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DIETARY INTAKE OF VITAMIN D IN ADULTS

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Abstract
Introduction: Vitamin D has several functions in the body. It affects calcium metabolism and various physiological functions, such as immunity, CNS, pregnancy, the cardiovascular system, etc. Its intake is mainly mediated by synthesis in the skin from 7-dehydrocholesterol thanks to UV radiation – specifically UVB with a wavelength of 290–320 nm. Another source of this vitamin is food. This article deals with vitamin D intake from food.
Goal: This paper aims to map the connection between the amount of vitamin D from an adult diet and its level in the blood.
Methods: To determine the level of vitamin D in the blood, we used the daily records of individual respondents according to the amount and type of food consumed for 9 months. During the research, venous blood was taken twice from the respondents to examine calcidiol, calcium, phosphatemia, and alkaline phosphatase levels. The study involved 9 respondents (6 women and 3 men) between 19–28 years, whose diets were monitored for 9 months.
Results: The diet's daily intake of vitamin D corresponded to literature data, i.e., 3.55 µg. Higher intake was found on weekends and lower in the autumn months. A correlation was found between vitamin D and calcium levels. No correlation was found between vitamin D levels and alkaline phosphatase and phosphatemia.
Conclusion: The results show that the intake of vitamin D from food in Czech conditions is sufficient.

Keywords: *Blood level of vitamin D; Dietary intake of vitamin D; Vitamin D*

Abbreviations: ALP – alkaline phosphatase

INTRODUCTION

Vitamin D level, dietary intake

There are two sources of vitamin D for humans. The first and main source is endogenous production. The second source is food. Endogenous synthesis in humans provides approximately 80–90% of the daily vitamin D intake, while the diet provides 10–20% (DACH, 2019).

Sources of vitamin D primarily include fish, meat and meat products, eggs, dairy, some varieties of mushrooms that grow in nature, and recently also vitamin D-fortified foods, which are increasingly appearing on the market (DACH, 2019).

The main effect of vitamin D is partial calcium and phosphorus resorption in the intestine, maintaining the stability of calcium and phosphorus in the body and con-

ORIGINAL ARTICLE

trolling bone mineralisation (Broulík, 2018). These are the so-called skeletal effects. In addition to these skeletal effects, there is a range of D vitamin effects on immunity (Horák, 2021), the cardiovascular system (Anderson et al., 2010), diabetes mellitus (Armstrong et al., 2017), and tooth growth and decay (Beer et al., 2006; Fatturri et al., 2020). Vitamin D's effect on haematology has been dealt with by Gnagnarella et al. (2020). A general overview of the effect of vitamin D on individual systems is provided in the publications by Özdemir (2021) and Spitz (2011). For these reasons, vitamin D is currently classified as a hormone.

The optimal vitamin D level can be evaluated according to the parameters of calcium homeostasis. Suppose the body is deficient in vitamin D. In that case, there is, among other things, reduced resorption of calcium from the intestine, a decrease in its level in the blood, and, subsequently, an increase in the parathyroid hormone level. The limit of 50 nmol/l 25-OHD could be determined based on serum levels of parathyroid hormone and measurement of intestinal calcium resorption when, above a value of 50 nmol/l, the feedback does not increase the level of parathyroid hormone in the serum (Tomíška, 2019). Bouillon et al. (2013) state that higher levels (at least 80 nmol/l) are needed to support natural immunity and the extrarenal effects of vitamin D.

MATERIALS AND METHODS

This research uses a prospective method. Respondents recorded the daily amount and type of food consumed for 9 months. During the research, venous blood was taken twice from the respondents to examine calcidiol, calcium, phosphatemia, and alkaline phosphatase levels.

The research took place between March 1, 2021, and November 30, 2021. Monitoring for 9 months should, among other things, catch sight of seasonal changes in diet composition.

Nine respondents were monitored; 6 women and 3 men aged 19–28. Only people without diseases of the gastrointestinal tract, a malabsorption disorder in idiopathic intestinal inflammation, or celiac disease, which could affect the absorption of vitamin D from the consumed diet, were included in the research. Another criterion was that the respondents had a body mass index (BMI – Body Mass Index) of 18.5–24.9 kg/m², i.e., a regular body weight. The respondents did not know the subject of the monitoring. The diet of all participating respondents was mixed, and none of the respondents deliberately restricted anything from their diet. None of the respondents used dietary supplements or medications containing vitamin D, nor did they take medications affecting vitamin D metabolism (e.g., chronic use of corticoids, anticonvulsants, etc.).

