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IMPACT OF THE COVID-19 PANDEMIC ON VITAMIN D, BLOOD GLUCOSE, AND LIPID PROFILES IN THE TURKISH POPULATION

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A – study design, **B** – data collection, **C** – statistical analysis, **D** – interpretation of data, **E** – manuscript preparation, **F** – literature review, **G** – sourcing of funding

ABSTRACT

Background: The frequency of 25-hydroxyvitamin D (vitamin D) deficiency may have increased due to less sun exposure during the COVID-19 pandemic. On the contrary, considering the data indicating that vitamin D deficiency increases susceptibility to respiratory tract infections, more people may have chosen to take vitamin D supplements as a precaution during the pandemic.

Aim of the study: To assess how the pandemic affected vitamin D levels, blood glucose levels, and lipid profiles in a Turkish population.

Material and methods: This retrospective single-center study was conducted at a university hospital. Data about age, gender, comorbidities, vitamin D_3, blood glucose, and lipid profiles were obtained from the hospital database. The patients were grouped into pre-pandemic (before 10 March 2020) and pandemic periods (between 10 March 2020 and 10 March 2021) and compared in terms of vitamin D, blood glucose, lipid profile, and other metabolic parameters.

Results: The hospital records of 8,658 patients were examined in this study. Of these, 3,551 (41.0%) were from the pre-pandemic period, and 5,107 (59.0%) were from the pandemic period. Females accounted for 5,980 (69.1%) of the patients, and the mean age was 44.15±16.72. The mean vitamin D level was significantly higher during the pandemic than during the pre-pandemic period ($p<0.001$; 21.30±11.92 ng/mL vs. 19.89±11.33 ng/mL, respectively). There were significant differences between the pre-pandemic and pandemic periods in blood glucose, low-density lipoprotein (LDL), high-density lipoprotein (HDL), and triglycerides ($p<0.05$).

Conclusions: This study determined that vitamin D, blood glucose, LDL, and triglyceride levels increased, while HDL levels decreased, during the COVID-19 pandemic in a Turkish population.

KEYWORDS: blood glucose, COVID-19, lipids, pandemic, vitamin D

Background

25-hydroxyvitamin D (vitamin D) plays a pivotal role in numerous physiological mechanisms that maintain homeostasis in the body. There is an increased susceptibility to respiratory tract infections in cases of vitamin D deficiency [1,2]. Vitamin D exerts anti-inflammatory and antimicrobial properties. A study that previously examined the relationship between vitamin D levels and coronavirus disease 2019 (COVID-19) showed that vitamin D deficiency was more common among patients with

COVID-19 [3]. Although not all studies of the relationship between vitamin D and COVID-19 are consistent, it is thought that vitamin D supplementation can limit the development and severity of COVID-19. Thus, a tendency for more people to consume vitamin D supplements during the COVID-19 pandemic has been observed. As a result, vitamin D levels in the population may have increased during the pandemic period compared to the pre-pandemic period.

On the other hand, outside activities and therefore sun exposure decreased during quarantine, which was implemented to control the spread of the virus. This may have resulted in decreased vitamin D levels. In addition, people may have had problems accessing vitamin D-rich foods due to disruptions in many service sectors, high costs, and unemployment.

Apart from vitamin D, blood glucose regulation and blood lipid concentrations may have been adversely affected due to reasons such as decreased daily activity, increased high carbohydrate snack consumption due to stress and boredom, and disrupted routine hospital visits during the pandemic. One of the comorbidities seen as a risk factor for severe COVID-19 is diabetes mellitus (DM). It has been reported that DM causes an increase in mortality related to acute respiratory distress syndrome in COVID-19 patients [4].

Societies may react differently to the restrictions and stressors of the pandemic. Therefore, countries should research the indirect effects of the pandemic on public health, identify problems caused by the pandemic, and plan preventive actions in their societies. In this study, the effects of the COVID-19 pandemic on vitamin D and other metabolic parameters were investigated in a Turkish population.

Aim of the study

The aim of this study was to evaluate the effect of the COVID-19 pandemic on vitamin D, blood glucose, and lipid profiles in a Turkish population.

Material and methods

Sample

This retrospective, single-center, observational study investigating differences in vitamin D_3 levels and metabolic parameters during the COVID-19 pandemic was performed at Akdeniz University Hospital. As the study was retrospective, it was not possible to obtain written informed consent from the patients.

