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# Vitamin D deficiency and its associated risk factors in normal adult population of Birjand, Iran

Samaneh Nakhaee [a], Mohammad Ali Yaghoubi [b], Asghar Zarban [c], Alireza Amirabadizadeh [a, *], Vahideh Faghihi [d], Seyed Yoosef Javadmoosavi [e], Homeira Ataei [a], Omid Mehrpour [f]

[a] Medical Toxicology and Drug Abuse Research Center (MTDRC), Birjand University of Medical Sciences, Birjand, Iran
[b] Metabolic Syndrome Research Center, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran
[c] Department of Clinical Biochemistry, Faculty of Medicine, Birjand University of Medical Sciences, Birjand, Iran
[d] Islamic Azad University, Science and Research Branch, Tehran, Iran
[e] Student Research Committee, Birjand University of Medical Sciences, Birjand, Iran
[f] Rocky Mountain Poison and Drug Center, Denver, CO, USA

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SUMMARY

*Background:* Vitamin D is required for calcium absorption, bone growth, and regulation of the immune system. Geographical location determines the intensity of the solar ultraviolet (UV) light as a significant determinant of vitamin D status in the many studies. This study was conducted to determine the status of vitamin D deficiency and its associated factors in adults of Birjand city, Iran (latitude: 32.87; longitude: 59.22).

*Methods:* This descriptive-analytic study was performed by random stratified sampling on 400 subjects over 40 years of age in Birjand, who signed the consent form for participation. Data were collected in winter within one month from eight municipal health centers. Information regarding demographic characteristics, blood pressure, and anthropometric indices were collected, and blood samples were collected to measure 25-hydroxyvitamin D concentration.

*Results:* The mean serum concentration of 25-OHD was 45.4 nmol/L. Twenty-six percent of subjects had vitamin D deficiency, 45.2% had insufficiency, and 28.8% of the subjects were healthy. The results of the multiple logistic regression showed that age (OR: 0.92, 95% CI = 0.89–0.96) and serum calcium concentration (OR: 0.52, 95% CI = 0.28–0.94) had a significant correlation with 25-OHD deficiency.

*Conclusion:* A high percentage of adults in the city of Birjand are suffering from vitamin D deficiency, which implies a need for extensive training and food enrichment programs, promoting healthy lifestyles, and exercise and walking.



## 1. Introduction

Vitamin D is conventionally recognized as an essential nutrient. It is a precursor of a strong steroid hormone that regulates a wide range of physiological processes. This substance regulates calcium and phosphorus homeostasis by exerting an effect on the parathyroid gland, intestines, and bones [1,2]. When vitamin D receptor was discovered in cells of different parts of the body, a new insight emerged about the significance of this vitamin for the body, as in decreasing the risk of autoimmune, cardiovascular, and infectious diseases [3]. The primary sources of vitamin D reception for humans are skin exposure to sunlight and, to a lesser extent, the diet [4].

According to statistics, the deficiency of this vitamin became a pandemic in 2008 [5]. Some studies have shown that vitamin D deficiency ranges from 40% to 100% among American men and women [6]. Persian Gulf countries also have a high prevalence of vitamin D deficiency [7].

* Corresponding author. Medical Toxicology and Drug Abuse Research Center (MTDRC), Birjand University of Medical Sciences (BUMS), Moallem Avenue, Birjand, Iran. Fax: +98 5632381250.
*E-mail address:* amirabadiza921@gmail.com (A. Amirabadizadeh).

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Studies conducted in Iran report different frequencies for vitamin D deficiency in different regions, including 100 and 81 percents for girls and boys in Qazvin and 99.1 and 66.5 percents for girls and boys in Arak, respectively [6,8]. The highest deficiency is in the city of Tehran, and the lowest deficiency belongs to Mashhad [8]. The principal contributors to the deficiency can be the excessive use of sunscreen cream, lack of sunlight, geographic location, diets lacking in sufficient vitamin D, and air pollution [9]. Despite the presence of this vitamin in food, some studies indicate that the young Iranian population does not receive an adequate amount of vitamin D [10]. Given the role of this vitamin in preventing diseases and promoting community health, there is an urgent need to treat and prevent the deficiency of this substance, especially in countries of the Persian Gulf region such as Iran.