The collection of menu records from the respondents occurred once a week. The Nutriservis Profi food database (2022) and literary sources were mainly used to determine the vitamin D content in foods.

Control blood sampling for all respondents occurred twice during the research. The first sampling took place from 1 to 8 June 2021. The second control sampling took place from 1 to 8 December 2021. The sampling was carried out at the Non-State Health Care Facility in Třeboň. Subsequently, calcidiol was determined in the samples using the IDS (Immunodiagnostic Systems) analyser in the clinical biochemistry laboratory Aeskulab České Budějovice.

All data were processed by the statistical program Statistica. Microsoft Excel was used to calculate medians, standard deviations, and means.

RESULTS

The median intake of vitamin D from the diet of all respondents over the entire follow-up period was 2.27 µg, and the average value of vitamin D intake from the diet of all respondents over the entire follow-up period was 3.55 µg (Table 1).

Chart 1 shows the amount of vitamin D received in the respondents' diet for 3 months

Table 1 – Median and average intake of vitamin D per day from the diet of all respondents for the entire follow-up period

	Median (µg)	Average (µg)
Intake	2.27	3.55

(i.e., March to May). This amount of dietary vitamin D intake was taken before the first blood draw and determination of the calcidiol level.

The chart shows that a higher amount of vitamin D consumed in the diet causes the value of calcidiol in the blood of the respondents to rise.

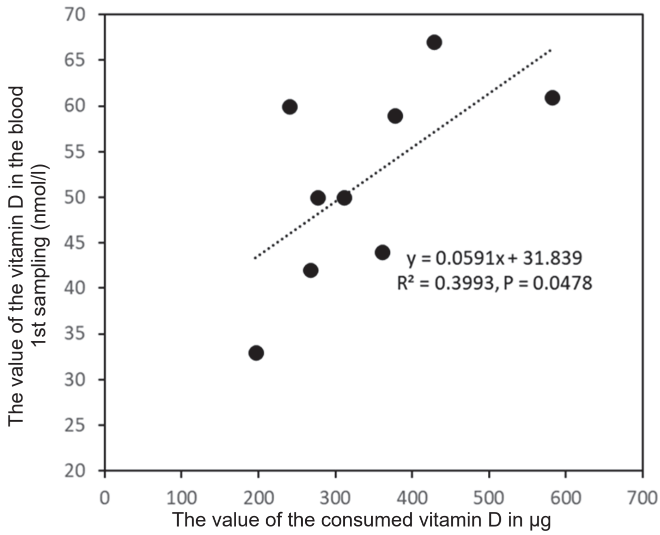

Chart 1 – The value of vitamin D received from the diet before the first sampling in relation to the level of calcidiol in the blood

Chart 2 shows the amount of vitamin D received from the diet for 6 months (i.e., June to November). This amount of dietary vitamin D intake was taken before the second blood draw and determination of the calcidiol level.

The chart shows that the calcidiol in the blood of the respondents increases with a higher amount of vitamin D received from the diet. However, this is not conclusive in this second sampling.

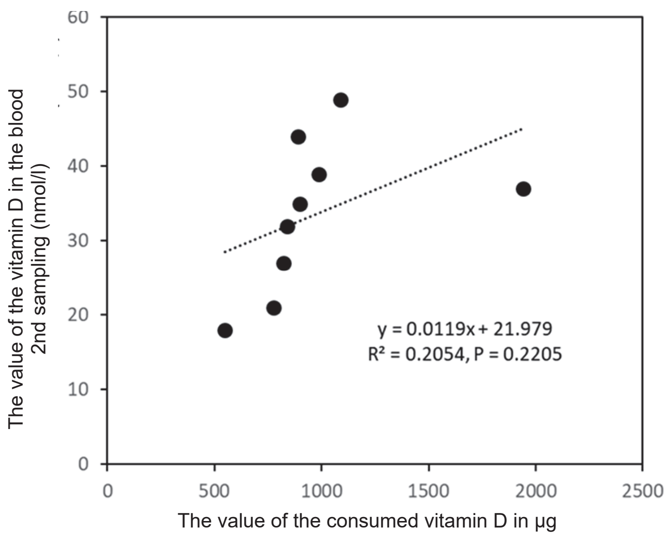

Chart 2 – The value of vitamin D received from the diet before the second sampling in relation to the level of calcidiol in the blood

Chart 3 shows the median values of vitamin D consumed by all respondents for the entire follow-up period (i.e., 9 months) in relation to individual days of the week.

