwise, the vitamin D levels of the married patients were found to be greater than those of the single patients, and this difference was found to be statistically significant ($p=0.046$). Although the occupations of the participants and their vitamin D levels were unrelated ($p=0.103$), the level of physical activity was found to be low and significant in housewives ($p=0.004$).

Vitamin D levels and the physical activity of the individuals were revealed regardless of their educational status ($p>0.05$).

The participants who traveled to work using public trans-

**Table 2.** Vitamin D and calcium supplementation state, vitamin D-containing food consumption state, daily and seasonal exposure to sunlight.

| Features | Male | | Female | | Total | |
|---|---|---|---|---|---|---|
| | Number | % | Number | % | Number | % |
| Calcium supplementation | | | | | | |
| Yes | - | - | 6 | 3.9 | 6 | 2.9 |
| No | 53 | 100.0 | 148 | 96.1 | 201 | 97.1 |
| Vitamin D supplementation | | | | | | |
| Yes | 2 | 3.8 | 17 | 11.0 | 19 | 9.2 |
| No | 51 | 96.2 | 137 | 89.0 | 188 | 90.8 |
| Vitamin D-containing food consumption | | | | | | |
| Yes | 49 | 92.5 | 122 | 79.2 | 171 | 82.6 |
| No | 4 | 7.5 | 32 | 20.8 | 36 | 17.4 |
| Vitamin D-containing food consumption amount | | | | | | |
| Little | 13 | 26.5 | 54 | 43.5 | 67 | 39.2 |
| Middle | 20 | 40.8 | 60 | 48.4 | 78 | 45.6 |
| A lot | 16 | 32.7 | 10 | 8.1 | 26 | 15.2 |
| Daily exposure to sunlight | | | | | | |
| less than 15 minutes | 18 | 34.0 | 99 | 64.3 | 117 | 56.5 |
| 15-60 minutes | 24 | 45.3 | 42 | 27.3 | 66 | 31.9 |
| more than 60 minutes | 11 | 20.8 | 13 | 8.4 | 24 | 11.6 |
| Exposure to direct sunlight between March 23 and September 23 between 10:00 and 15:00 | | | | | | |
| Yes | 35 | 66.0 | 45 | 29.2 | 80 | 38.6 |
| No | 18 | 34.0 | 109 | 70.8 | 127 | 61.4 |
| Total | 53 | | 154 | | 207 | 100 |

**Table 3.** The correlation between the vitamin D levels of the participants and their physical activity level and anthropometric characteristics.

| | Vitamin D level (ng/ml) | |
|---|---|---|
| | r | p |
| Physical activity level | 0.604 | **<0.001** |
| Weight (kg) | -0.196 | **0.005** |
| Height (cm) | 0.173 | **0.013** |
| BMI (kg/m$^2$) | -0.280 | **<0.001** |

BMI: Body mass index.

**Table 4.** The effect of vitamin D and calcium supplementation state, vitamin D-containing food consumption state, daily and seasonal exposure to sunlight on physical activity and vitamin D levels.

| Features | Physical activity level | Vitamin D level (ng/ml) |
|---|---|---|
| | Mean±SD | Mean±SD |
| Calcium supplementation ** | | |
| Yes | 32.83±8.066 | 12.66±7.850 |
| No | 36.38±6.699 | 16.58±9.148 |
| p value | 0.928 | 0.273 |
| Vitamin D supplementation ** | | |
| Yes | 40.71±9.412 | 23.94±10.878 |
| No | 35.83±6.277 | 15.71±8.603 |
| p value | 0.122 | **0.001** |
| Vitamin D-containing food consumption ** | | |
| Yes | 37.12±6.981 | 18.00±9.170 |
| No | 32.29±3.362 | 9.19±3.898 |
| p value | **<0.001** | **<0.001** |
| Vitamin D-containing food consumption amount * | | |
| Little | 34.32±5.095 | 14.22±6.826 |
| Middle | 37.93±7.378 | 19.20±9.364 |
| A lot | 41.90±6.952 | 24.14±9.834 |
| p value | **<0.001** | **<0.001** |
| Daily exposure to sunlight * | | |
| less than 15 minutes | 33.97±5.000 | 12.90±7.012 |
| 15-60 minutes | 38.04±6.669 | 19.80±8.476 |
| more than 60 minutes | 42.66±8.785 | 24.70±11.262 |
| p value | **<0.001** | **<0.001** |
| Exposure to direct sunlight between March 23 and September 23 between 10:00 and 15:00 ** | | |
| Yes | 39.73±7.84 | 22.12±9.288 |
| No | 34.10±4.844 | 12.91±6.991 |
| p value | **<0.001** | **<0.001** |

* Kruskal Wallis analysis of variance was performed. **Mann Whitney U test was performed. SD: Standard deviation.

portation had statistically significantly lower levels of vitamin D ($p<0.001$).