Few studies have examined the status of 25-hydroxyvitamin D (OHD) concentration in Birjand. This study aimed to determine the level of vitamin D deficiency and its associated factors in adults in the city of Birjand.

## 2. Materials & methods

In a descriptive-analytic study, 400 subjects over 40 years of age were enrolled. The population of Birjand's comprehensive urban health centers was considered to determine the share of each center. Subsequently, stratified sampling was employed to recruit the participants. Data were gathered in winter within one month from eight municipal health centers in Birjand. Participants were asked to provide information, including demographic characteristics, blood pressure, and anthropometric indices. Blood samples were collected to measure vitamin D, complete blood count, calcium, phosphorus, and iron concentrations.

A nurse practitioner measured blood pressure and performed anthropometric measurements according to pre-set instructions. All the samples were centrifuged, and serums were stored at −20 °C until analyses were made. In this study, complete blood count was performed on EDTA-containing blood, using a Cell Dynamic Hematology Analyzer, following standard measures. The serum was used to determine the amounts of uric acid, creatinine, calcium, phosphorus, and 25-OHD concentration. The blood samples were collected in February.

The measurement was performed using the Selectra automatic machine. The fully automated Roche Cobas E411 system, manufactured in Germany in 2013, was employed to measure serum 25-OHD concentration, using the Electro-Chemi-Luminescence kits (Roche) and Roche Calibrators and controls [11–13]. Amounts smaller than 30 nmol/L (12 ng/ml) of 25-OHD concentration was considered a deficiency. Values between 30–50 nmol/L (12–20 ng/ml) AND those higher than 50 nmol/L (20 ng/mL) were considered as insufficient and normal levels of 25-hydroxyvitamin D concentration, respectively [14,15].

Data analysis was performed in SPSS19 software using descriptive statistical tests including mean and standard deviation. Quantitative variables were analyzed using the Kolmogorov–Smirnov test for normalization. In the case of normality, independent t-test and one-way ANOVA were used. If the data were not distributed normally, Mann–Whitney and Kruskal–Wallis tests were applied. Correlation of variation was investigated using the Pearson and Spearman correlation coefficients. The variables that were significant in the single-variable test were introduced into the multiple logistic regression model, and their association was evaluated.

The measured 25-OHD concentration was defined as the mean of 10, 25, 50, 75, 90, and 95 percentiles with a 95% confidence interval (CI). P values lower than 0.05 were considered statistically significant.

## 3. Results

In this study, 400 individuals were enrolled of whom 212 (55.5%) were female and 179 (44.5%) were male. Their mean age was 53.28 ± 10.02 years (minimum: 40, maximum: 91 years), and their mean BMI was 28.41 ± 5.41 kg/m$^2$ (range: 17.09–52.39 kg/m$^2$). The mean systolic and diastolic blood pressures were 122.68 ± 19.46 and 77.48 ± 11.47 mmHg, respectively. Moreover, 89 (22.1%) had systolic blood pressure ≥140 mmHg and 81 (20.1%) had diastolic blood pressure ≥90 mmHg. The median blood serum 25-OHD level in February was 45.42 nmol/L [25.58–81.37] (Table 1). A total of 115 (26%) individuals had serum 25-OHD deficiency (median 25-OHD: 16.7 nmol/L [IQR: 13.2–19.7]), 181 (45.2%) had insufficiency (median 25-OHD: 40.9 nmol/L [IQR: 32.4–61.9]), and 104 (28.8%) had sufficient 25-OHD (median 25-OHD: 109.3 nmol/L [IQR: 87.8–134.3]). The median serum 25-OHD level was significantly higher in women (i.e., 64.15 nmol/L [24.46–98.84]) compared to men (i.e., 36.69 nmol/L [25.88–64.65]) ($p < 0.001$). Serum 25-OHD correlated significantly with age ($r = 0.28$, $p < 0.001$), weight ($r = -0.17$, $p = 0.001$), and height ($r = -0.22$, $p < 0.001$).

