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Original article

Prevalence of vitamin D deficiency in seniors – A retrospective study

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SUMMARY

Background & aims: Vitamin D deficiency is a condition with different causes. It is associated with numerous comorbidities such as autoimmune diseases, bone diseases, cancer, cardiovascular diseases, neurodegenerative diseases, psychiatric diseases, and respiratory infections like COVID-19. Due to its high prevalence all over the world, it is a major task for health care systems worldwide. Through a combination of low sunlight exposure, insufficient nutrition, and age-related changes in skin, liver, and kidney function, especially seniors and nursing home residents, in particular, have a significantly increased risk of developing a vitamin D deficiency.

Methods: This retrospective study analyzed the prevalence of vitamin D deficiency (serum 25-hydroxyvitamin D [25(OH)D] < 12 ng/ml) amongst selected Austrian nursing home seniors. It also examined whether demographic data and other laboratory values like calcium correlate with vitamin D levels by using the Pearson correlation coefficient. This correlation was graphically illustrated with a scatter plot and regression line. A total of 478 patients admitted to a nursing home in Vienna between January 3, 2017, and August 31, 2020, were included.

Results: A total of 106 seniors (22,2%) suffered from a manifest vitamin D deficiency. The vitamin D level of the men was significantly lower than the level of the women (22.9 ± 12.6 ng/ml vs. 26.2 ± 14.8 ng/ml, $p = 0.027$). The vitamin D serum levels significantly correlated with the serum calcium levels of the participants ($r = 0.19$, $p < 0.001$). 39.5% (189 out of 478) of the nursing home residents had inadequate serum vitamin D levels.

Conclusions: In summary, it can be said that the prevalence of vitamin D deficiency among nursing home residents is considerably high. Inadequate vitamin D levels were often associated with reduced calcium levels. Given the high prevalence, the numerous negative health consequences of inadequate levels, and the large therapeutic index, this risk group should get a general supplementation with a dose of 25 μg (1000 IU) vitamin D3 per day. In addition, a blood examination should be performed as early as three months after the start of the supplementation therapy. If some residents do not achieve an adequate vitamin D concentration, the substitution has to be adapted to the individual needs to treat them as precisely as possible.

1. Introduction

More than 100 years ago, it became apparent that an adequate vitamin D supply is essential for bone health and physical development [1]. In addition to the well-known effects on calcium and phosphate metabolism, numerous immunomodulatory properties have also been detected [2]. Therefore, the consequences of a vitamin D deficiency (serum 25-hydroxyvitamin D [25(OH)D] < 12 ng/ml) are extensive, from mineralization disorders with accelerated bone turnover and reduced bone density (osteopenia and osteoporosis) to extra-skeletal consequences such as reduced muscle strength, acute respiratory infections, and even cancer [3–5]. In addition, vitamin D deficiency could also be linked with neurodegenerative diseases, psychiatric disorders, and autoimmune diseases

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such as diabetes mellitus, multiple sclerosis, psoriasis, and rheumatoid arthritis [6–10]. Furthermore, an association between vitamin D levels and the risk of developing cardiovascular disease could also be found [11].

Despite the numerous diseases associated with vitamin D inadequate levels, more than 40% of the European population show insufficient vitamin levels (below 20 ng/ml). Also, more than 13% have an acute deficiency (less than 12 ng/ml) [12]. Especially the elderly often suffer from low vitamin D levels in their blood serum, and several studies have already demonstrated that nursing home residents, particularly, have a significantly increased risk [13]. On the one hand, the concentration of the vitamin D_3 precursor 7-dehydrocholesterol in the blood decreases with advancing age; on the other hand, the ability of the skin to synthesize vitamin D_3 under UV radiation declines. A little sunlight exposure, a poor diet, and age-related changes in the skin, liver, and kidney function predispose this population group to develop a vitamin D deficiency [14]. In addition, medication such as antiepileptics and glucocorticoids can affect the vitamin D status [12].

Due to the increasing life expectancy and demographic changes, geriatric problems will become even more critical in the future. As a result, an increasing prevalence of vitamin D deficiency and its consequences can be expected.

Studies investigating this topic, especially focusing on seniors in care facilities, are rare. Some international studies found very divergent prevalence among retirement home residents. Depending on the study, 16%–98% of the study participants had a serum vitamin D deficiency, with a blood level below 20 ng/ml [13]. Since the numerous negative consequences of a vitamin D deficiency have been known for several decades, current studies and evaluations are required, especially for vulnerable risk groups like nursing home residents.

