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Pattern of vitamin D deficiency in a Middle Eastern population: A cross-sectional study

DAHAT A. HUSSEIN[1,2], GASHA S. AHMED[3], SHAHO F. AHMED[1], RAWEZH Q. SALIH[1,2], FAHMI H. KAKAMAD[1,2,4], ABDULWAHID M. SALIH[1,4], BNAR J. HAMA AMIN[1], BERUN A. ABDALLA[1,2], SHVAN H. MOHAMMED[2], RIVAN O. SALIM[1], SAWEN E. HAMARAHIM[1], SHAIMA S. HAMID[1], AWARA K. HAMARASHID[1], CHAWAN M. RASHID[1], WAFA A. HAMADAMEEN[1] and KARZAN M. SALIH[1]

[1]Scientific Affair Department, Smart Health Tower; [2]Kscien Organization; [3]College of Health Sciences, Medical Laboratory Science Department, University of Human Development; [4]Department of Surgery, College of Medicine, University of Sulaimani, Sulaimani, Kurdistan 46000, Iraq

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Abstract. Vitamin D is a critical micronutrient required by almost all body tissues. Globally, vitamin D deficiency is highly prevalent to the extent that it is considered a pandemic. The present study aimed to examine the vitamin D status among the healthy population in a specific region. The present study was a cross-sectional study carried out from June, 2021 to January, 2022. A total of 991 apparently healthy individuals of various ages were randomly recruited from various public areas, and their blood samples were obtained. Among the enrolled participants, 582 (58.7%) were male and 409 (41.3%) were female. They had a mean age of 30.6±12.2 years. Of note, ~74.3% of the population had vitamin D deficiency (20 ng/ml), 21.1% had insufficient levels (20-29.9 ng/ml) and only 4.5% had normal levels (30-60 ng/ml). The mean 25-hydroxyvitamin D level of the study population was 16.29±7.1 ng/ml, with female participants having lower levels (14.05±7.55 ng/ml). There was an overall difference in the mean 25-hydroxyvitamin D level among the different age groups, with lower concentrations observed in subjects <40 years of age. On the whole, vitamin D deficiency was highly prevalent among the studied population, particularly among females and those in the younger age groups. Efforts to raise public awareness and the vitamin D fortification of food and dairy products are strongly recommended.

Correspondence to: Dr Fahmi H. Kakamad, Department of Surgery, College of Medicine, University of Sulaimani, 334 Madam Mitterrand Street, Sulaimani, Kurdistan 46000, Iraq
E-mail: fahmi.hussein@univsul.edu.iq

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Introduction

Since the start of the 21st century, vitamin D has received increasing attention from the health and biomedical scientific community, more so than any other micronutrient (1). Vitamin D is a crucial nutrient as it promotes calcium absorption from the intestines, prevents calcium excretion via renal reabsorption, bone development and metabolism, and prevent the development of rickets during childhood (2). Over the past few decades, evidence regarding the extra-skeletal functions of vitamin D has been increasing, such as in the muscular, reproductive, immune and integumentary systems. Such evidence indicates that an improved vitamin D status leads to improved overall health (3,4). Vitamin D is primarily obtained through exposure to the sun and, to a lesser extent, through dairy products and vitamin D supplements (5). Failure to acquire the necessary amounts of vitamin D has been linked to an increased risk of a wide range of conditions, including osteoporosis, diabetes, cardiovascular diseases, cancer, musculoskeletal conditions and hypertension (6). Serum 25-hydroxyvitamin D[25(OH)D] is a highly reliable biomarker that has been recommended for use to assess the vitamin D status (7). Currently, there is controversy as regards the optimum serum levels of 25(OH)D, as there is considerable variation between the normal values of different populations (4,8). A wide range of minimum values have been proposed, ranging from 12 to 40 ng/ml. Despite the disagreements, a serum 25(OH)D level of <20 ng/ml is the most commonly used value among studies to indicate vitamin D deficiency (6). Globally, vitamin D deficiency is highly prevalent, to the extent that it is considered a pandemic and a major global health issue (1,7). The worldwide prevalence of vitamin D deficiency varies from 30 to 93% (8). It has been observed that 41.6% of adults in the USA are vitamin D-deficient (9). Similarly, according to the study by Cashman *et al* (10), >40% of the European population suffers from vitamin D deficiency (<20 ng/ml). Even though the Middle Eastern populations have ample exposure to sunlight, vitamin

D deficiency is even more prevalent (8). However, to date, at least to the best of our knowledge, no study has been performed to evaluate the prevalence of vitamin D deficiency among the general population of Iraq or the Kurdistan region.