The effect of vitamin D-containing food consumption state, vitamin D and calcium supplementation state, daily and seasonal exposure to sunlight on physical activity and vitamin D levels are presented in Table 4. Accordingly; daily exposure tu sunlight and exposure to direct sunlight between March 23 and September 23 between 10:00 and 15:00 are significantly associated with both vitamin D levels and physical activity ($p<0.001$).

Serum vitamin D levels vs BMI groups are presented in Table 5. It was found that people with normal body mass index had the highest serum vitamin D levels and there was a statistically significant difference between the groups according to body mass index classification ($p<0.001$).

## Discussion

Vitamin D deficiency has become a very widespread public health problem affecting people of all ages. Despite the fact that the causes differ by society, inadequate nutrient intake and inadequate exposure to sunlight come to the fore [12]. It was determined that 60 (29%) of the patients participating in our study had adequacy vitamin D levels. This demonstrates that vitamin D deficiency is a substantial public health problem in both our area and around the world. Although we considered vitamin D adequacy level as 21 ng/ml and above in our study, the adequacy rate was 29%. AlQuaiz et al. [13] evaluated the vitamin D adequacy rate as 75 nmol/l (~30 ng/ml) and above, while it was 10.5% in men and 17.0% in women. These values, which were also found to be lower in our study, may be related to the higher proficiency level.

After smoking, obesity is the second most common preventable cause of mortality [14]. Ogden et al. [15] discovered a rise in BMI with age in adults, similar to our study. According to the results of the Diabetes, Hypertension, Obesity and Endocrinological Diseases Study-II (TURDEP II) study in Turkey, the prevalence of obesity was found to be 44% in women, 27% in men, and 35% in our society on average. The Eastern Anatolia Region of our country has a lower incidence of obesity than other regions, despite the fact that the prevalence varies little from region to region [16]. The prevalence of obesity (with a BMI of 30 and more) was found to be 29.93% in this study. In our study for the Erzincan region, which is located in the Eastern Anatolia Region, the obesity prevalence was recorded as lower than the results of the TURDEP II study and this may be due to the difference between regions. The prevalence of obesity was 16.98% in men and 34.41% in women. In contrast to our study, a study by Mokdad et al. [17] in the USA revealed that it is 21.0% in men and 20.8% in women. This may be related to the nutritional habits and sociocultural level of women in our country. Future studies are needed to investigate the reasons for this situation.

It is accepted that obesity and vitamin D deficiency are at the forefront of the most important public health problems in the world and in our country. The prevalence of obesity and vitamin D deficiency is observed quite frequently in normal individuals today. Vitamin D deficiency and insufficiency have been found to be associated with chronic diseases, including cardiovascular diseases, infectious and autoimmune diseases, metabolic syndrome, and malignancies in recent studies [18]. It has been demonstrated in numerous studies that 25(OH)D levels are lower in overweight and obese individuals than those with normal body mass index [19, 20]. In our study, it was demonstrated that the patients' vitamin D levels and height had a positive and significant correlation, while the patients' weight and body mass indexes had a negative and significant correlation. As the body mass index of the patients participating in the study increased, vitamin D levels decreased, and a statistically significant association was found between them. As BMI increase and weight, vitamin D levels decrease, and

**Table 5.** Serum Vitamin D levels according to BMI Groups.

| Obesity Classification | BMI (kg/m$^2$) | Mean±SD (ng/ml) | Minimum | Maximum | p* |
|---|---|---|---|---|---|
| Underweight | <18.5 | 12.88±5.57 | 8.60 | 17.17 | |
| Normal | 18.5 - 24.9 | 21.05±10.20 | 18.63 | 23.46 | |
| Overweight | 25.0 - 29.9 | 15.64±8.42 | 13.55 | 17.72 | **<0.001** |
| Obese class 1 | 30.0 – 34.9 | 12.79±6.62 | 10.61 | 14.96 | |
| Obese class II | 35.0 – 39.9 | 12.60±7.43 | 8.48 | 16.71 | |
| Obese class III | $\geq$ 40.0 | 11.95±3.43 | 9.31 | 14.59 | |
| Total | | 16.47±9.12 | 15.22 | 17.72 | |