The chart shows that the respondents had a higher amount of vitamin D in their diet on Saturdays and Sundays in comparison to weekdays.

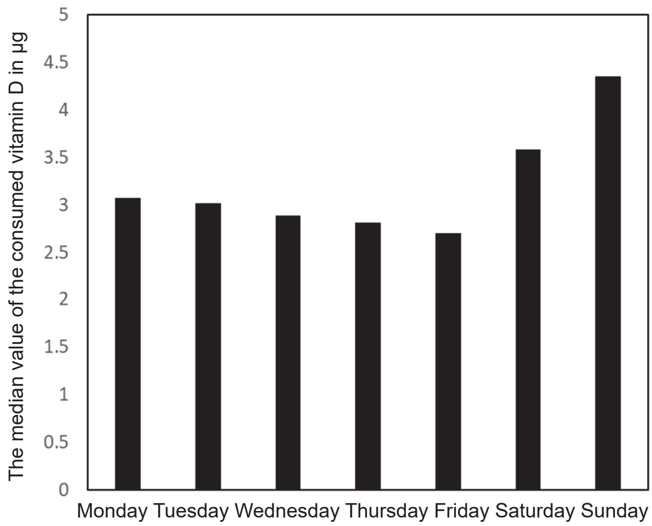

Chart 3 – Median values of vitamin D consumed in the respondents' diet for the entire monitored period concerning individual days of the week

Chart 4 shows the average values of vitamin D consumed by the respondents for the entire follow-up period (i.e., 9 months) in relation to individual days of the week.

This chart also shows that the average intake of vitamin D from the respondents' diet was higher at the weekend.

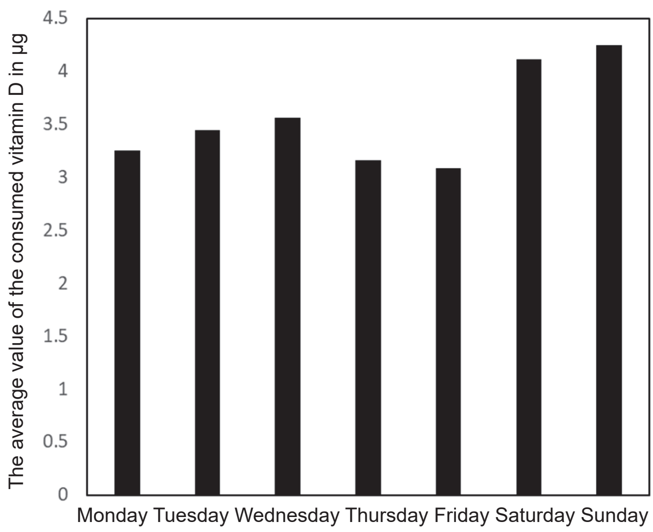

Chart 4 – Average values of vitamin D consumed in the respondents' diet for the entire monitored period in relation to individual days of the week

Chart 5 shows the median vitamin D intake from the respondents' diet combined for individual months for the entire follow-up period (9 months). The chart shows that the respondents receive a significantly lower amount of vitamin D in their diet in the summer months compared to the spring and autumn months.

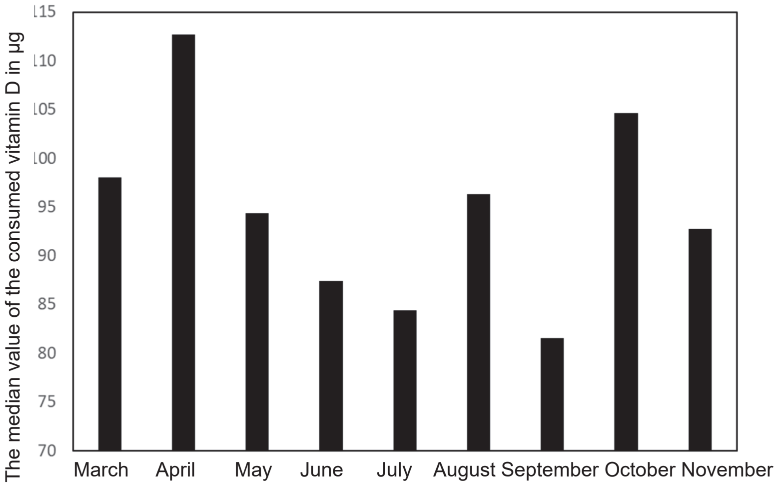

Chart 5 – Median intake of vitamin D received from the diet of all respondents in individual months throughout the monitored period