Therefore, the present study aimed to examine the vitamin D status among the healthy population of the Kurdistan region in northern Iraq.

Subjects and methods

Study design and setting. The present study was a community-based cross-sectional study carried out from June, 2021 to January, 2022 at the Kurdistan region of Iraq. In total, 991 apparently healthy individuals (582 males and 409 females) of various ages were randomly recruited from various public areas after obtaining ethical permission. Both written and informed consent were obtained from each participant. The study was approved by the Sulaimani University Ethics Committee.

Inclusion and exclusion criteria. In the present study, only healthy individuals currently residing in the Kurdistan region were enrolled. The exclusion criteria were as follows: Individuals with any medical or chronic condition (apart from obesity, so as to determine any possible link between obesity and vitamin D levels), pregnant women, or those taking vitamin D supplements or other potentially interfering medications were not enrolled.

Data collection. Each participant completed a questionnaire to provide socio-demographic characteristics (age, marital status, smoking status, alcohol consumption and occupation), medical history, and medications. For children, consent was acquired from the parents. Bodyweight and height were measured for the participants for the calculation of body mass index (BMI).

Clinical measures. Trained health workers performed the data collection and obtained blood samples from the individuals who consented to participate. All the blood samples were obtained during the day and were collected in gel tubes (Greiner Bio-One). On the same day of sample collection, the samples were immediately sent to the Smart Laboratory (at Smart Health Tower in Sulaimani, Iraq) for sera separation by centrifugation (5,000 rpm, 10 min, at 25˚C) and storage in a -70˚C environment for later use in the evaluation of vitamin D status.

Vitamin D assessment. Chemiluminescence immunoassay was performed via Cobas E411 using the Vitamin D total Elecsys Cobas E100 kit (Lot no. 56154801; Roche Diagnostics) to analyze the serum 25(OH)D concentrations of the samples, as it is the most utilized form of vitamin D and accounts for the majority of the circulating 25(OH)D. In the present study, the vitamin D status was categorized into three major cut-offs based on serum 25(OH)D concentrations: <20 ng/ml for deficiency, 20-29.9 ng/ml for insufficiency and 30-60 ng/ml for optimality. Levels >60 ng/ml were considered toxic (11).

Statistical analysis. The acquired data were analyzed using SPSS software 24.0 (IBM Corp.). Quantitative variables were analyzed using an independent samples t-test (comparisons between means of more than two groups were performed using one-way ANOVA), and the data are presented in the form of the mean ± standard deviation. In the case of significant results from ANOVA, Hochberg's GT2 post hoc test was used (due to unequal sample size of the groups) to determine which groups led to the significant differences. Qualitative data are presented as proportions and percentages. A P-value <0.05 was considered to indicate a statistically significant difference.

Results

Demographics and characteristics of the participants. Of the total number of healthy subjects enrolled in the present study (n=991), 582 (58.7%) were male, and 409 (41.3%) were female. The subjects had a mean age of 30.6±12.2 years (range, 2-80 years), with the majority of the subjects (60.5%) being between 18-39 years of age. The mean BMI of the participants was 25.07±4.7 (13-50). The difference between the mean age of the male and female participants was insignificant (P=0.265). The majority of the subjects were non-smokers (88.3%). Further characteristics of the enrolled participants are presented in Table I.

Prevalence of vitamin D deficiency and insufficiency. In the present study population, the prevalence of vitamin D deficiency (<20 ng/ml) was markedly high (74.3%), with another large proportion of the study population (21.1%) having insufficient levels of vitamin D (20-29.9 ng/ml). Only 4.5% of the subjects had serum 25(OH)D levels within the optimal range (30-60 ng/ml), and one individual (0.1%) had a toxic level of 25(OH)D (>60 ng/ml) (Table II). Vitamin D deficiency was more prevalent among the females of all age groups (80.4%) compared to the males (69.9%) in the population studied. Additionally, the highest prevalence of vitamin D deficiency was found in participants aged <18 years and in those >60 years. The vitamin D status in both sexes according to age groups is illustrated in Fig. 1.

Predictors for lower serum 25(OH)D concentrations. The mean serum 25(OH)D concentration of the study population was 16.29±7.1 ng/ml (3.78-62.16 ng/ml). No significant difference in 25(OH)D levels was noted as regards the BMI, smoking status, or alcohol consumption. Despite the high prevalence of vitamin D deficiency, the mean 25(OH)D level was significantly lower in females (14.05±7.55 ng/ml) than in males (17.87±6.46 ng/ml) (P<0.001) (Table III). Despite an overall noticeable difference in the mean 25(OH)D concentration among the different age groups, which revealed lower serum 25(OH)D levels in participants <40 years, significant age group differences were only found in males (P=0.028) and not in females (P=0.259) (Table IV).