* Kruskal Wallis analysis of variance was performed. BMI: Body mass index, SD: Standard deviation.

as physical activity levels of patients increase, vitamin D levels increase. In a study conducted by Buffington et al. 60 overweight individuals were recruited and an inversely proportional association was found between body mass indexes and vitamin D levels of these individuals, and these results are similar to our study [21]. It may be possible to interpret these findings in reverse and conclude that weight gain and obesity will decline with vitamin D replacement. Marcotorchino et al. [22] support this in the results of a study; Vitamin D replacement increases fat oxidation by ensuring that the genes involved in fatty acid oxidation and mitochondrial metabolism function properly; revealed that as a result of this, weight gain decreased. Contrary to these studies, however, in the study of Pathak et al., it was revealed that vitamin D replacement did not have a reducing effect on adipose tissue without dietary and calorie restriction in patients who received vitamin D replacement [23]. In this regard, there is a need for prospective studies in which weight monitoring will be observed in patients with vitamin D replacement.

The vitamin D level of 72 (34.8%) of the participants in our study was between 0-10 ng/ml and it was evaluated as vitamin D deficiency. Seventy-five (36.2%) of them had vitamin D levels between 11-20 ng/ml and it was defined as vitamin D deficiency. The sum of the two is 71%, and sixty (29%) of them have vitamin D levels between 21-100 ng/ml and vitamin D was considered adequate. In a study by Pearce et al.; The sum of vitamin D deficiency and vitamin D deficiency in the adult population in the winter and spring seasons in England has been determined as 66% [24]. The greater overall data in our study may be related to dietary habits, dressing preferences, and restrictions on the intake of vitamin D supplements in our country as compared to England, where climatic conditions are more likely to result in vitamin D deficiency. All these data indicate that vitamin D deficiency is at a serious level.

Conditions that lead to the emergence of vitamin D deficiency with aging can be listed as less exposure to sunligt, a decrease in physical activity, a reduction in the vitamin D synthesis capacity of the skin, a reduction in the absorption of vitamin D from the intestines [25]. However, no statistically significant association between age groups and vitamin D levels was discovered in our study. Analyzing vitamin D levels by gender revealed that women's serum levels were much lower than men's, which is consistent with research performed in our nation [1, 26].

The majority of the vitamin D is produced in our skin with the use of sunlight. It is not necessary to take additional vitamin D supplements if the sun's rays are exploited to their full potential. The studies of Akpınar et al. [26] in our country and Holick et al. [27] in the world; It shows that exposing the hands, arms and face to sunlight for 5-15 minutes a day 2-3 times a week provides enough time for the body to synthesize the vitamin D it needs. Despite the fact that our nation is in contact with the sunlight excessively due to its geographical location, the lack of vitamin D levels in our population demonstrate that we do not experience direct sunlight [28]. We revealed that vitamin D levels increase as the duration of sunlight exposure increases, that vitamin D levels reach sufficient levels in people exposed to sunlight for more than 15 minutes, and that people exposed to sunlight for less than 15 minutes have severely low levels of vitamin D. The outcomes are consistent with results from other research [29-31].

The averages of physical activity levels and vitamin D levels of individuals who were exposed to direct sunlight between March 23-September 23 and between 10.00 and 15.00 were found to be higher than those who stated that they were not exposed to direct sunlight. Our study's substantial correlation between vitamin D levels and sun exposure resembles a French study by Chapuy et al [32]. Kull et al. [33] determined that vitamin D deficiency, which was 8% in winter, decreased to 1% in summer.

The physical performance of those with blood 25(OH)D levels <20 ng/ml was also found to be low, and the variation was determined to be significant statistically in a collaborative research by Sohl et al., in which the outcomes of three major research were analyzed [34]. Mesci et al. revealed high physical activity levels in patients with serum 25(OH)D levels above 20 ng/mL [35]. Similarly, in this study, a positive and significant association was revealed between physical activity level and vitamin D levels. It was determined that individuals who maintained higher levels of physical activity had also statistically significantly higher serum vitamin D values.