The hematology and biochemistry risk markers were compared between deficient, insufficient, and sufficient groups (Table 2). Based on the results presented in Table 2, individuals who had a serum deficiency of 25-OHD had significantly lower calcium levels (9.25 ± 0.49 vs. 9.31 ± 0.52 vs. 9.43 ± 0.48 mg/dl, $p = 0.02$), and those with insufficiency had significantly higher hemoglobin (14.3 [13.2–15.2] vs. 14.6 [13.6–15.7] vs. 14.0 [13.1–14.75], $p < 0.001$). Iron was higher (87.95 ± 32.11 vs. 88.68 ± 29.24 vs. 86.88 ± 28.4 mg/dl), and phosphorus was lower (4.12 ± 0.55 vs. 4.09 ± 0.49 vs. 4.21 ± 0.57 mg/dl) in the insufficient group without a significant association. Tukey post-hoc analysis showed that age in the sufficient group was significantly higher than in the deficient ($p < 0.001$) and insufficient groups ($p < 0.001$), while there was no significant difference in the deficient and insufficient groups concerning age ($p = 0.57$). Tukey post-hoc test showed that the calcium level was significantly lower in the deficient than in the insufficient group ($p = 0.02$), while there was no significant difference between sufficient group and the insufficient group ($p = 0.08$) or the deficient group ($p = 0.64$) (Table 3).

The data presented in Table 4 display the mean of the 10, 25, 50, 75, 90 and 95 percentiles with the 95% confidence interval (CI). In individuals over 70 years, the mean for 25-OHD was highest, amounting to 93.55 nmol/L. In subjects with a BMI less than 18.5, the mean was 48.9 nmol/L, and subjects with BMI from 18.5 to 24.9 had the highest value amounting to 64.7 nmol/L. The mean 25-OHD level was lower in men than in women (48.4 nmol/L vs. 71.8 nmol/L).

**Table 1**
Descriptive characteristics of the study population.

| Variable | Mean ± SD/Median [IQR] | Minimum | Maximum |
|---|---|---|---|
| Age (years) | 53.28 ± 10.02 | 39 | 91 |
| Weight (kg) | 72.05 ± 14.36 | 40 | 143.5 |
| Height (cm) | 159.43 ± 9.92 | 138 | 186 |
| **Blood pressure** | | | |
| Systolic (mmHg) | 122.68 ± 19.47 | 80.00 | 200.00 |
| Diastolic (mmHg) | 77.48 ± 11.47 | 50.00 | 126.00 |
| **BMI (kg/m$^2$)** | | | |
| Male | 26.85 ± 4.37 | 17.09 | 37.75 |
| Female | 29.65 ± 5.67 | 17.46 | 52.39 |
| Total | 28.41 ± 5.41 | 17.09 | 52.39 |
| **Blood serum 25-OHD (nmol/L)** | | | |
| Male | 36.69 [25.88–64.65] | 9.98 | 346.94 |
| Female | 64.15 [24.46–98.84] | 9.98 | 374.4 |
| Total | 45.42 [25.58–81.37] | 9.98 | 374.4 |

**Table 2**
Descriptive statistics of each variable with deficiency, insufficiency, and sufficient serum 25OHD level.

| Variable | Serum 25-OHD deficiency (<30 nmol/L) | Serum 25OHD insufficiency (30–50 nmol/L) | Serum 25-OHD sufficiency (≥50 nmol/L) | *p*-Value |
|---|---|---|---|---|
| Age (year) | 48.0 [45.0–56.0]# | 50.0 [45.0–57.0] | 55.5 [49.0–65.0] | **<0.001** |
| BMI (kg/m$^2$) | 28.90 ± 5.63† | 28.23 ± 5.26 | 28.27 ± 5.49 | 0.58 |
| SBP (mmHg) | 120.0 [110.0–135.0] | 120.0 [110.0–130.0] | 120.0 [110.0–140.0] | 0.97 |
| DBP (mmHg) | 80.0 [70.0–80.0] | 80.0 [70.0–80.0] | 80.0 [70.–80.0] | 0.48 |
| Hemoglobin (g/dl) | 14.3 [13.2–15.2] | 14.6 [13.6–15.7] | 14.0 [13.1–14.75] | **<0.001** |
| Hematocrit (%) | 41.97 ± 4.21 | 43.13 ± 3.51 | 41.33 ± 3.32 | **<0.001** |
| Platelets (10$^3$/μl) | 238.6 ± 59.7 | 239.7 ± 67.4 | 235.5 ± 66.5 | 0.86 |
| Creatinine (mg/dl) | 1.0 [0.9–1.1] | 1.1 [1.0–1.2] | 1.0 [0.9–1.1] | **0.006** |
| Calcium (mg/dl) | 9.25 ± 0.46 | 9.31 ± 0.52 | 9.43 ± 0.48 | **0.02** |
| Phosphorus (mg/dl) | 4.12 ± 0.55 | 4.09 ± 0.49 | 4.21 ± 0.57 | 0.19 |
| Iron (μ/dl) | 87.95 ± 32.11 | 88.68 ± 29.24 | 86.88 ± 28.40 | 0.87 |