The type of occupation appeared to have some influence on the serum 25(OH)D levels. However, despite a small difference, the mean value of 25(OH)D levels in all occupational categories was still within the vitamin D deficiency threshold. Thus, of note, the prevalence of vitamin D deficiency was still high, not regarding the occupations of the participants (Fig. 2).

Table I. Characteristics of the participants enrolled in the present study.

Characteristic	Frequency/ mean	Percentage
Sex		
Male	582	58.7
Female	409	41.3
Age, years	30.6	
<18	161	16.2
18-39	599	60.5
40-60	221	22.3
>60	10	1
Marital status		
Married	573	57.8
Single	418	42.2
BMI	25.07	
<18.5	74	7.5
18.5-24.9	377	38
25-29.9	379	38.2
≥30	161	16.3
Smoking status		
Ever smoker	116	11.7
Non-smoker	875	88.3
Alcohol consumption		
Yes	18	1.8
No	973	98.2
Occupation category		
Indoor workers (barber, cleaner, clerk, receptionist, government employee)	298	30.1
Health care professionals (Pharmacist, nurse, laboratorian, physician, radiologist)	67	6.8
Unemployed (housewife, retired)	131	13.2
Student	214	21.6
Teaching professionals	52	5.2
Outdoor workers (engineer, driver, construction worker, farmer)	154	15.5
Security and military	75	7.6
Blood group		
A^+	263	26.5
A^-	23	2.3
B^+	188	19
B^-	16	1.6
AB^+	65	6.6
AB^-	6	0.6
O^+	409	41.3
O^-	21	2.1

Table II. Vitamin D status in the studied population according to the serum 25(OH)D level.

Parameter	Frequency	Percentage
Deficient	736	74.3
Insufficient	209	21.1
Optimal	45	4.5
Toxic	1	0.1

25(OH)D, 25-hydroxyvitamin D.

Table III. Mean serum 25(OH)D levels according to different characteristics.

Characteristic	Mean 25(OH)D	P-value
Sex		<0.001
Male	17.8671±6.45803	
Female	14.0544±7.55038	
Age, years		<0.001
<18	14.8242±6.70206	
18-39	16.0220±7.03543	
40-60	18.0099±7.67882	
>60	18.2860±3.96385	
Marital status		0.534
Married	17.0817±7.14544	
Single	15.2131±7.08522	
BMI		0.366
<18.5	15.5951±6.76480	
18.5-24.9	15.9714±7.41235	
25-29.9	16.7744±7.14961	
≥30	16.2371±6.84541	
Smoking status		0.817
Ever smoker	19.1954±7.19120	
Non-smoker	15.9088±7.08957	
Alcohol consumption		0.185
Yes	20.2956±7.79813	
No	16.2195±7.14740	
Blood group		0.335
A^+	16.5320±6.96608	
A^-	13.4663±7.83233	
B^+	15.9848±6.67549	
B^-	13.0046±7.35624	
AB^+	17.3835±7.35428	
AB^-	14.0320±7.21451	
O^+	16.3114±7.28488	
O^-	18.0722±12.92086	

25(OH)D, 25-hydroxyvitamin D.