Chart 6 shows the average vitamin D intake from the diet for all respondents for individual months throughout the follow-up period. As with Chart 5, we can see a lower vitamin D intake from the diet in the summer months, especially in June and July.

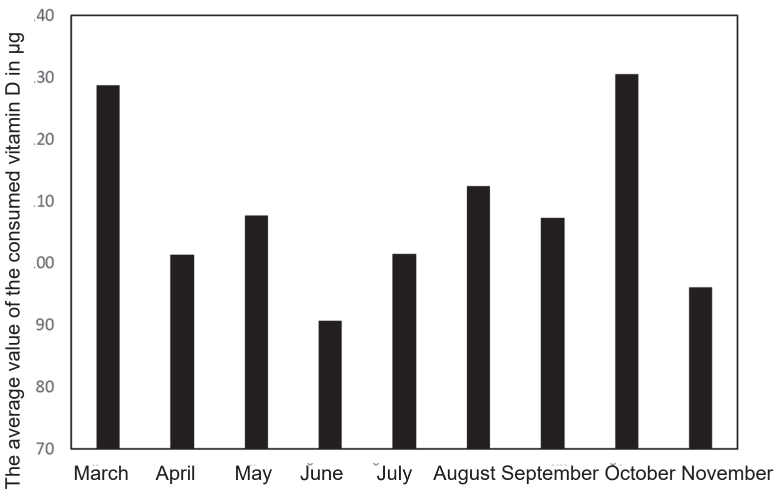

Chart 6 – Average intake of vitamin D received from the diet of all respondents in individual months throughout the monitored period

Chart 7 shows the calcidiol levels in the respondents concerning the serum concentration of alkaline phosphatase at the first blood sampling. Serum ALP concentration does not correlate with calcidiol level.

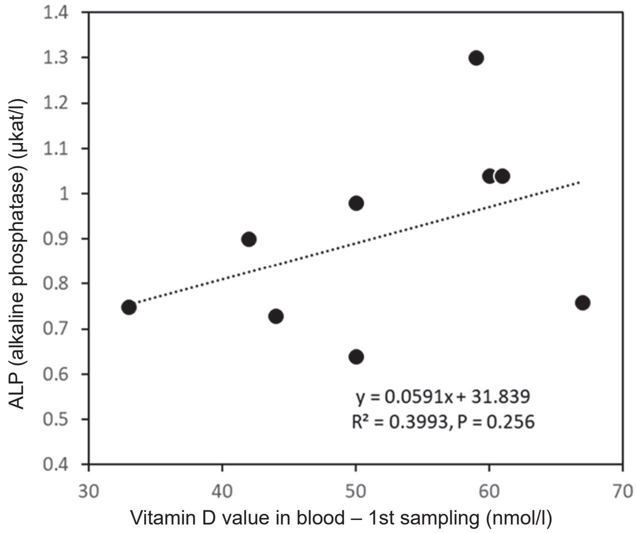

Chart 7 – Blood calcidiol level concerning serum alkaline phosphatase concentration at first blood draw

Chart 8 shows the calcidiol levels in the respondents concerning the serum concentration of ALP at the second blood sampling. Here, too, the ALP concentration in the serum does not correlate with the calcidiol level.