Due to the described problems, this retrospective study aimed to analyze the prevalence of vitamin D deficiency amongst selected Austrian seniors in a nursing home. In addition, we examined whether demographic data and other laboratory values like serum calcium and phosphate correlate with the vitamin D level. Finally, we discussed if a general supplement therapy should be considered for this at-risk group.

2. Materials and methods

This was a retrospective study with a detailed data analysis. The demographic data (age and sex), the body mass index (BMI), and calcium and phosphate blood values were acquired from January 3, 2017, to August 31, 2020. In this period 542 people were admitted in the Viennese nursing home. 32 residents were excluded because of the young age (<65 years) and 23 persons refused to participate. On the basis of missing data a total amount of 478 participants could be included.

Serum vitamin D (25-hydroxyvitamin D [25(OH)D]) was determined by electro-chemiluminiscence (ECLIA immunoassay, Modular Analytics E170, Roche Diagnostics GmbH, Mannheim, Germany). Fasting venous blood samples were taken and vitamin D analyzed when participants were admitted to the nursing home. Insufficient and deficiency serum levels of vitamin D were determined as values < 20 ng/ml and <12 ng/ml respectively, for both sexes [12].

In order to measure the anthropometric indices a standardized protocol was conducted, which included height measured with a meter scale and weight, measured with an electronic body scale. Body mass index (BMI) was computed as weight in kg/(height in m)2.

2.1. Statistical analysis

Continuous variables were expressed as mean and standard deviation (SD) and categorical variables as the absolute and percentage proportion (with 95% Clopper-Pearson confidence interval). The correlation between vitamin D serum levels and age, BMI, and calcium and phosphate serum levels were studied using the Pearson correlation coefficient. Statistical difference in vitamin D serum levels between sex was tested using the Eta Coefficient test and the Mann–Whitney U test.

In order to identify the percentage of elderly according to categories of vitamin D status (optimal >30 ng/ml; sufficient 20–30 ng/ml; insufficient 12–20 ng/ml; deficiency <12 ng/ml), the absolute and percentage proportion (with 95% Clopper-Pearson confidence interval) was calculated.

SPSS Statistics (Version 27, IBM, New York, USA) was used for all statistical calculations and for creating figures and graphics. Statistical significance was considered a p-value <0.05.

3. Results

The mean age of participants was 83 years old (SD 7.9), with a minimum and maximum age of 65 and 100 years old, respectively. 65.3% were women, and 34.7% were men ($p = 0.027$). The subjects' mean serum vitamin D concentration was 25 ng/ml (SD 14.1, IQR 14.3–34.0) and ranged from 1 to 90.7 ng/ml.

Figure 1 shows that 22.2% (106/478) of the seniors have a vitamin D deficiency. In addition, 17.4% (83/478) had an insufficient vitamin D level. This means that 39.5% [95% CI 0.353, 0.443] (189/478) of the nursing home residents had inadequate levels of vitamin D. 23.9% (114/478) of participants had an adequate vitamin D concentration of 20–30 ng/ml, while an optimal blood level (>30 ng/ml) was found in 36.6% (175/478). High levels of vitamin D in blood (such as intoxication) were not observed.

Table 1 shows the results of the Pearson correlations between the vitamin D concentration and demographic data or other laboratory parameters such as the calcium and phosphate concentration. Statistically significant values are highlighted.

As expected, we could find a statistically significant correlation between the calcium and vitamin D concentration (Pearson correlation coefficient [PC = 0,12 ($p < 0.001$)]. A scatter diagram with a regression line was used to graphically illustrate this relationship (Fig. 2). No statistically significant correlations could be found for age, BMI, and phosphate concentration.

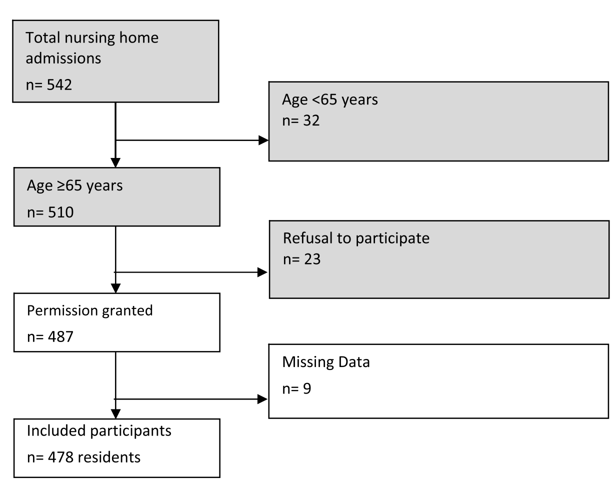

Fig. 1. Flow-chart of patient selection.