BMI: Body mass index; SBP: Systolic Blood Pressure; DBP: Diastolic blood Pressure; #: Median [IQR]; †: Mean ± SD.
p-value < 0.05 was considered significant.

**Table 3**
Comparison of deficient, insufficient, and sufficient serum 25OHD levels concerning different variables using Tukey comparison test.

| Variable | Comparison | Mean difference | *p*-Value |
|---|---|---|---|
| Age (year) | Deficiency vs. insufficiency | −1.21 | 0.57 |
| | Deficiency vs. sufficiency | −6.95 | **<0.001** |
| | Insufficiency vs. sufficiency | −5.73 | **<0.001** |
| Hemoglobin (g/dl) | Deficiency vs. insufficiency | −0.44 | 0.07 |
| | Deficiency vs. sufficiency | 0.42 | 0.14 |
| | Insufficiency vs. sufficiency | 0.86 | **<0.001** |
| Hematocrit (%) | Deficiency vs. insufficiency | −1.16 | **0.03** |
| | Deficiency vs. sufficiency | 0.64 | 0.41 |
| | Insufficiency vs. sufficiency | 0.43 | **<0.001** |
| Creatinine (mg/dl) | Deficiency vs. insufficiency | −0.07 | **0.01** |
| | Deficiency vs. sufficiency | −0.03 | 0.28 |
| | Insufficiency vs. sufficiency | 0.02 | 0.41 |
| Calcium (mg/dl) | Deficiency vs. insufficiency | −0.05 | 0.64 |
| | Deficiency vs. sufficiency | −0.17 | **0.02** |
| | Insufficiency vs. sufficiency | −0.12 | 0.08 |

p-value < 0.05 was considered significant.

**Table 4**
Vitamin D concentration concerning different variables and proposed means (nmol/L) in Birjand.

| Variable | P10 | P25 | P50 | P75 | P90 | P95 | 95% CI (P95) | Mean |
|---|---|---|---|---|---|---|---|---|
| **Age group** | | | | | | | | |
| 40–55 | 14.8 | 21.9 | 36.9 | 68.5 | 91.1 | 112.7 | 103.0–135.1 | 49.1 |
| 55–70 | 16.6 | 25.9 | 53.3 | 92.0 | 130.0 | 157.1 | 135.7–245.0 | 65.9 |
| ≥70 | 25.5 | 43.2 | 77.1 | 133.0 | 174.12 | 224.8 | 164.8–374.4 | 93.55 |
| **BMI** | | | | | | | | |
| <18.5 | 19.2 | 22.6 | 39.2 | 80.2 | 91.1 | 91.1 | 69.6–91.1 | 48.9 |
| 18.5–24.9 | 17.2 | 28.4 | 38.9 | 82.4 | 126.5 | 185.2 | 129.0–337.3 | 64.7 |
| 25–29.9 | 17.1 | 27.2 | 51.4 | 88.0 | 125.2 | 147.3 | 130.6–168.4 | 62.8 |
| ≥30 | 13.2 | 21.3 | 43.8 | 77.7 | 116.4 | 147.5 | 125.4–210.8 | 57.4 |
| **Gender** | | | | | | | | |
| Male | 18.7 | 25.8 | 36.7 | 65.0 | 91.1 | 114.4 | 95.4–147.6 | 48.4 |
| Female | 13.2 | 25.2 | 64.1 | 98.8 | 138.2 | 173.9 | 151.4–244.4 | 71.8 |