The level of physical activity levels in the housewives participating in this study were substantially low than the other occupational groups. When the way of going to work and vitamin D levels were compared; It has been determined that the vitamin D levels in the participants who use public transportation while going to work are quite low compared to the patients who walk to work. Since the physical activity levels of those who walk to work will be higher than those who use public transportation, our findings are in line with a research of Mesci et al. [35] that found vitamin D levels rise along with levels of physical activity. We can infer from this study that we need to increase awareness of the need to encourage our patients, if they live nearby, to walk to work. Just this will help the patients' levels of physical activity rise slightly.

Vitamin D levels of the participants who take vitamin D supplements in daily life, who also consume foods containing vitamin D and whose consumption is high, are higher than those who do not take supplements. On the other hand, a research by Sahin et al. [36] that examined the association between a diet high in vitamin D and vitamin D level revealed no significant difference between them. However, since the patients in the study were only women and the number of patients was as low as 54, the results may have been different from this study.

In a Danish-based research by Brot et al. [37] of 510 women aged between 45-58 years; Serum vitamin D levels of smokers were found to be 17.4 ng/mL and non-smokers as 22 ng/mL, and low serum vitamin D levels in smokers were discovered. Serum vitamin D levels of non-smoking male participants were discovered in our study to be significantly greater than those of smoking male participants. However, when we evaluate female patients and all patients participating in the study (without discrimination between men and women); no significant difference was detected.

Okyay et al. [38] demonstrated that obesity rates are higher in married individuals than in single individuals. In our study, similar to the results of this study; BMI of married individuals was found to be significantly higher than singles. It is considered that this condition may be influenced by married people's allegedly diminished sensitivity to weight control.

Bulur et al. [39] compared age with obesity prevalence and revealed that obesity prevalence increased significantly with increasing age. Similarly, we determined that the BMI of the patients participating in the study increased significantly as their age increased. This may be associated with decreased physical activity levels, decreased basal metabolic rate, and comorbid diseases as age progresses.

Dogan et al. [40] evaluated the prevalence of obesity in a certain location in our country as 20.7% in men, 39.8% in women and 31.7% in the general population, and the rate of obesity in women was found to be higher than in men. In our study, unlike this study, the gender of the patients was compared according to the body mass index groups, and no statistically significant difference was found between them. This may be related to the nutritional habits of women in our region and their awareness of obesity, or it may be related to the fact that 77.4% of the male patients in our study were office workers.

## Conclusion

The physical activity status of the participants affects their vitamin D levels, and as the physical activity level of the individuals rises, their vitamin D values also rise. It has been revealed that gender, body mass index, marital status, physical activity level, ways of going to work, vitamin D-containing food consumption state and consumption amount, vitamin D supplementation state, daily exposure to sunlight, seasonal exposure to sunlight affects vitamin D levels.

### *Conflict of interests*

There are no apparent conflicts of interest between the authors' writing this article and publishing it.

### *Funding*

The authors did not receive any funding for the study or writing of this publication.

### *Ethical approval*

The study was accorded the go-ahead by the Erzincan Binali Yıldırım University Clinical Research Ethics Committee, (Date: 26.09.2018 Decision no: 31/04).