Table 1
Summary of the mean values and the correlation results between the selected variables and the vitamin D concentration.

Variable	Mean value ± standard deviation or percent	*r PC*	p-value[a]
Age (years)	83.4 ± 8.0	−0.032	0.48
Gender	312 (65.3%) Men 166 (34.7%) Women	0.112 (Eta)	**0.015**
BMI (kg/m2)	23.1 ± 5.2	0.019	0.73
Calcium (mmol/l)	2.25 ± 0.16	0.19	**0.000034**
Phosphate (mmol/l)	1.09 ± 0.19	0.054	0.25

Reference: PC: Pearson Coeficient, BMI: body mass index.
[a] With the indication of the p-values.

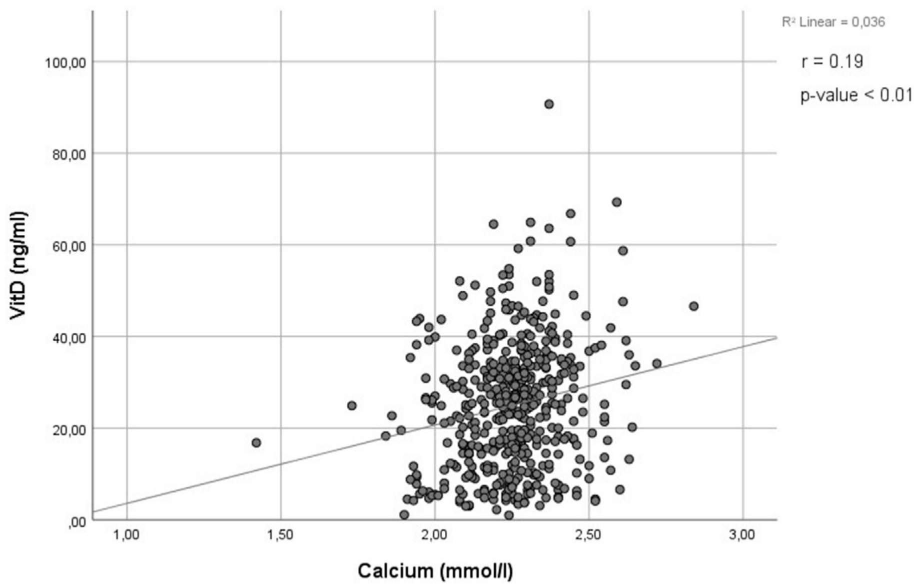

Fig. 2. Categorical classification of vitamin D levels.

The mean value of the serum calcium was 2.25 mmol/l. The majority of the examined nursing home residents (68.6%, 327/477) had a serum calcium concentration within the normal range. However, hypocalcaemia (<2.2 mmol/l) was diagnosed in 31% (148/477), while only two people (0.4%) were affected by hypercalcaemia (>2.65 mmol/l).

Table 2 shows that the mean and the median of the serum vitamin D concentration were higher in women than in men ($p = 0.027$). The mean vitamin D value measured in women was 3.31 ng/ml higher than in men (Fig. 3) (see Fig. 4).

4. Discussion

The primary objective of this study was to determine the prevalence of vitamin D deficiency among seniors in an Austrian nursing home. Our results show that about 4 out of 10 nursing home residents had insufficient serum levels of vitamin D (<20 ng/ml), and over 20% of participants had a manifest vitamin D deficiency (<12 ng/ml).

Table 2
Measured values of the sex-specific vitamin D concentrations of the patients [in ng/ml], p-value = 0.027.