Patients who presented to the Akdeniz University Medical Faculty Hospital Internal Diseases outpatient clinic between 10.03.2019 and 10.03.2021 and whose vitamin D levels had been measured were included in the study. All of the patients were over 18 years old. The exclusion criteria were as follows: patients with a diabetes diagnosis less than two years earlier; patients using corticosteroids; patients with newly diagnosed hypothyroidism/hyperthyroidism; patients with liver disease or chronic kidney disease; and patients with granulomatous diseases such as tuberculosis and sarcoidosis.

Methods

Data about age, gender, comorbidities, vitamin D, blood glucose, creatinine, LDL, HDL, triglycerides, thyroid-stimulating hormone (TSH), free thyroxine (T4), ferritin, vitamin B12, and hemoglobin levels were obtained from the hospital database. We categorized vitamin D levels as deficient at < 20 ng/ml, low at 21–29 ng/ml, adequate at 30–150 ng/ml, and toxic at > 150 ng/ml. The patients were grouped according to hospital admission dates as pre-pandemic period (before 10 March 2020) and pandemic period (between 10 March 2020 and 10 March 2021), and the listed parameters were compared between groups.

Ethics

Ethical approval for the study was obtained from the Akdeniz University Faculty of Medicine Clinical Research Ethics Committee (decision no: KAEK-559-560, dated: 18.08.2021). The study was conducted according to the principles of the Declaration of Helsinki.

Statistical analysis

Descriptive statistics were presented as numbers and percentages for categorical variables and as mean, standard deviation, and median for continuous variables. The Kolmogorov–Smirnov test was used to check whether the data conformed to a normal distribution. Comparisons between groups were made using the Mann–Whitney U and chi-square tests. Spearman's correlation was used to evaluate the correlation between variables. The statistical analysis was conducted using IBM SPSS Statistics version 23.0 software (IBM Corp., Armonk,

NY, USA). A p-value <0.05 was considered statistically significant.

RESULTS

Descriptive data

The hospital records of 8,658 patients were examined in this study. Of these, 3,551 (41.0%) were from the pre-pandemic period, and 5,107 (59.0%) were from the pandemic period. Females accounted for 5,980 (69.1%) of the patients, and the mean age was 44.15±16.72 (Table 1). The mean vitamin D level was 20.72±11.70 ng/mL (Table 2).

Table 1. Age and gender of the patients

Variables	All patients	Groups	
		Pre-pandemic period	Pandemic period
n (%)	8,658 (100%)	3,551 (41.0%)	5,107 (59.0%)
Gender n (%*)			
Male	2,678 (30.9%)	1,038 (29.2%)	1,640 (32.1%)
Female	5,980 (69.1%)	2,513 (70.8%)	3,467 (67.9%)
Age (Mean±Std)	44.15±16.72	43.76±17.48	44.43±16.16

Gender characteristics of the patients are given as number and percentage.
Age characteristics are given as mean and standard deviation.
* Column percentage was used.

Table 2. Metabolic parameters and vitamin D levels of the patients

Variables	All patients	Groups		p values
		Pre-pandemic period	Pandemic period	
	Ort±Ss (Ortanca)	Ort±Ss (Ortanca)	Ort±Ss (Ortanca)	
25-hydroxyvitamin D3 (ng/mL) (n=8,658)	20.72±11.70 (18.49)	19.89±11.33 (17.73)	21.30±11.92 (18.99)	**<0.001**
Creatinine (mg/dL) (n=7,569)	0.749±0.241 (0.710)	0.745±0.246 (0.710)	0.752±0.238 (0.710)	0.060
LDL (mg/dL) (n=6,045)	122.76±38.01 (120.20)	121.20±38.23 (118.50)	123.68±37.84 (121.10)	**0.010**
HDL (mg/dL) (n=5,186)	50.59±14.24 (48.50)	51.94±14.26 (50.20)	49.67±14.16 (47.50)	**<0.001**
Triglycerides (mg/dL) (n=5,927)	141.65±112.84 (115.00)	130.11±93.28 (107.00)	148.67±122.72 (121.00)	**<0.001**
Glucose (mg/dL) (n=7,053)	95.53±34.42 (87.00)	91.46±30.42 (85.00)	98.01±36.41 (89.00)	**<0.001**
Vitamin B12 (pg/mL) (n=7,667)	355.44±192.48 (313.00)	349.48±191.64 (307.00)	359.44±192.96 (317.00)	**<0.001**
Hemoglobin (g/L) (n=8,056)	13.31±1.74 (13.30)	13.27±1.72 (13.20)	13.33±1.75 (13.30)	0.058
Ferritin (ng/mL) (n=6,829)	51.46±77.36 (27.50)	52.37±71.20 (29.20)	50.84±81.28 (26.50)	**0.001**
TSH (uIU/mL) (n=7,102)	2.16±6.05 (1.62)	2.05±3.33 (1.57)	2.23±7.28 (1.65)	0.055
T4 (ng/dL) (n=6,206)	1.1764±0.2135 (1.1600)	1.1718±0.1925 (1.1600)	1.1794±0.2260 (1.1700)	0.389