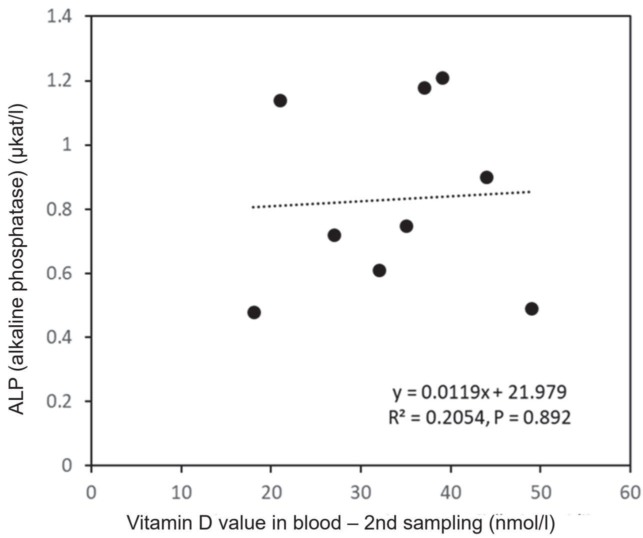

Chart 8 – Blood calcidiol level concerning serum alkaline phosphatase concentration at second blood draw

Chart 9 shows the positive correlation between the calcium concentration in the blood and the calcidiol level at the first blood sampling. This relationship is statistically significant.

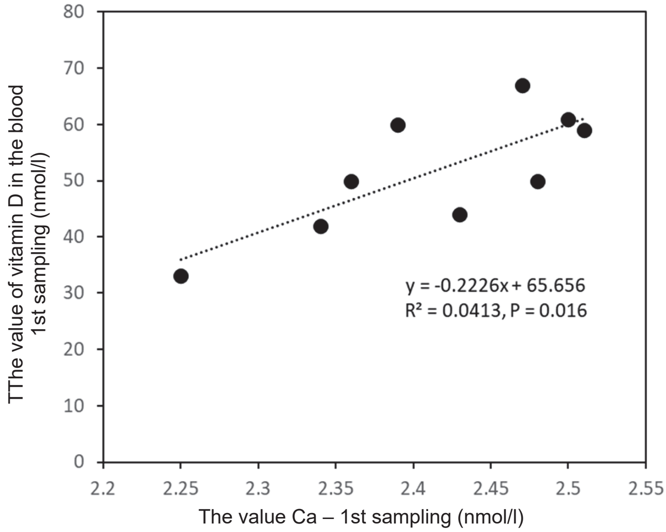

Chart 9 – Blood calcidiol level concerning calcemia at first blood draw

Chart 10 shows the correlation between the level of calcidiol and the concentration of calcium in the blood at the second sampling. There is no longer a statistically significant relationship.

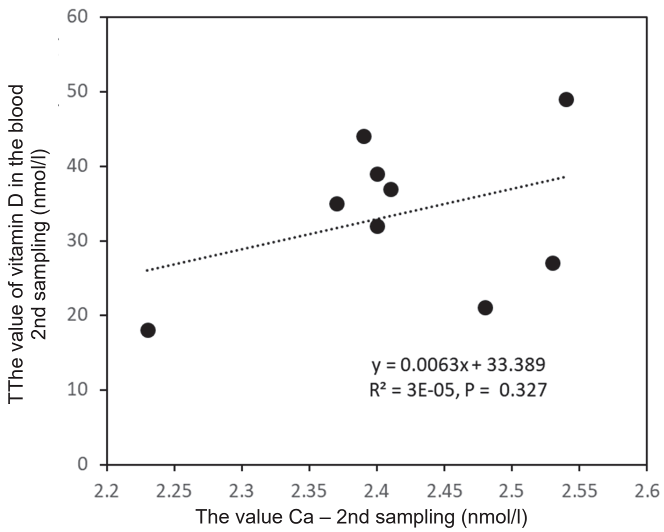

Chart 10 – Blood calcidiol level concerning calcemia at the second blood draw

Chart 11 shows the respondents' blood phosphorus concentration concerning their calcidiol level at the first blood draw. No statistically significant relationship was shown.