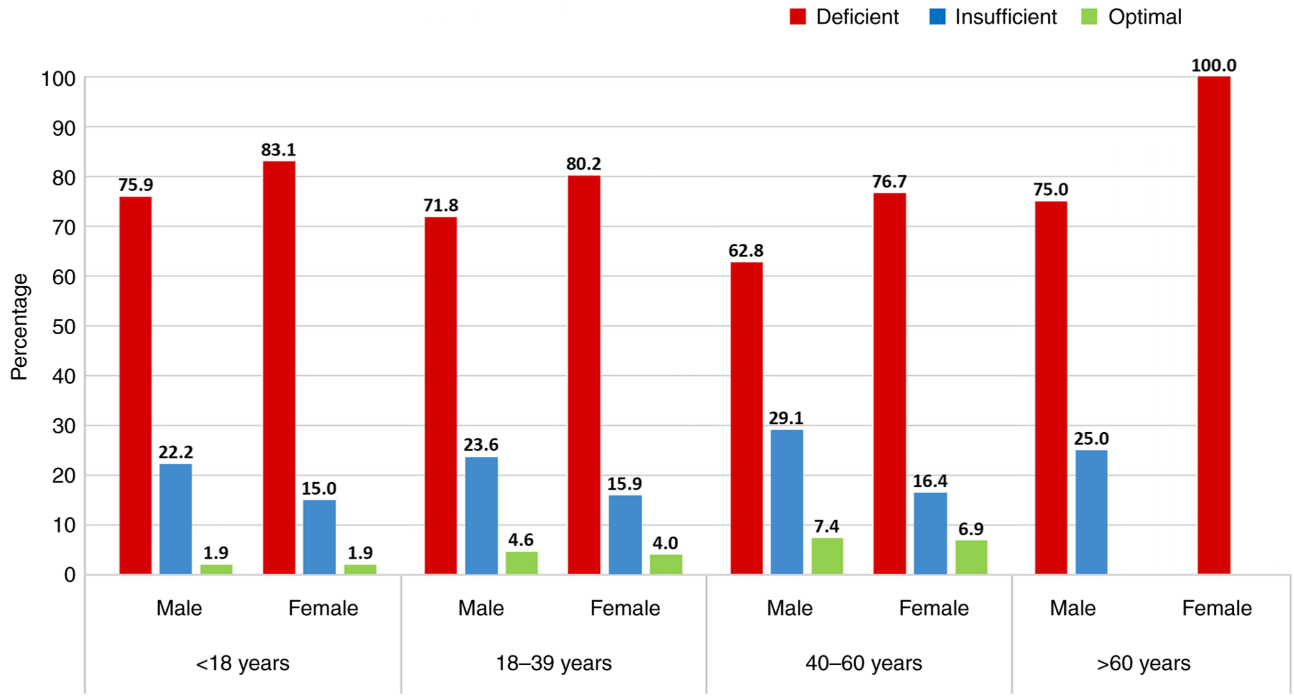

Figure 1. Vitamin D status in the study population according to sex and age. The young population appeared to have a higher prevalence of vitamin D deficiency. Although the mean serum 25(OH)D levels were lower in females, the percentage of deficiency did not differ significantly between the sexes of any age group, as most of the population was deficient.

Table IV. Comparison of the mean serum 25(OH)D levels between different sexes and age groups.

		Serum 25(OH)D levels (ng/ml)				
Sex	Age group	Frequency	Mean	SD	P-value	
Male	<18 years	54	17.4096	5.45653	0.028	<0.001
	18-39 years	372	17.3783	6.23975		
	40-60 years	148	19.2297	7.23821		
	>60 years	8	18.4775	4.29270		
	Total	582	17.8671	6.45803		
Female	<18 years	107	13.5193	6.91299	0.259	
	18-39 years	227	13.7994	7.68548		
	40-60 years	73	15.5367	7.99638		
	>60 years	2	17.5200	3.30926		
	Total	409	14.0544	7.55038		

25(OH)D, 25-hydroxyvitamin D.

Discussion

The Kurdistan region in the northern part of Iraq has a semi-arid climate. The days in this area are often sunny and provide a sufficient amount of sunlight for the inhabitants. Hence, in the present population, the vitamin D status was expected to be mostly within the normal range. However, according to the findings, this expectation was far from true, with the majority of the population either having deficient or insufficient values of vitamin D (74.3 and 21.1%, respectively).

Vitamin D is a micronutrient that is primarily acquired from sunlight; hence, avoiding the sun can lead to various complications (12). Moreover, it has been reported that almost all body tissues have vitamin D receptors, and the majority even possess the hydroxylase enzyme required for the conversion of 25(OH)D to the active form, indicating their importance for the proper functioning of the body (1).

Currently, there is some controversy regarding the optimum levels of serum 25(OH)D (4). A wide range of minimum values have been proposed, ranging from 12 to 40 ng/ml, primarily depending on whether that value can suppress the parathyroid