HDL: high density lipoprotein; LDL: low density lipoprotein; TSH: thyroid-stimulating hormone; T4: free thyroxine

The parameters of the patients are given as mean±standard deviation and median.
The results of the Mann-Whitney U test, in which the pre-pandemic period and pandemic period values were compared, are given as p-values. Statistically significant results are indicated in bold.

Main outcomes

Effect of the pandemic on vitamin D levels

A statistically significant difference was found for vitamin D levels between the pre-pandemic period and the pandemic period (p<0.05). Vitamin D deficiency was more common during the pre-pandemic period, and the number of patients with adequate vitamin D levels was higher during the pandemic period compared to the pre-pandemic period (Table 3). There was a statistically significant difference in vitamin D levels between the male and female patients (p<0.05). The vitamin D levels of the female patients were lower than those of the male patients in both the pre-pandemic and pandemic periods (Table 4). The vitamin D levels

Table 3. Distribution of patients according to 25-hydroxyvitamin D_3 levels

Vitamin D levels	All patients n (%*)	Groups		p value
		Pre-pandemic period n (%*)	Pandemic period n (%*)	
Deficient	4,887 (56.4%)	2,126 (59.9%)	2,761 (54.1%)	**<0.001**
Inadequate	2,575 (29.7%)	986 (27.8%)	1,589 (31.1%)	
Adequate	1,194 (13.8%)	439 (12.4%)	755 (14.8%)	
Toxic	2 (0.0%)	0 (0.0%)	2 (0.0%)	

Vitamin D levels are given as numbers and percentages.
The results of the chi-square test, in which the pre-pandemic period and pandemic period values were compared, are given as p-values. Statistically significant results are indicated in bold.
* Column percentage is used.

Table 4. Distribution of 25-hydroxyvitamin D_3 levels by gender

Period	Gender	25-hydroxyvitamin D3		p values
		Mean±Std	Median	
Pre-pandemic period	Female (2,513)	19.65±11.83	17.43	**<0.001**
	Male (1,038)	20.49±9.97	18.57	
Pandemic period	Female (3,467)	20.95±12.40	18.53	**<0.001**
	Male (1,640)	22.04±10.79	20.22	
Both periods	Female (5,980)	20.40±12.18	18.05	**<0.001**
	Male (2,678)	21.44±10.50	19.60	

Vitamin D values according to gender are given as mean±standard deviation and median.
Results of the Mann-Whitney U test, in which the values of females and males were compared, are given as p-values. Statistically significant results are indicated in bold.

were significantly higher during the pandemic compared to the pre-pandemic period for both genders.

Effect of the pandemic on blood glucose and lipid profiles

There were statistically significant differences in the blood glucose levels and lipid profiles between the pre-pandemic and pandemic periods ($p<0.05$). HDL levels were lower, while blood glucose, LDL, and triglycerides were higher during the pandemic period compared to the pre-pandemic period (Table 2). There was a negative correlation between triglycerides and vitamin D levels, while age, creatinine, HDL, vitamin B12, hemoglobin, ferritin, and T4 were positively correlated with vitamin D levels (Table 5).

Table 5. Correlation between 25-hydroxyvitamin D3 and other parameters

Variables	r	p*
Age	0.113	**<0.001**
Glucose	0.007	0.564
Creatinine	0.142	**<0.001**
LDL	0.022	0.084
HDL	0.073	**<0.001**
Triglycerides	-0.130	**<0.001**
Vitamin B12	0.191	**<0.001**
Hemoglobin	0.073	**<0.001**
Ferritin	0.096	**<0.001**
TSH	–0.051	**<0.001**
T4	0.154	**<0.001**

HDL: high-density lipoprotein; LDL: low-density lipoprotein; TSH: thyroid-stimulating hormone; T4: free thyroxine

The relationships between the patients' vitamin D values and the other parameters are indicated by the correlation coefficient. The results of the Spearman correlation test, which examined the relationship between the vitamin D values and the other parameters, are given as p-values. Statistically significant results are indicated in bold.