	Min.	Max.	Median	Mean value	SD
Female	1	90.7	25.8	26.2	14.8
Male	2.2	54.8	22.6	22.9	12.6

Although inadequate serum vitamin D levels were high, the percentage of residents with insufficient vitamin D concentration levels (<20 ng/ml) was lower than in the “Vienna Active Aging Study” [15], which included participants of similar age in retirement homes. Moreover, in this study by Franzke et al. [15], a lower median vitamin D concentration was measured (17.6 ng/ml). This could result from the fact that the residents already lived longer in a retirement home than those in our study, as our participants were examined relatively soon after their admission. As a poor sunlight exposure and age-related capacity of the skin to develop vitamin D is well-known in the elderly [16], probably serum levels of vitamin D in those residents already living for some years in a nursing home are lower, as exposure to sunlight is not as regular as a free-living elder.

In the adult population, commonly women show lower values of vitamin D than men [17–19]. Nevertheless, some studies could not find a statistical difference between the sexes [20,21], others have shown that, like in this elderly sample, women tended to have a significantly higher vitamin D mean serum concentration than man [22–25]. In the future, randomized controlled trials and genetic analysis should clarify the mechanism underlying the gender differences in vitamin D deficiency.

Despite the proven high prevalence of vitamin D deficiency in nursing home residents [21], effective strategies for the prevention and treatment have hardly been implemented so far, especially concerning the demographic development, which predicts an immensely growing proportion of the population over 65 years of age. Therefore, an increasing prevalence of vitamin D deficiencies and their consequences can be expected.

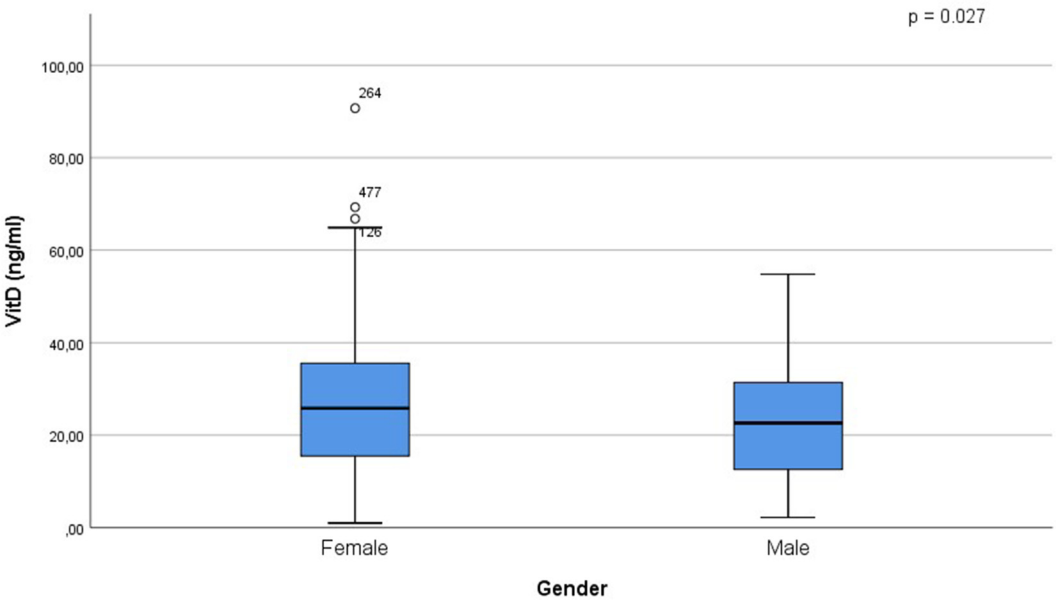

Fig. 3. Correlation between calcium [mmol/l] and vitamin D concentration [ng/ml].