## References

1. Uçar F, Taşlıpınar MY, Soydaş AÖ, Özcan N. Ankara etlik ihtisas eğitim ve araştırma hastanesine başvuran hastalarda 25-OH Vitamin D düzeyleri. European Journal of Basic Medical Sciences. 2012;2(1):12-5.
2. Daniel D, Hardigan P, Bray N, Penzell D, et al. The incidence of vitamin D deficiency in the obese: a retrospective chart review. Journal of Community Hospital Internal Medicine Perspectives. 2015;5(1):26069.
3. Parikh SJ, Edelman M, Uwaifo GI, Freedman RJ, Semega-Janneh M, Reynolds J, et al. The relationship between obesity and serum 1, 25-dihydroxy vitamin D concentrations in healthy adults. The Journal of Clinical Endocrinology & Metabolism. 2004;89(3):1196-9.
4. Kremer R, Campbell PP, Reinhardt T, Gilsanz V. Vitamin D status and its relationship to body fat, final height, and peak bone mass in young women. The Journal of clinical endocrinology and metabolism. 2009;94(1):67-73.
5. Aydin M. Vitamin D ve obezite. Turkiye Klinikleri Journal of Pediatric Sciences. 2012;8(2):88-90.
6. Mai X-M, Chen Y, Camargo Jr CA, Langhammer A. Cross-sectional and prospective cohort study of serum 25-hydroxyvitamin D level and obesity in adults: the HUNT study. American Journal of Epidemiology. 2012;175(10):1029-36.
7. Earthman CP, Beckman L, Masodkar K, Sibley S. The link between obesity and low circulating 25-hydroxyvitamin D concentrations: considerations and implications. International Journal of Obesity. 2012;36(3):387.
8. Tzotzas T, Papadopoulou FG, Tziomalos K, Karras S, Gastaris K, Perros P, et al. Rising serum 25-hydroxy-vitamin D levels after weight loss in obese women correlate with improvement in insulin resistance. The Journal of Clinical Endocrinology & Metabolism. 2010;95(9):4251-7.
9. Tosunbayraktar G, Bas M, Kut A, Buyukkaragoz AH. Low serum 25 (OH) D levels are associated to higher BMI and metabolic syndrome parameters in adult subjects in Turkey. African Health Sciences. 2015;15(4):1161-9.
10. Liu E, Meigs JB, Pittas AG, McKeown NM, Economos CD, Booth SL, et al. Plasma 25-hydroxyvitamin D is associated with markers of the insulin resistant phenotype in nondiabetic adults. The Journal of Nutrition. 2008;139(2):329-34.
11. Baysal A, Aksoy M, Bozkurt N, Kutluay Merdol T, Pekcan G, Keçecioğlu S. Diyet El Kitabı. Ankara: Hatipoğlu Yayınevi. 2008;s:145-58.
12. Binkley N, Ramamurthy R, Krueger D. Low vitamin D status: definition, prevalence, consequences, and correction. Endocrinology and Metabolism Clinics. 2010;39(2):287-301.
13. AlQuaiz AM, Kazi A, Fouda M, Alyousefi N. Age and gender differences in the prevalence and correlates of vitamin D deficiency. Archives of Osteoporosis. 2018;13(1):49.
14. Satman I, Yumuk VD, Erem C, Bayram F, Bahçeci M, Araz M, et al. Obezite Tanı ve Tedavi Kılavuzu Türkiye Endokrinoloji ve Metabolizma Derneği. Ankara: Pelin Ofset Matbaacılık Ltd Şti, . 2015;s:11-5.