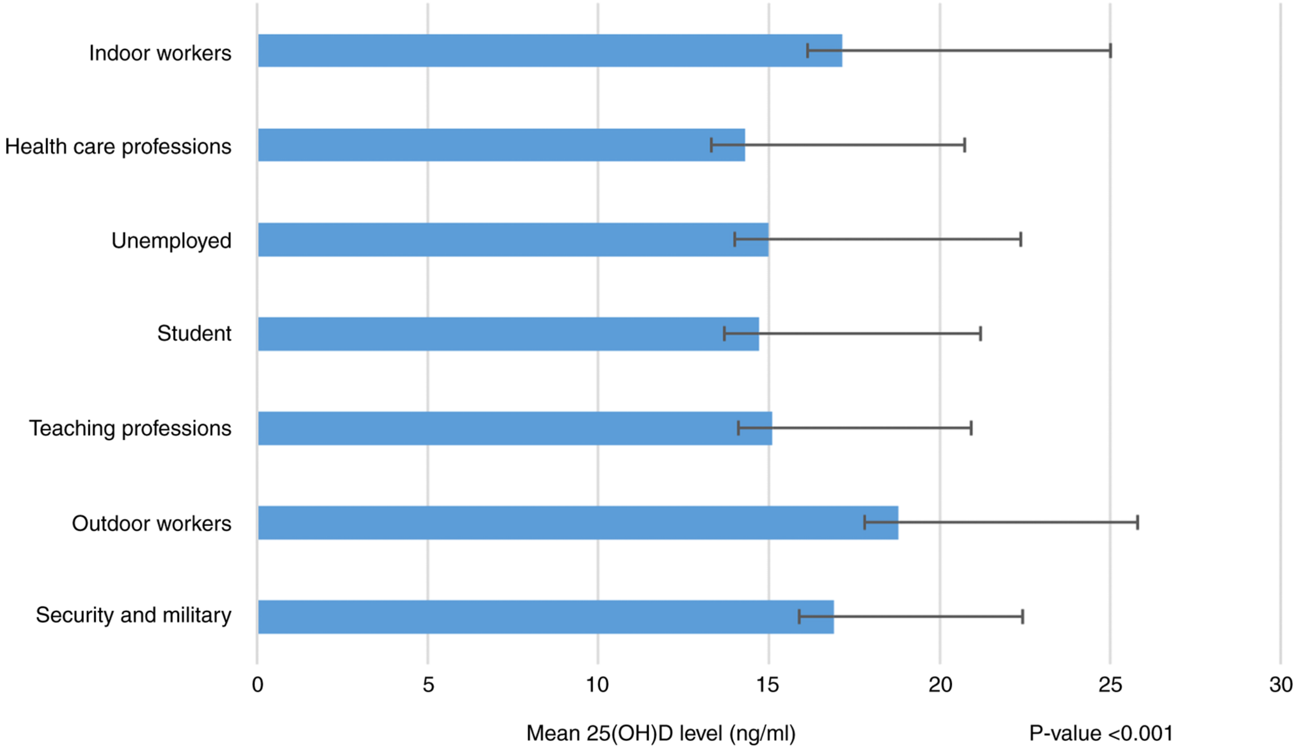

Figure 2. Serum 25(OH)D levels according to occupation. Indoor workers included accountants, hair dressers, cleaners, etc., and outdoor workers included drivers, engineers, construction workers, etc. The mean 25(OH)D level differed significantly between the different occupations (P-value <0.001). This difference was mostly due to higher 25(OH)D levels in participants who were outdoor workers.

hormone to its minimum. The Endocrine Society Clinical Practice Guidelines consider a serum 25(OH)D level of >30 ng/ml to be sufficient for the body. By contrast, the National Academy of Medicine recommends a level of >20 ng/ml to be sufficient (11). Despite the disagreements however, a serum 25(OH)D level <20 ng/ml is the most commonly used value among studies to indicate vitamin D deficiency, and it is the value that was regarded to indicate deficiency throughout the present study (6). When measuring vitamin D levels, the time of the year can influence the concentration of serum 25(OH)D levels. In this regard, summer is considered an ideal season for the measurement of vitamin D levels (13). The present study was conducted during the summer and autumn seasons.

The worldwide prevalence of vitamin D deficiency varies largely, ranging from 30 to 93% (8). It has been observed that 41.6% of adults in the USA are vitamin D-deficient (9). Other community-based studies have reported that vitamin D deficiency ranges between 45-52% in New Zealand, 25% in Canada, 47-65% in Korea and 45% in Portugal (7,14-16). In Europe, vitamin D deficiency has been observed to range between 30-60% of Western, Southern, and Eastern European populations and >20% of populations in Northern Europe (17).