Table 5 shows the results of the multinomial logistic regression model. Based on the multinomial logistic model, age (OR: 0.92, 95% confidence interval = 0.89–0.96) and calcium concentration (OR: 0.52, 95% confidence interval = 0.28–0.94) had significant associations with deficiency. The factors that had a statistically significant association with deficiency were also significantly associated with insufficiency. Moreover, creatinine correlated significantly with insufficiency, but not with deficiency. For instance, the odds ratio for the association between insufficiency and creatinine was OR: 4.05, 95%, confidence interval = 1.02–16.06.

## 4. Discussion

Recent studies have highlighted the critical role played by vitamin D in bone metabolism and extra-skeletal function, such as immune regulation, cancer prevention, and hypertension. The major goal followed in this study was to determine the extent to which vitamin D deficiency is prevalent among adults residing in the city of Birjand. The results showed that the level of vitamin D (25-OHD) deficiency was common in residents of Birjand, where 70.8% of subjects in the study had a 25-OHD level below average (24.2% had a deficiency, and 46.6% had insufficiency). It seems that non-exposure to sunlight, non-intake of vitamin D supplements, or inadequate intake of vitamin D in the diet are among the contributory factors in this deficiency.

Bettencourt et al. (2018) concluded that the mean 25-OHD serum level was 55.4 ± 23.4 nmol/L in the total healthy population of northern Portugal, while 48% of the population had vitamin D insufficiency (less than 50 nmol/L), which raised to 74% in the winter time [16]. Rabenberg et al. (2015) reported that the serum 25-OHD level was less than 50 nmol/L among adults in Germany, especially in winter and spring and at higher latitudes [17]. The study of Hintzpeter et al. (2008) also suggested an outbreak of vitamin D deficiency among the adult population in Germany [18]. In a study of the Canadian adult population, Greene-Firestone et al. (2011) concluded that vitamin D levels were less than 75 nmol/L, especially in obese and non-white people (2011) and that it was commonplace in spring and winter. Vitamin D consumption via diet and supplement and weight control within a healthy range are the key modifiers affecting the level of vitamin D [19].

Gill et al. (2014) also examined the levels of vitamin D in an Australian population and concluded that vitamin D deficiency is

**Table 5**
Multinomial logistic regression analysis.

| Variable | Deficiency OR (95% CI) | *p*-Value | Insufficiency OR (95% CI) | *p*-Value |
|---|---|---|---|---|
| Age (year) | 0.92 (0.89–0.96) | **<0.001** | 0.93 (0.90–0.95) | **<0.001** |
| Hemoglobin (g/dl) | 1.14 (0.81–1.59) | 0.45 | 1.14 (0.85–1.54) | 0.36 |
| Hematocrit (%) | 1.06 (0.91–1.24) | 0.44 | 1.14 (0.99–1.30) | 0.05 |
| Creatinine (mg/dl) | 0.66 (0.12–3.79) | 0.64 | 4.05 (1.02–16.06) | **0.04** |
| Calcium (mg/dl) | 0.52 (0.28–0.94) | **0.03** | 0.55 (0.32–0.93) | **0.03** |

p-value < 0.05 was considered significant.

common in South Australia, affecting nearly a quarter of the population. They enumerated the activity level, obesity, and season as factors influencing vitamin D status [20]. Brouwer-Brolsma et al. (2016) also reported a 45% rate of 25-OHD deficiency [21]. All of these reports are consistent with the results of our study.

The mean serum level of 25-OHD was 64.15 nmol/L in women and 36.69 nmol/L in men, indicating a higher level in women than in men According to the studies conducted in the cities of Tehran, Tabriz, Mashhad, Shiraz, and Bushehr, both sexes have been shown, especially those above 60 years, to suffer from severe vitamin D deficiency [22]. According to the results of this study, the mean serum level of 25-OHD is lower in men than in women because women work in closed environments or because they direct less attention to health recommendations, such as the use of vitamin D supplements and fortified foods.