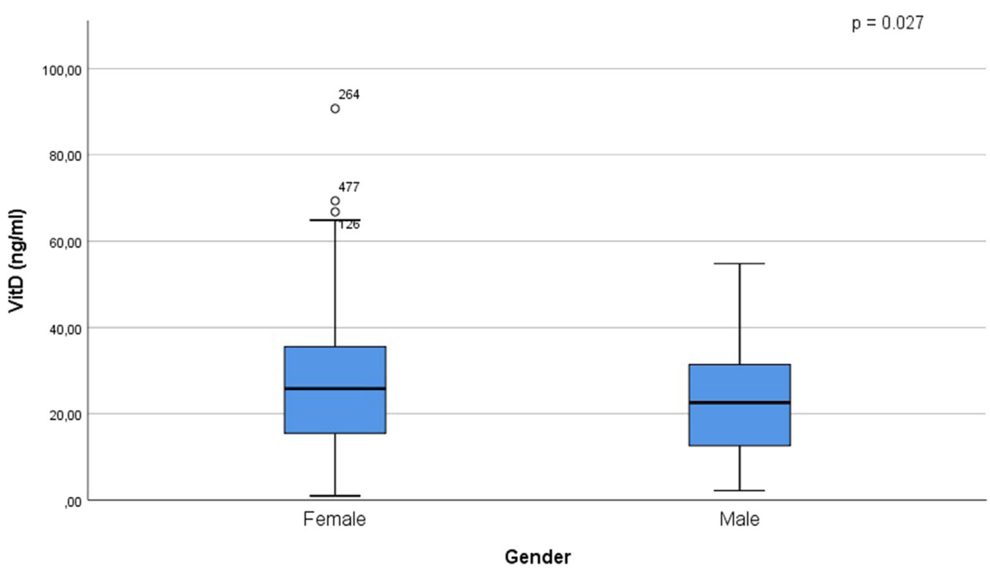

Fig. 4. Boxplot of the mean vitamin D concentration [ng/mL] by gender.

Although the serious consequences of a vitamin D deficiency have been well researched, the risks for nursing home residents are often not recognized, let alone treated. Especially in nursing homes, sufficient preventive and therapeutic countermeasures could be implemented relatively easily [13].

The literature shows that people with lower vitamin D concentration levels are more likely to have hypocalcemia because calcitriol promotes renal tubular and intestinal calcium reabsorption. In this way, calcitriol contributes to sufficient calcium-phosphate products for crystallization in the collagen matrix, and therefore adequate bone mineralization can occur. Consequently, vitamin D deficiency leads to hypocalcemia with mineralization disorders and accelerated bone remodeling, which can lead to osteopathies such as osteopenia and osteoporosis and osteomalacia, and rickets [26].

Due to the numerous negative consequences and the high prevalence of vitamin D deficiency, especially among the elderly, it must be discussed how the deficiency could be detected and treated adequately. As the number of older people in the population continues to increase, the future impact will be momentous. The reduced quality of life of those affected and the resulting considerable costs for the healthcare systems should be taken into account.

One way to increase the vitamin D concentration of the affected risk group is to expand sun exposure. This action can significantly increase the vitamin D level, and in addition, the radiation also leads to a subjective improvement in mental health [27]. Studies have shown that sun exposure in seniors is likely to be an extremely important determinant for the vitamin D serum concentration [28]. Although the required dose and duration of sun exposure are not entirely clear, the available results implicate that seniors should be encouraged to spend more time outdoors. However, it must be noted that residents of retirement homes often suffer from diseases that restrict their mobility and that it would only be possible to increase the sun exposure with great effort by the nursing staff. Particularly during the cold season, the organizational effort poses a major challenge. Finally, the risk of skin cancer from increased sun exposure cannot be ignored.

On the other hand, the serum concentration can slightly be increased by optimizing the diet with few vitamin D-rich foods such as fish, eggs, and mushrooms [29–31]. Since only up to 20% of the vitamin D requirement can be supplied through food, it is hardly possible to achieve vitamin D values over 20 ng/ml through the exclusive consumption of food. Especially considering that over 90% of the population in most European countries consumes less vitamin D than recommended [32]. Appropriate fortification of foods with vitamin D can contribute to addressing the vitamin D inadequate levels; however, only a few countries have implemented this measure mandatory [33]. Diet planning in retirement homes should pay attention to including adequate sources of vitamin D foods (particularly fortified foods), energy intake and other nutrient needs (such as calcium).

For most people, especially the elderly, sunlight exposure and dietary intake are insufficient to achieve an optimal vitamin D concentration. The most effective and quickest way to compensate for a vitamin D deficiency is supplementation [32]. It is still being discussed which prophylactical dosage should be used to prevent a deficiency. National recommendations range from 400 IU (10 μg) to 2000 IU (50 μg) daily [12]. This dose range is considered medically safe so that neither the kidney function nor the calcium concentration has to be monitored regularly. In principle, a daily vitamin D supplementation of 800 IU (20 μg) is enough for most people to achieve at least a calcidiol concentration of 20 ng/ml (50 nmol/l). With a daily dose of 2000 IU (50 μg), values above 30 ng/ml (75 nmol/l) are usually reached [12]. A commonly used supplementation dose is 25 μg (1000 IU) of vitamin D_3 per day, which raises the calcidiol concentrations by an average of 6–10 ng/ml (15–25 nmol/l) over several weeks [12].