Although sunlight is abundant in developing countries, particularly in the Middle East, vitamin D deficiency appears to be a much more prevalent, with only a minority of these populations having adequate vitamin D levels (1,8). In China, Ning *et al* (18) reported that 87.1% of the Beijing population were vitamin D-deficient, and only 2.9% of the participants achieved optimal levels. In Pakistan, the prevalence of vitamin D deficiency and insufficiency were reported to be 70 and 21.1%, respectively (8). A study conducted in Qatar revealed a prevalence of 64% (6). A meta-analysis on the prevalence of vitamin D deficiency in Saudi Arabia also revealed that 81% of the population were deficient (1). In Kuwait, the prevalence of deficiency was found to be 83% (19). Bachhel and colleagues found that 90% of the Indian population were vitamin D insufficient (<30 ng/ml) (20). In Iran, vitamin D deficiency prevalence was found to be around 85.2% (21). Notably, the study by Öztürk *et al* (22) in southeast Turkey, in which the inhabitants have the same cultural and ethnic background as the Kurdistan region in northern Iraq, revealed very similar findings to those of the present study, with a mean serum level of 25(OH)D of 16.61±6.90 ng/ml, with the prevalence of vitamin D deficiency and insufficiency being 75.54 and 19.38%, respectively (22). In a recent study performed in the Dohuk Governorate, Kurdistan Region, Iraq by Abdulrahman *et al* (23), only 24% of the participants had a normal level of total 25(OH)D, which is higher than that observed in the present study population.

The present study demonstrated that vitamin D deficiency was more prevalent in females than in males (80.4 vs. 69.9%), and sex was associated with a lower mean serum 25(OH)D concentration (14.05 vs. 17.87 ng/ml). However, the findings in the literature are conflicting regarding this aspect. Some studies have indicated a higher prevalence among females due to less sun exposure, which may be explained by the frequent use of sunscreens, fewer outdoor activities and the Islamic culture of covering the body from head to toe (24-27). However, other studies have demonstrated lower 25OHD levels and a higher prevalence of vitamin D deficiency among males, probably due to the more common use of vitamin D supplements among the females of these populations (6,28).

In the present study, the levels of 25(OH)D differed considerably between the age groups, with subjects <40 years of age having the lowest levels of 25(OH)D, particularly among females. This is in agreement with other studies conducted in developing countries (22,23,29,30). This finding may be explained by the fact that elders may have more frequent exposure to sunlight and may consume more healthy foods than younger individuals. However, an inverse association of age with the 25(OH)D level has also been reported, with higher serum concentrations of 25(OH)D found among younger subjects (12). As regards the association between obesity and vitamin D deficiency, previous studies have indicated a positive association between the two (6,31), with only a few studies reporting no association (32,33). In the present study, no significant difference in 25(OH)D levels was found with regards to BMI.

Similar findings between the mentioned studies regarding the prevalence of vitamin D deficiency can somewhat be explained by the shared geographical location of the stated populations, in which high temperatures and the intensity of sunlight during the summer prevent individuals from exposing their skin. Additionally, dressing culture and the lack of awareness regarding the importance of consuming healthy foods that contain vitamin D and exposure to sunlight may also play a role in the high prevalence of deficiency (30).

The international recommendation for the correction of vitamin D deficiency is vitamin D supplementation and increased sunlight exposure. However, current international guidelines may not apply to the local communities of Middle Eastern countries as these guidelines have been specifically tailored for North American or European communities, which are vastly different (genetically, geographically, economically and culturally) from Middle Eastern countries (1). Additionally, the optimal level of vitamin D may differ from one nation to another. Hence, it is highly recommended that further research is conducted to accurately determine the amounts of vitamin D required by these populations.

The ministry of health of the Kurdistan region of Iraq needs to develop a public health policy to raise community awareness on this matter by promoting healthy exposure to sunlight and the consumption of vitamin D-containing foods. The ministry should possibly also take the necessary measures for vitamin D fortification of food and dairy products to correct the high vitamin D deficiency prevalence found in this population.

Although a point of strength of the present study is the fact that it was a community-based study, it also has multiple limitations, as information regarding diet, the amount of sun exposure, and dressing habits was not acquired from the participants. In addition, the concentrations of serum calcium and parathyroid hormone were not measured for the participants.

In conclusion, vitamin D deficiency is highly prevalent among the population of the Kurdistan region in Iraq, particularly among females and the younger age group. Efforts are thus required to raise public awareness regarding this health concern. The vitamin D fortification of foods and dairy products is strongly recommended as a first-line measure to correct vitamin D deficiency. Further studies are warranted to determine other potential factors that contribute to the high prevalence of vitamin D deficiency among these populations.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Authors' contributions

FHK was involved in the literature selection, in the conception and design of the study, and in the writing of the first draft of the manuscript. GSA was involved in data interpretation and in the writing of the first draft of the manuscript. DAH, SHM, ROS, SEH, SSH, AKH, CMR, WAH, BAA, SFA, KMS, RQS, AMS and BJHA were involved in obtaining patient data, and in the final reading and approval of the manuscript. BAA and GSA confirm the authenticity of all the raw data. All authors have read and approved the final manuscript.