The results of the current study indicate a deficiency of 25-OHD in both genders, which can be attributed to the lifestyle of individuals. In a study in the United States, based on the national study data in the two periods of 1998–2004 and 2001–2004, the average serum levels of vitamin D was reduced from 74.88 nmol/L to 59.90 nmol/L. Moreover, the prevalence of severe vitamin D deficiency (less than 30 nmol/L) increased from 2% to 6% in the studied population [23]. The prevalence of vitamin D deficiency in the Middle East is higher than in Europe and the United States [24]. It seems that the habit of covering the skin, especially in women, is a crucial contributor to affecting the prevalence of vitamin D deficiency in the Middle Eastern and Islamic countries. Vitamin D deficiency is of a higher prevalence in countries, such as Saudi Arabia, the United Arab Emirates, Jordan, Turkey, and Lebanon, where women's veil prevents from exposure to sunlight [24]. Alongside this, L-Kindi (2011) found a correlation between serum 25-OHD levels and lack of exposure to sunlight ($p < 0.001$) [25].

Daudov et al. (2011) have reported that limited skin exposure to sunlight as the most important determinant of vitamin D status in the studied population [26]. In this study, significant correlations between serum 25-OHD and age ($r = 0.28$, $p < 0.001$), weight ($r = -0.17$, $p = 0.001$), and height ($r = -0.22$, $p < 0.001$) were found. Rabenberg et al. (2015) have mentioned higher BMI and lack of exercise as the factors affecting vitamin D deficiency [17]. Gill et al. (2014) concluded that the average level of 25-OHD was lower in those classified as obese [20]. In the same line, Bettencourt et al. (2018) concluded that serum levels of 25-OHD in obese individuals were significantly lower than in non-obese subjects ($46.6 \pm 17.6$ vs. $24.2 \pm 57.7$ nmol/L, $p = 0.0112$) [16]. It has also been reported that the concentration of 25-OHD, an indicator of the vitamin D status in the body, has a negative relationship with obesity [27,28]. Some studies have, nonetheless, shown that vitamin D precursor levels in obese people are not significantly different from those of non-obese subjects [29,30]. The explanation for obesity to be associated with low vitamin D status is not yet definite.

Other results show that age of the healthy group was significantly higher than the deficient group ($p < 0.001$) and the insufficient group ($p < 0.001$), while there was no significant difference between the age in the deficient and insufficient group ($p = 0.57$). Sherman et al. (1990) concluded that asymptomatic PTH serum levels of over 35% were significantly increased in both sexes at any age ($p < 0.005$). Moreover, in healthy subjects, serum vitamin D levels were not consistent with increased age [31], which is consistent with our findings given the higher age in the normal vitamin D group in a healthy population.

In the end, our results showed that those with a serum deficiency of 25-OHD have considerably lower serum calcium concentration. In subjects with serum 25-OHD insufficiency, the concentration of hemoglobin and iron were higher, and phosphorus concentration was lower than in other groups.

According to the polynomial logistic model, the two factors of age and serum calcium concentration had a significant correlation with 25-OHD deficiency. Unfortunately, limited studies have been conducted to investigate how these factors correlate with the 25-OHD level. In one study, Lips (2012) concluded that high calcium intake increases the half-life of 25-OHD. These results suggest a relationship between calcium and 25-OHD [32].

Sherman et al. (1990) concluded that serum phosphorus, ionized calcium, and total calcium concentration remain constant with age in women. However, they reported that in men, phosphorus decreased along with age by about 25% ($r = -0.564$; $p < 0.001$), total and ionized calcium reduced by 4% [31]. In the present study, our results appear justified given the above-average age of our population, the prevalence of vitamin D deficiency in men, the association between lower levels of 25-OHD and lower levels of calcium and phosphorus, and the results of the study by Sherman et al. [31].

## 5. Conclusion

In conclusion, because of the physiological role of vitamin D and various determinants affecting its level as well as the diseases and complications resulting from its deficiency, vitamin D deficiency should undoubtedly be considered as one of the critical health priorities. Alongside this, a few measures can be taken to promote public health. These include the design and implementation of programs for the prevention and control of vitamin D deficiency at the national level, food enrichment programs, promotion of a healthy lifestyle and exercise among the general population, and the use of supplements at the personal level as a cost-effective and easy-to-do strategy.