Risk groups, such as retirement home residents, should be tested regularly for vitamin D deficiency and treated appropriately [32]. Due to the high prevalence of deficiency states, the numerous positive health effects with adequate levels, and the large therapeutic range, we recommend a general substitution of this risk group with a dose of 25 μg (1000 IU) vitamin D_3 per day should occur. This dosage is effective and below the maximum daily dose of 4000 IU (100 μg) recommended by the Institute of Medicine and the European Food Safety Authority (EFSA) [34,35]. Since this dosage is not associated with an increased risk of side effects or intoxications, the treatment should start on the day of admission for all home residents and continue throughout their stay. As a result of the higher effectiveness and lower side effect rates, daily or weekly supplementation must be preferred to vitamin D bolus administration [4,32].

The retrospective character and the monocentric design as well as the restricted number of subjects are the limiting factors of this study. Although our in- and exclusion criteria aimed at getting a homogenous sample of elderly people, the advanced age of our participants led to a broad standard deviation in most of our parameters by nature. On the other hand, this is one of the strengths of the study because our findings reflect the broadness of this age group. This is also mirrored in the high number of female participants in this study, as the average age in our study population was around four years older than the average life expectancy for males.

5. Conclusions

In conclusion, it can be summarized that there was a high prevalence of vitamin D deficiency in the examined nursing home residents. The vitamin D serum level significantly correlated with the calcium level of the participants, and females had slightly lower vitamin D concentrations than men.

Given the numerous adverse health consequences and because a vitamin D deficiency can be easily treated, all nursing home residents should get a general supplementation of a dose of 25 μg (1000 IU) vitamin D_3 per day. This dosage is considered safe, and therefore neither the kidney function nor the calcium needs to be monitored regularly. A blood test should be used no earlier than three months after starting the vitamin D supplementation therapy to check whether a sufficient serum concentration has been reached. If this is not the case, the vitamin D substitution must be adapted to individual needs and treated precisely.

In addition, further action is needed to make health workers aware of the high incidence and risks associated with vitamin D deficiency. Further research is required to establish clear, evidence-based guidelines for the prophylaxis, detection, and treatment of vitamin D deficiency in nursing homes.

Ethics approval and consent to participate

The included patients had no direct benefit from this study, but no risk could be expected because it was only a retrospective evaluation of their data. The only possible risk was disclosing sensitive patient data, which was minimized by pseudonymization and access restrictions. On the one hand, the results of this study can serve as a basis for generating hypotheses for further studies, and, on the other hand, possible recommendations for treatment or behavior can result. In the nursing home, obligatory examinations (including blood tests) were carried out regularly; therefore, we did not have to perform additional examinations or blood tests for this retrospective study.

The ethics committee of the Medical University of Vienna approved this study (number 1486/2021).

Consent for publication

This manuscript does not contain any individual person's data in any form.

Availability of data and materials

Data are available from the corresponding author on reasonable request.

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Limitations

The retrospective character and the monocentric design as well as the restricted number of subjects are the limiting factors of this study. Although our in- and exclusion criteria aimed at getting a homogenous sample of elderly people, the advanced age of our participants led to a broad standard deviation in most of our parameters by nature. On the other hand, this is one of the strengths of the study because our findings reflect the broadness of this age group. This is also mirrored in the high number of female participants in this study, as the average age in our study population was around four years older than the average life expectancy for males.

Author contributions

Stefan Haitchi: Conceptualization, Methodology, Software, Formal analysis, Interpreting results, Data Curation, Writing - Original Draft, Visualization.

Paula Moliterno: Writing – Review and Editing.

Kurt Widhalm: Conceptualization, Methodology, Validation, Investigation, Resources, Writing - Review & Editing, Supervision, Project administration.

All authors: Critical revision of the manuscript for important intellectual content.

Declaration of competing interest

All authors declare that they have no conflict of interest related to the present study.

Abbreviations

BMI	Body mass index
COVID-19	Coronavirus disease 2019
EFSA	European Food Safety Authority
IU	International Units (1 μg of vitamin D is equal to 40 IU)
IQR	Interquartile range
Min	Minimum
Max	Maximum
SD	Standard deviation
USA	United States of America
UV	Ultraviolet

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