Ethics approval and consent to participate

The present study was approved by the Sulaimani University Ethics Committee. Written informed consent was obtained from all participants or the parents in the case that the participants were underage.

Patient consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

References

1. Al-Daghri NM: Vitamin D in Saudi Arabia: Prevalence, distribution and disease associations. J Steroid Biochem Mol Biol 175: 102-107, 2018.
2. Gordon CM, DePeter KC, Feldman HA, Grace E and Emans SJ: Prevalence of vitamin D deficiency among healthy adolescents. Arch Pediatr Adolesc Med 158: 531-537, 2004.
3. Holick MF: High prevalence of vitamin D inadequacy and implications for health. In: Mayo Clinic Proceedings. Vol 81. Elsevier, Amsterdam, pp353-373, 2006.
4. Cashman KD: Vitamin D deficiency: Defining, prevalence, causes, and strategies of addressing. Calcif Tissue Int 106: 14-29, 2020.
5. Tabrizi R, Moosazadeh M, Akbari M, Dabbaghmanesh MH, Mohamadkhani M, Asemi Z, Heydari ST, Akbari M and Lankarani KB: High prevalence of vitamin D deficiency among Iranian population: A systematic review and meta-analysis. Iran J Med Sci 43: 125-139, 2018.

6. Al-Dabhani K, Tsilidis KK, Murphy N, Ward HA, Elliott P, Riboli E, Gunter M and Tzoulaki I: Prevalence of vitamin D deficiency and association with metabolic syndrome in a Qatari population. Nutr Diabetes 7: e263, 2017.
7. Duarte C, Carvalheiro H, Rodrigues AM, Dias SS, Marques A, Santiago T, Canhão H, Branco JC and da Silva JAP: Prevalence of vitamin D deficiency and its predictors in the Portuguese population: A nationwide population-based study. Arch Osteoporos 15: 36, 2020.
8. Mansoor S, Habib A, Ghani F, Fatmi Z, Badruddin S, Mansoor S, Siddiqui I and Jabbar A: Prevalence and significance of vitamin D deficiency and insufficiency among apparently healthy adults. Clin Biochem 43: 1431-1435, 2010.
9. Forrest KY and Stuhldreher WL: Prevalence and correlates of vitamin D deficiency in US adults. Nutr Res 31: 48-54, 2011.
10. Cashman KD, Dowling KG, Škrabáková Z, Gonzalez-Gross M, Valtueña J, De Henauw S, Moreno L, Damsgaard CT, Michaelsen KF, Mølgaard C, *et al*: Vitamin D deficiency in Europe: Pandemic? Am J Clin Nutr 103: 1033-1044, 2016.
11. Holick MF, Binkley NC, Bischoff-Ferrari HA, Gordon CM, Hanley DA, Heaney RP, Murad MH and Weaver CM; Endocrine Society: Evaluation, treatment, and prevention of vitamin D deficiency: An Endocrine society clinical practice guideline. J Clin Endocrinol Metab 96: 1911-1930, 2011.
12. Badawi A, Arora P, Sadoun E, Al-Thani AA and Al Thani MH: Prevalence of vitamin d insufficiency in Qatar: A systematic review. J Public Health Res 1: 229-235, 2012.
13. Bolland MJ, Chiu WW, Davidson JS, Grey A, Bacon C, Gamble GD and Reid IR: The effects of seasonal variation of 25-hydroxyvitamin D on diagnosis of vitamin D insufficiency. N Z Med J 121: 63-74, 2008.
14. Rockell JEP, Skeaff CM, Williams SM and Green TJ: Serum 25-hydroxyvitamin D concentrations of New Zealanders aged 15 years and older. Osteoporos Int 17: 1382-1389, 2006.
15. Langlois K, Green-Finestone L, Little J, Hidiroglou N and Whiting S: Vitamin D status of Canadians as measured in the 2007 to 2009 Canadian health measures survey. Health Rep 21: 47-55, 2010.
16. Choi HS, Oh HJ, Choi H, Choi WH, Kim JG, Kim KM, Kim KJ, Rhee Y and Lim SK: Vitamin D insufficiency in Korea-a greater threat to younger generation: The Korea national health and nutrition examination survey (KNHANES) 2008. J Clin Endocrinol Metab 96: 643-651, 2011.