## Ethical approval

Birjand University of Medical Sciences supported this study (Project No. 4623).

## Authorship contribution

SN, AA, OM, MAY, VF, AZ, SYJ, and HA were responsible for the design and preparation of the manuscript. VF, HA, and AA conducted the data collection. AA designed the study's analytic strategy and helped in the data interpretation. SN, MAY, AA, and OM made substantial contributions in drafting the manuscript and revising it critically for important intellectual content. All authors have read and approved the final version of the manuscript.

## Consent for publication

All authors agreed to the submission and approved the final version of the manuscript.

## Declaration of conflicting interests

The authors declare no potential conflicts of interest concerning the research, authorship, and publication of this article.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.clnesp.2019.04.002.

## References


[1] Gupta A. Vitamin D deficiency in India: prevalence, causalities and interventions. Nutrients 2014;6(2):729–75.
[2] Karonova T, Andreeva A, Nikitina I, Belyaeva O, Mokhova E, Galkina O, et al. Prevalence of Vitamin D deficiency in the North-West region of Russia: a cross-sectional study. J Steroid Biochem Mol Biol 2016;164:230–4.
[3] Moradzadeh K, Keshtkar A, Hossein NA, Rajabian R, Nabipour I, Omrani G, et al. Normal values of vitamin D and prevalence of vitamin D deficiency among Iranian population 2006;10(4):33–43.
[4] Tabrizi R, Moosazadeh M, Akbari M, Dabbaghmanesh MH, Mohamadkhani M, Asemi Z, et al. High prevalence of vitamin d deficiency among Iranian population: a systematic review and meta-analysis. Iran J Med Sci 2018;43(2):125.
[5] Holick MF, Chen TC. Vitamin D deficiency: a worldwide problem with health consequences. Am J Clin Nutr 2008;87(4):1080S–6S.
[6] Zehni K, Ashjaardalan A, Bagherisaweh MI, Rokhzadi MZ. The serum level of 25 hydroxy vitamin D and factors affecting its level among students in Kurdistan University of Medical Sciences in 2015. Sci J Kurdistan Univ Med Sci 2015;20(5):1–10.
[7] Heidarpour R, Moussavi M, Âminorroaya A, Pournaghshband Z, Âmini M. The prevalence of vitamin D deficiency is Isfahani students. J Mazandaran Univ Med Sci 2006;16(51):88–95.
[8] Ghanei L, Jalilolghadr SH, Javadi M, Ghorbani A, Khoeiniha MH. Epidemiology of vitamin D deficiency among 10–18 years old population of Minoodar district, Qazvin (2010). JQUMS 2015;18(6):24–32.
[9] Lips P. Vitamin D status and nutrition in Europe and Asia. J Steroid Biochem Mol Biol 2007;103(3–5):620–5.
[10] Heshmat R, Mohammad K, Majdzadeh S, Forouzanfar M, Bahrami A, Ranjbar Omrani G. Vitamin D deficiency in Iran: a multi-center study among different urban areas. Iran J Public Health 2008;37(Suppl.).
[11] Martins-Costa P, Martins H, Bravo F, Cruz M, Reis J, Oliveira JC. Comparison of automated methods for measurement of 25-hydroxyvitamin D. Clin Lab 2013;59(7–8):885–91.
[12] Abdel-Wareth L, Haq A, Turner A, et al. Total vitamin d assay comparison of the roche diagnostics "vitamin D total" electrochemiluminescence protein binding assay with the chromsystems HPLC method in a population with both D2 and D3 forms of vitamin D. Nutrients 2013;5(3):971–80.
[13] Sebastian A, Vijayaselvi R, Nandeibam Y, Natarajan M, Paul TV, Antonisamy B, et al. A case control study to evaluate the association between primary cesarean section for dystocia and vitamin D deficiency. J Clin Diagn Res 2015;9(9):QC05.