15. Ogden CL, Fryar CD, Carroll MD, Flegal KM. Mean body weight, height, and body mass index, United States 1960-2002. Advance data. 2004(347):1-17.
16. Satman I, Omer B, Tutuncu Y, Kalaca S, Gedik S, Dinccag N, et al. Twelve-year trends in the prevalence and risk factors of diabetes and prediabetes in Turkish adults. European Journal of Epidemiology. 2013;28(2):169-80.
17. Mokdad AH, Ford ES, Bowman BA, Dietz WH, Vinicor F, Bales VS, et al. Prevalence of obesity, diabetes, and obesity-related health risk factors, 2001. The Journal of the American Medical Association. 2003;289(1):76-9.
18. Hyppönen E, Boucher BJ, Berry DJ, Power C. 25-hydroxyvitamin D, IGF-1, and metabolic syndrome at 45 years of age: a cross-sectional study in the 1958 British Birth Cohort. Diabetes. 2008;57(2):298-305.
19. Ortega RM, Aparicio A, Rodríguez-Rodríguez E, Bermejo LM, Perea JM, López-Sobaler AM, et al. Preliminary data about the influence of vitamin D status on the loss of body fat in young overweight/obese women following two types of hypocaloric diet. British Journal of Nutrition. 2008;100(2):269-72.
20. McGill A, Stewart J, Lithander F, Strick C, Poppitt S. Relationships of low serum vitamin D3 with anthropometry and markers of metabolic syndrome and diabetes in overweightand obesity. Obesity and Metabolism. 2009;6(4):52-3.
21. Buffington C, Walker B, Cowan GS, Scruggs D. Vitamin D deficiency in the morbidly obese. Obesity Surgery. 1993;3(4):421-4.
22. Marcotorchino J, Tourniaire F, Astier J, Karkeni E, Canault M, Amiot M-J, et al. Vitamin D protects against diet-induced obesity by enhancing fatty acid oxidation. The Journal of Nutritional Biochemistry. 2014;25(10):1077-83.
23. Pathak K, Soares M, Calton E, Zhao Y, Hallett J. Vitamin D supplementation and body weight status: a systematic review and meta-analysis of randomized controlled trials. Obesity Reviews. 2014;15(6):528-37.
24. Pearce SH, Cheetham TD. Diagnosis and management of vitamin D deficiency. British Medical Journal. 2010;340:b5664.
25. Griend JPV, Linnebur SA, Ruscin JM, Vondracek SF, Wolfe P, McDermott MT. Vitamin D intervention by pharmacists in geriatric outpatients. Journal of the American Pharmacists Association. 2008;48(4):501-9a.
26. Akpınar P, İçağasıoğlu A. D vitamininin yaşam kalitesi ile ilişkisi. Türk Osteoporoz Dergisi. 2012;18(1):13-8.
27. Holick MF. Vitamin D and bone health. The Journal of Nutrition. 1996;126:1159-64.
28. Bozkaya G, Örmen M, Bilgili S, Aksit M. D Vitamini için Güneşten Yeterince Faydalanıyor muyuz? Türk Klinik Biyokimya Dergisi. 2017;15(1):24-9.
29. Van der Mei IA, Ponsonby A-L, Engelsen O, Pasco JA, McGrath JJ, Eyles DW, et al. The high prevalence of vitamin D insufficiency across Australian populations is only partly explained by season and latitude. Environmental Health Perspectives. 2007;115(8):1132-9.
30. Rucker D, Allan JA, Fick GH, Hanley DA. Vitamin D insufficiency in a population of healthy western Canadians. The Canadian Medical Association Journal. 2002;166(12):1517-24.
31. Patel R, Collins D, Bullock S, Swaminathan R, Blake G, Fogelman I. The effect of season and vitamin D supplementation on bone mineral density in healthy women: a double-masked crossover study. Osteoporosis International. 2001;12(4):319-25.
32. Chapuy M-C, Preziosi P, Maamer M, Arnaud S, Galan P, Hercberg S, et al. Prevalence of vitamin D insufficiency in an adult normal population. Osteoporosis International. 1997;7(5):439-43.
33. Kull M, Kallikorm R, Tamm A, Lember M. Seasonal variance of 25-(OH) vitamin D in the general population of Estonia, a Northern European country. BMC Public Health. 2009;9(1):22.
34. Sohl E, De Jongh R, Heijboer A, Swart K, Brouwer-Brolsma E, Enneman A, et al. Vitamin D status is associated with physical performance: the results of three independent cohorts. Osteoporosis International. 2013;24(1):187-96.
35. Mesci E, Mesci N, İçağasıoğlu A. D vitamini eksikliğinin yorgunluk, gündüz uykululuk hali ve fiziksel aktivite düzeyi ile ilişkisi. Turkish Journal of Physical Medicine & Rehabilitation/Turkiye Fiziksel Tip ve Rehabilitasyon Dergisi. 2016;62(3).
36. Şahin Z, Kumbasar F, Yiğit S, Yaman V, Turhan B, Kartal İ. Kış mevsiminde D vitamini düzeyi üzerine giyim tarzının etkisi. Turkish Journal of Osteoporosis. 2011;17(1):6-9.
37. Brot C, Jørgensen NR, Sørensen OH. The influence of smoking on vitamin D status and calcium metabolism. European Journal of Clinical Nutrition. 1999;53(12):920.
38. Okyay P, Uçku R. İzmir'de kentsel bir bölgedeki doğurgan çağdaki kadınlarda şişmanlık prevalansı ve risk faktörleri. Adnan Menderes Üniversitesi Tıp Fakültesi Dergisi 2002;3(3):5-12.
39. Bulur Ş, Çeçen S, Eren F. Spor fizyolojisi bölümüne fazla kilo yakınması ile başvuran bireylerin antropometrik ve biyokimyasal özellikleri. Adnan Menderes Üniversitesi Tıp Fakültesi Dergisi 2014;15(1):29-35.
40. Doğan N, Toprak D, Demir S. Afyonkarahisar ilinde obezite prevalansı ve ilgili risk faktörleri. Turkiye Klinikleri Journal of Medical Sciences. 2011;31(1):122-32.