Discussion

This study demonstrated that the mean vitamin D level of the patients was higher in the pandemic period compared to the pre-pandemic period. Vitamin D toxicosis was more common in the pandemic period than in the pre-pandemic period, but it was still quite rare. Only two patients in the pandemic period had toxic vitamin D levels, while there was no vitamin D toxicosis in the pre-pandemic period. Compared to the pre-pandemic period, there were fewer patients with vitamin D deficiency and more

patients with adequate vitamin D levels during the pandemic period. Female patients had lower vitamin D levels than male patients for both the pre-pandemic and pandemic periods. Vitamin B12 levels were higher during the pandemic period than during the pre-pandemic period. This suggests that patients may have taken vitamin D and vitamin B12 supplements during the pandemic period to protect themselves from COVID-19. It was also observed that the pandemic had a negative impact on fasting blood glucose levels and lipid profiles. The patients' fasting blood glucose, LDL, and triglyceride levels were higher during the pandemic than during the pre-pandemic period, while HDL levels were lower during the pandemic period.

Based on the anti-inflammatory and antimicrobial properties of vitamin D, it has been suggested that vitamin D supplementation could protect people from developing COVID-19. A study investigating the relationship between vitamin D levels and COVID-19 infection revealed that vitamin D deficiency is more common in patients with COVID-19 [3]. It has also been suggested that there may be a relationship between vitamin D levels and the severity of COVID-19 [5]. However, a causal relationship between vitamin D and COVID-19 has not yet been established. This is because the low vitamin D levels of patients who develop COVID-19 may actually be a result of COVID-19. In a previous study, vitamin D levels were initially measured in nine healthy volunteers. Then, a polysaccharide obtained from *Escherichia coli* was injected to trigger systemic inflammation; vitamin D levels and simultaneous interleukin 6, interleukin 8, and tumor necrosis factor levels were measured after the injection [6]. It was observed that vitamin D levels decreased and were inversely correlated with elevated inflammatory markers during the peak period of inflammation. They concluded that systemic inflammation reduced vitamin D levels. The low vitamin D levels measured during COVID-19 may be mediated by a similar mechanism.

The low vitamin D levels observed in COVID-19 patients may be cause or effect, but this finding neither proves nor excludes the possible beneficial effects of vitamin D supplementation during or before COVID-19 [7]. Although this issue has not yet been clarified, it has generally been observed that people use vitamin D supplements to protect themselves from COVID-19. However, such widespread and uncontrolled use of a drug can be risky because vitamin D toxicity has potentially serious consequences [8,9]. Vitamin D is known to increase calcium absorption from the gastrointestinal tract, and vitamin D intoxication causes hypercalcemia and hypercalciuria. Although its efficacy against COVID-19 has not yet been proven, intensive use of vitamin D may cause vitamin D toxicosis, which can result in muscle weakness, hypertension, neuropsychiatric disorders, gastrointestinal distress, polyuria, polydipsia, kidney stones, and, in extreme cases, kidney failure. It should also be kept in mind that the accumulation of calcium phosphate crystals in tissues can cause cardiac arrhythmias (low action potential), calcification of coronary vessels and heart valves, and potentially even death. This study found that while there was no vitamin D toxicosis before the pandemic, vitamin D toxicosis developed in two patients during the pandemic period.

Pandemics may cause an increase in the consumption of snacks rich in carbohydrates and a decrease in daily activity. Together, these can result in blood glucose and lipid dysregulation. However, the reaction of a population to the pandemic can vary. A study investigating the effect of lockdowns on patients with type 1 DM determined that blood glucose parameters were not significantly affected despite dietary habits and physical activities being adversely affected [10]. During the pandemic, Spanish patients with type 2 DM increased vegetable consumption and decreased fast food consumption while under quarantine [11]. There was no significant difference in glucose parameters between the pre-pandemic and pandemic periods [12]. In the present study, mean fasting blood glucose and glycated hemoglobin (HbA1c) levels were higher during the pandemic period compared to the pre-pandemic period. The effects of the pandemic on blood glucose may differ depending on whether the patient has DM or not. Furthermore, reactions to the pandemic may differ according to the capability of the population to manage stressors. Since patients with DM are aware they have the disease, they can act more carefully. However, patients who are prone to DM may lose control of their blood glucose regulation during the pandemic.

Inactivity and a high-calorie diet due to stress may have resulted in negatively affected blood lipids during the pandemic period [13]. LDL and triglyceride levels were higher, and HDL levels were lower, during the pandemic compared to the pre-pandemic period.

The findings from this study suggest that the burden of pandemics goes beyond the known direct harm and that attention should be paid to their harmful indirect long-term effects on cardiometabolic health. Given the current COVID-19 pandemic, these findings may inform public health prevention strategies to reduce the impact of future cardiometabolic diseases [14].