[14] Calvo MS, Lamberg-Allardt CJ. Vitamin D research and public health nutrition: a current perspective. Publ Health Nutr 2017;20(10):1713–7.
[15] Santos A, Amaral TF, Guerra RS, Sousa AS, Álvares L, Moreira P, et al. Vitamin D status and associated factors among Portuguese older adults: results from the Nutrition UP 65 cross-sectional study. BMJ Open 2017;7(6):e016123.
[16] Bettencourt A, Boleixa D, Reis J, Oliveira JC, Mendonça D, Costa PP, et al. Serum 25-hydroxyvitamin D levels in a healthy population from the North of Portugal. J Steroid Biochem Mol Biol 2018;175:97–101.
[17] Rabenberg M, Scheidt-Nave C, Busch MA, Rieckmann N, Hintzpeter B, Mensink GB. Vitamin D status among adults in Germany – results from the German Health Interview and Examination Survey for Adults (DEGS1). BMC Public Health 2015;15(1):641.
[18] Hintzpeter B, Mensink G, Thierfelder W, Müller M, Scheidt-Nave C. Vitamin D status and health correlates among German adults. Eur J Clin Nutr 2008;62(9):1079.
[19] Greene-Finestone L, Berger C, de Groh M, Hanley DA, Hidiroglou N, Sarafin K, et al. 25-Hydroxyvitamin D in Canadian adults: biological, environmental, and behavioral correlates. Osteoporos Int 2011;22(5):1389–99.
[20] Gill TK, Hill CL, Shanahan EM, Taylor AW, Appleton SL, Grant JF, et al. Vitamin D levels in an Australian population. BMC Public Health 2014;14(1):1001.
[21] Brouwer-Brolsma EM, Vaes AM, van der Zwaluw NL, van Wijngaarden JP, Swart KM, Ham AC, et al. Relative importance of summer sun exposure, vitamin D intake, and genes to vitamin D status in Dutch older adults: the B-PROOF study. J Steroid Biochem Mol Biol 2016;164:168–76.
[22] Solanki T, Hyatt R, Kemm J, Hughes E, Cowan R. Are elderly Asians in Britain at a high risk of vitamin D deficiency and osteomalacia? Age Ageing 1995;24(2):103–7.
[23] Ginde AA, Liu MC, Camargo CA. Demographic differences and trends of vitamin D insufficiency in the US population, 1988–2004. Arch Intern Med 2009;169(6):626–32.
[24] Sullivan SS, Rosen CJ, Halteman WA, Chen TC, Holick MF. Adolescent girls in Maine are at risk for vitamin D insufficiency. J Am Diet Assoc 2005;105(6):971–4.
[25] Marwaha RK, Tandon N, Reddy DRH, Aggarwal R, Singh R, Sawhney RC, et al. Vitamin D and bone mineral density status of healthy schoolchildren in northern India. Am J Clin Nutr 2005;82(2):477–82.
[26] Maghboli Z, Hossein Nezhad A, Shafaei A, Karimi F, Mdani FS, Larijani B. Vitamin D status in pregnant women and their newborns. Sci J Kurdistan Univ Med Sci 2006;11(3):64–73.
[27] Liel Y, Ulmer E, Shary J, Hollis BW, Bell NH. Low circulating vitamin D in obesity. Calcif Tissue Int 1988;43(4):199–201.
[28] Arunabh S, Pollack S, Yeh J, Aloia JF. Body fat content and 25-hydroxyvitamin D levels in healthy women. J Clin Endocrinol Metab 2003;88(1):157–61.
[29] Need AG, Morris HA, Horowitz M, Nordin C. Effects of skin thickness, age, body fat, and sunlight on serum 25-hydroxyvitamin D. Am J Clin Nutr 1993;58(6):882–5.
[30] MacLaughlin J, Holick MF. Aging decreases the capacity of human skin to produce vitamin D3. J Clin Investig 1985;76(4):1536–8.
[31] Sherman SS, Hollis BW, Tobin JD. Vitamin D status and related parameters in a healthy population: the effects of age, sex, and season. J Clin Endocrinol Metab 1990;71(2):405–13.
[32] Lips P. Interaction between vitamin D and calcium. Scand J Clin Lab Investig 2012;72(sup243):60–4.