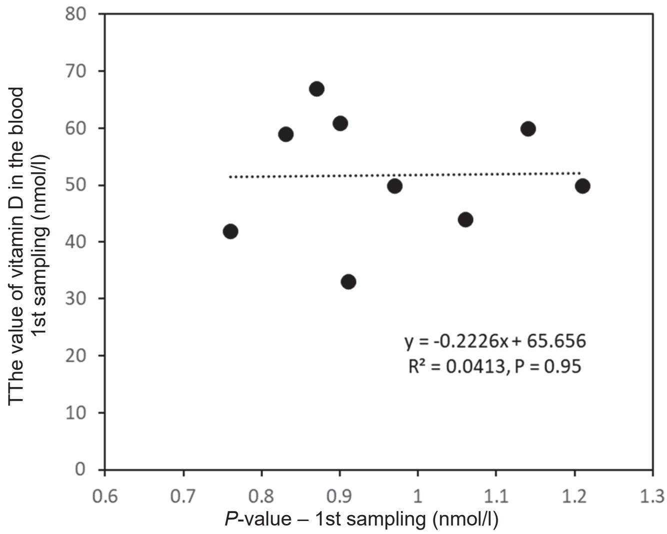

Chart 11 – Blood calcidiol level concerning phosphatemia at first blood draw

Chart 12 shows the respondents' blood phosphorus concentration concerning their calcidiol level at the second blood draw. Here, the calcidiol level tends to be positively correlated with phosphatemia, but the relationship is not statistically significant.

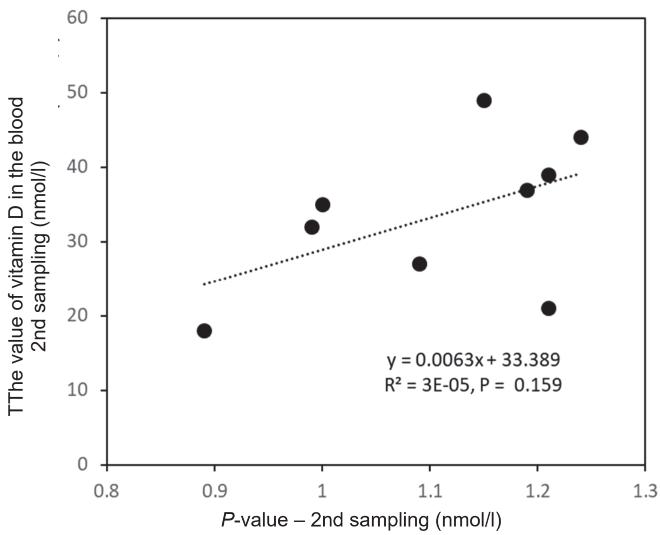

Chart 12 – Blood calcidiol level concerning phosphatemia at the second blood draw

DISCUSSION

Based on the evaluation of the menus, the median vitamin D intake from the diet was calculated at 2.27 μg/day. DACH (2019) reports that, according to the data from the National Study conducted in Germany, the median intake of vitamin D from food was 1.8 μg/day for women aged 15–80 years, and 2.3 μg/day for men of the same age.

In their study, Bescós García and Rodríguez Guisado (2011) evaluated the intake of vitamin D from the diet in the winter months by studying blood calcidiol levels in young athletes. The study found that athletes with calcidiol levels below 50 nmol/l had an average dietary vitamin D intake of approximately 3.475 μg per day. Our study partially proved that respondents who consumed more vitamin D in their diet also had more of it in their blood. The average intake of vitamin D from the diet was very similar among respondents from our research.

Ruprich et al. (2022) mention that the average vitamin D intake from the standard diet in the adult population is 3.6 μg. The average vitamin D intake from the respondents' diet in our research was 3.55 μg/day, almost identical values. The study results reported by González-Rodríguez et al. (2013) showed that 418 respondents aged 18–60 years had a mean vitamin D intake of 3.5 μg/day.

We would attribute the observed relationship of greater intake of vitamin D from the diet in the respondents on the weekend to the fact that the respondents have more time to cook and visit a family/friend for lunch or a restaurant. Also, family celebrations are usually held at the weekend, where dishes and foods rich in vitamin D are often consumed, such as meat, meat products, fish, dishes and foods that contain eggs or dairy products, certainly play a role.

In the COMED Study, which dealt with hospitalised patients with COVID-19 and focused mainly on the level of vitamin D in hospitalised patients and its possible correlation with a lower risk of serious complications (especially mortality), Ruprich et al. (2022) state that high values of calcidiol in the blood (<75 nmol/l) did not lead to a reduction in mortality. Conversely, with very low calcidiol values (<36.7 nmol/l), increased mortality was statistically proven. It is not only this study that demonstrates how vital vitamin D is.