Limitations

This study has numerous limitations. The patients who were examined from the pre-pandemic

period may not be the same as those examined during the pandemic. The patients who were considered controls during the pandemic period may have had some health problems. Therefore, there may be differences between the patients in the pre-pandemic period and the pandemic period. Additionally, this study did not assess the factors that may affect a patient's glycemic parameters, such as lifestyle changes during quarantine, adherence to diet, stressors, and access to medications. This information could help us interpret the results with greater certainty.

Conclusions

The pandemic seems to have had a positive effect on the vitamin D levels of the Turkish population. However, vitamin D toxicosis was more common during the pandemic. The pandemic adversely affected the blood glucose levels and lipid profiles of the Turkish population studied. We believe that it is essential to identify the indirect health effects of pandemics. Knowing the secondary effects of the pandemic will enable us to take preventive and corrective actions going forward.

References

1. White JH. Vitamin D signaling, infectious diseases, and regulation of innate immunity. Infect Immun 2008; 76(9): 3837-43.
2. Giustina, A, Adler RA, Binkley N, Bouillon R, Ebeling PR, Lazaretti-Castro M, et al. Controversies in vitamin D: summary statement from an international conference. J. Clin Endocrinol Metab 2019; 104: 234–240.
3. Katz J, Yue S, Xue W. Increased risk for COVID-19 in patients with vitamin D deficiency. Nutrition 2021; 84:111106.
4. Gupta R, Ghosh A, Singh AK, Misra A. Clinical considerations for patients with diabetes in times of COVID-19 epidemic. Diabetes Metab Syndr 2020;14(3): 211-2.
5. Carpagnano GE, Di Lecce V, Quaranta VN, Zito A, Buonamico E, Capozza E, et al. Vitamin D deficiency as a predictor of poor prognosis in patients with acute respiratory failure due to COVID-19. J Endocrinol Invest 2021; 44(4): 765-771.
6. Geven C, van Lier D, Blet A, Peelen R, Ten Elzen B, Mebazaa A, et al. Safety, tolerability and pharmacokinetics/pharmacodynamics of the adrenomedullin antibody adrecizumab in a first-in-human study and during experimental human endotoxaemia in healthy subjects. Br J Clin Pharmacol 2018; 84(9): 2129–41.
7. Pizzini A, Aichner M, Sahanic S, Böhm A, Egger A, Hoermann G, et al. Impact of vitamin D deficiency on COVID-19: a prospective analysis from the COVID registry. Nutrients 2020; 12(9): 2775.
8. Lee JP, Tansey M, Jetton JG, Krasowski MD. Vitamin D Toxicity: A 16-year retrospective study at an academic medical center. Lab Med 2018; 49(2): 123-129.
9. Spiller HA, Good TF, Spiller NE, Aleguas A. Vitamin D exposures reported to US poison centers 2000-2014: temporal trends and outcomes. Hum Exp Toxicol 2016; 35(5): 457-61.
10. Capaldo B, Annuzzi G, Creanza A, Giglio C, De Angelis R, Lupoli R, et al. Blood glucose control during lockdown for COVID-19: CGM metrics in Italian adults with type 1 diabetes. Diabetes Care 2020; 43(8): e88-e89.
11. Ruiz-Roso MB, Knott-Torcal C, Matilla-Escalante DC, Garcimartín A, Sampedro-Nuñez MA, Dávalos A, et al. COVID-19 lockdown and changes of the dietary pattern and physical activity habits in a cohort of patients with type 2 diabetes mellitus. Nutrients 2020; 12(8): 2327.
12. Christoforidis A, Kavoura E, Nemtsa A, Pappa K, Dimitriadou M. Coronavirus lockdown effect on type 1 diabetes management on children wearing insulin pump equipped with continuous glucose monitoring system. Diabetes Res Clin Pract 2020;166:108307.
13. Kemmler W, Schoene D, Kohl M, von Stengel S. Changes in body composition and cardiometabolic health after detraining in older men with osteosarcopenia: 6-month follow-up of the randomized controlled Franconian osteopenia and sarcopenia trial (FrOST) Study. Clin Interv Aging 2021;16: 571-582.
14. De Rubeis V, Lee J, Anwer MS, Yoshida-Montezuma Y, Andreacchi AT, Stone E, et al. Impact of disasters, including pandemics, on cardiometabolic outcomes across the life-course: a systematic review. BMJ Open 2021;11(5): e047152.

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