17. Lips P, Cashman KD, Lamberg-Allardt C, Bischoff-Ferrari HA, Obermayer-Pietsch B, Bianchi ML, Stepan J, El-Hajj Fuleihan G and Bouillon R: Current vitamin D status in European and Middle East countries and strategies to prevent vitamin D deficiency: A position statement of the European calcified tissue society. Eur J Endocrinol 180: P23-P54, 2019.
18. Ning Z, Song S, Miao L, Zhang P, Wang X, Liu J, Hu Y, Xu Y, Zhao T, Liang Y, *et al*: High prevalence of vitamin D deficiency in urban health checkup population. Clin Nutr 35: 859-863, 2016.
19. Zhang FF, Al Hooti S, Al Zenki S, Alomirah H, Jamil KM, Rao A, Al Jahmah N, Saltzman E and Ausman LM: Vitamin D deficiency is associated with high prevalence of diabetes in Kuwaiti adults: Results from a national survey. BMC Public Health 16: 100, 2016.
20. Bachhel R, Singh NR and Sidhu JS: Prevalence of vitamin D deficiency in north-west Punjab population: A cross-sectional study. Int J Appl Basic Med Res 5: 7-11, 2015.
21. Kaykhaei MA, Hashemi M, Narouie B, Shikhzadeh A, Rashidi H, Moulaei N and Ghavami S: High prevalence of vitamin D deficiency in Zahedan, southeast Iran. Ann Nutr Metab 58: 37-41, 2011.
22. Öztürk ZA, Gol M and Türkbeyler İH: Prevalence of vitamin D deficiency in otherwise healthy individuals between the ages of 18 and 90 years in southeast Turkey. Wien Klin Wochenschr 129: 854-855, 2017.
23. Abdulrahman MA, Alkass SY and Mohammed NI: Total and free vitamin D status among apparently healthy adults living in Duhok Governorate. Sci Rep 12: 1778, 2022.
24. Zargar AH, Ahmad S, Masoodi SR, Wani AI, Bashir MI, Laway BA and Shah ZA: Vitamin D status in apparently healthy adults in Kashmir Valley of Indian subcontinent. Postgrad Med J 83: 713-716, 2007.
25. Atli T, Gullu S, Uysal AR and Erdogan G: The prevalence of vitamin D deficiency and effects of ultraviolet light on vitamin D levels in elderly Turkish population. Arch Gerontol Geriatr 40: 53-60, 2005.
26. Goswami R, Kochupillai N, Gupta N, Goswami D, Singh N and Dudha A: Presence of 25(OH) D deficiency in a rural North Indian village despite abundant sunshine. J Assoc Physicians India 56: 755-757, 2008.
27. Hussain AN, Alkhenizan AH, El Shaker M, Raef H and Gabr A: Increasing trends and significance of hypovitaminosis D: A population-based study in the Kingdom of Saudi Arabia. Arch Osteoporos 9: 190, 2014.
28. Hagenau T, Vest R, Gissel TN, Poulsen CS, Erlandsen M, Mosekilde L and Vestergaard P: Global vitamin D levels in relation to age, gender, skin pigmentation and latitude: An ecologic meta-regression analysis. Osteoporos Int 20: 133-140, 2009.
29. Khan AH, Iqbal R, Naureen G, Dar FJ and Ahmed FN: Prevalence of vitamin D deficiency and its correlates: Results of a community-based study conducted in Karachi, Pakistan. Arch Osteoporos 7: 275-282, 2012.
30. Al-Daghri NM, Hussain SD, Ansari MGA, Khattak MNK, Aljohani N, Al-Saleh Y, Al-Harbi MY, Sabico S and Alokail MS: Decreasing prevalence of vitamin D deficiency in the central region of Saudi Arabia (2008-2017). J Steroid Biochem Mol Biol 212: 105920, 2021.
31. Sadiya A, Ahmed SM, Skaria S and Abusnana S: Vitamin D status and its relationship with metabolic markers in persons with obesity and type 2 diabetes in the UAE: A cross-sectional study. J Diabetes Res 2014: 869307, 2014.
32. Majumdar V, Nagaraja D and Christopher R: Vitamin D status and metabolic syndrome in Asian Indians. Int J Obes (Lond) 35: 1131-1134, 2011.
33. Oosterwerff MM, Eekhoff EM, Heymans MW, Lips P and van Schoor NM: Serum 25-hydroxyvitamin D levels and the metabolic syndrome in older persons: A population-based study. Clin Endocrinol (Oxf) 75: 608-613, 2011.