Tláskal et al. (2012) reported that the mean daily dietary intake of vitamin D in younger school children (7–10 years of child age) is 3.43 μg per day (median 1.2 μg/day). In the group of older school children (10–15 years of age), the average daily vitamin D intake is 2.8 μg (median 0.5 μg/day). Interestingly, the average intake of vitamin D from the diet of younger school children aged 7–10 years (3.43 μg/day) is almost identical to the result of the average intake of vitamin D in adult respondents in our research (3.55 μg/day). One might assume that adults eat more food than children and thus consume more vitamin D.

In a study conducted in Japan, Nakamura et al. (2015) reported that the average dietary vitamin D intake of Japanese adults is 352 IU/day (i.e., 8.8 μg/day). In Japan, they, therefore, have more than twice the average daily intake of vitamin D from the diet. This could be related to their higher consumption of fish. Broulík and Broulíková (2013) state that marine fish living freely in the sea contain three times more vitamin D than fish raised in marine farms.

The issue is the possible fortification of other foods, as is required in the European Nordic countries (Tláskal, 2013). While there are such fortified foods on the market, many of them are vegan analogues of common ingredients. Therefore, they are unlikely to become a source of vitamin D in the diet of the wider population. They will be a source mainly for vegans and vegetarians, or people consuming these raw materials and foods. Enriching foods with vitamin D in commonly consumed foods would be one way to increase vitamin D levels without supplementation. The consumption of ordinary, vitamin D-enriched foods would be especially beneficial in the winter, when the endogenous synthesis of vitamin D is insufficient, and the supply through ordinary foods and dishes is low. The question of which foods to enrich and by what amount to ensure that hypervitaminosis D does not occur is appropriate only in case of impaired kidney function.

Tláskal (2013) states that fortifying milk and margarine with vitamin D has been widely introduced in Finland since 2003. He also states that during periods without the influence of sun rays, a person depends on the intake of vitamin D from the diet.

Another question regarding vitamin D may be its optimal supply to the body, with different professional societies stating different target optimal values for vitamin D levels in the blood. Some professional societies indicate an adequate level of calcidiol for optimal supply of vitamin D, starting with a value of 75 nmol/l. Tláskal (2013) also mentions this value in his work.

Conversely, DACH (2019) states a serum calcidiol level of 50 nmol/l as the threshold value for an adequate organism supply.

Although the recommended cut-off levels of calcidiol differ from individual professional societies, there is broad agreement on a serum calcidiol concentration of 50 nmol/l, which should not be lower. Munns et al. (2016) state that a value of 50 nmol/l and higher is considered a sufficient level of vitamin D in the blood.

In this work, the evaluation of vitamin D levels in the blood was based on the criteria stated by DACH (2019).

Calcidiol levels are highest in late summer and lowest at the end of winter and the beginning of spring. This could also be seen in our research respondents; in the summer (at the first blood sampling in June), most respondents had a blood calcidiol level above 50 nmol/l, a value considered sufficient by most professional societies. In the winter (the second blood sampling occurred in December), the respondents' calcidiol levels dropped, some even below 20 nmol/l. It is necessary to remember that the blood was collected at the beginning of December. The level of calcidiol then only decreases in the winter.

Broulík and Broulíková (2013) state that only 50–150 IU/day (i.e., 1.25–3.75 µg/day) can be obtained from the standard diet. Our research respondents exceeded this limit several times on some days if they had fish in their diet that day. However, in our study, the average vitamin D intake from the respondents' diet corresponds to that which the mentioned authors describe in their work.

In our study, the concentration of alkaline phosphatase in the serum of the respondents does not correlate with the blood levels of calcidiol. An increase in the concentration of alkaline phosphatase in the serum occurs as the organism's reaction to a lack of vitamin D or calcium. Here, the increase in ALP with reduced blood calcidiol was not manifested. A possible explanation may be an increase in the serum concentration of ALP only when there is a lack of calcium.

CONCLUSION

It has been proven that with a higher amount of vitamin D consumption from the diet, the value of calcidiol in the respondents' blood increases significantly. The average vitamin D intake from the respondents' diet was higher at the weekends. Respondents receive a significantly lower amount of vitamin D in their diet in the summer compared to the spring and autumn. The relationship between vitamin D, alkaline phosphatase, phosphorus, and calcium levels in the blood has not been demonstrated.

Ethical aspects and conflict of interest

The authors have no conflict of interest to declare.

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