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Prevalence and Associated Risk Factors of Vitamin D Deficiency Among Female Adolescents in Sulaimaniyah, Iraq: A Community-Based Cross-Sectional Study

Galawezh Jalal Salih[1*] and Sanaa Abdul Sahib[2]

[1]Department of Community Health Nursing, College of Nursing, University of Sulaimani, Sulaimaniyah, Iraq.
[2]Department of Community Health Nursing, College of Nursing, University of Raparin, Sulaimaniyah, Iraq.
*Correspondence to: Galawezh Jalal Salih (E-mail: galawzh.salih@univsul.edu.iq)
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Abstract
Objective: This study aims to examine the prevalence and risk factors related to VD deficiency among female adolescents.
Methods: This cross-sectional study was done in secondary and preparatory schools in Sulaimaniyah, Iraq, from May 2022 to July 2023. A total of 120 schools were included in the study, with a calculated sample size of 340 female adolescents using a probability multistage random sampling method. Data was collected through a validated questionnaire, and blood samples were analyzed for VD levels.
Results: In a study of 340 female adolescents aged 14–18 years, the findings showed that 39.4% of participants had severe VD deficiency, 42.6% were deficient, and 17.9% had insufficiency. The mean VD level was 13.29 ± 6.45 ng/mL. Seasonal variation significantly impacted VD level ($P = 0.001$), with the highest levels seen in summer and the lowest in winter. Skin colour also significantly influenced VD level ($P = 0.020$), as individuals with lighter skin have higher levels. There were positive correlations between VD levels, milk intake ($r = 0.138$, $P = 0.011$), and cheese consumption ($r = 0.135$, $P = 0.013$). The use of sunscreen had mixed effects. Interestingly, there was a positive correlation between SPF 15 and VD level ($r = 0.132$, $P = 0.015$), while higher SPF values were associated with lower levels.
Conclusion: The findings highlight the importance of seasonal adjustments, improved dietary habits, and lifestyle changes to address VD deficiency in the population effectively.
Keywords: Vitamin D, female adolescents, prevalence, related risk factors

Introduction

Vitamin D (VD) is critical in maintaining bone and musculoskeletal health by regulating calcium and phosphates, crucial for appropriate bone growth and mineralization.[1] Extensive research has shown that the active form of VD, 1,25-dihydroxyvitamin D [1,25(OH)2D], has beneficial effects on keratinocytes.[2] It promotes differentiation and inhibits proliferation, making it a promising agent for cancer prevention and therapy[3] It has demonstrated antitumorigenic and antimetastatic properties in various cancer cells[4]. In addition to its skeletal functions, VD also has significant immunomodulatory effects that affect the activity of macrophages and activated T and B lymphocytes, enhancing overall immune responses.[5]

Furthermore, it impacts skeletal muscle function and protects against various cardio-metabolic disorders, including hypertension and diabetes. Emerging evidence also suggests that VD may reduce the risk of pregnancy-related complications such as preeclampsia and gestational diabetes.[6] Vitamin D is an immunomodulant, anti-inflammatory, and anti-infective, highlighting its significance in overall health. These effects are attributed to various mechanisms, such as monocyte stimulation, cell-mediated immunity enhancement, lymphocyte proliferation suppression, and regulation of antibody production and cytokine synthesis.[7] The global occurrence of VD deficiency is a significant concern, affecting many individuals worldwide.[8] Developing countries, in particular, have high rates of deficiency. In some regions, up to 70% of the population has suboptimal levels.[9] Among women, the Middle East has one of the highest rates of deficiency, ranging from 30–90%.[10,11]

Similarly, regions such as China, Mongolia, Africa, and South Asia have observed high prevalence rates, with 69–82% of individuals affected.[12] In Iraq, 74.3% of the population suffers from VD deficiency, highlighting the widespread nature of this public health concern.[13] People in the Middle East, are highly susceptible to hypovitaminosis D.[14] Research shows that this demographic is more affected by deficiency than adults and older people, which is concerning given the critical role of VD in their growth and development.[7] Despite the growing evidence on the significance of VD, the occurrence and risk factors associated with deficiency among female adolescents (14–18 years old) are not well addressed. This demographic is vital because adolescence is critical for bone development and overall health. Thus, the current study addresses this gap by investigating VD deficiency prevalence and associated risk factors among female adolescents in secondary and preparatory schools in Sulaimaniyah City, Iraq.

Materials and Methods

Study Design and Setting

This cross-sectional study was performed in secondary and preparatory schools in Sulaimaniyah, Iraq, from May 2022 to July 2023. One hundred twenty schools participated in the study, each having 3 to 6 levels and an average of 28–30 students per level.

Sample Size and Sampling Technique

A calculation based on an estimated prevalence rate of 70% for VD deficiency was done to find the exact sample size.[13]

Then, a sample size of 340 female adolescents would be necessary. To achieve this, we used a probability multistage random sampling technique that involved randomly selecting schools from 120 in Sulaimaniyah, randomly selecting classrooms within these schools, and finally selecting students from these classrooms. Using this sampling approach, we ensured a representative group of female adolescents aged 14–18. We also excluded individuals who were on VD supplements or multivitamins.

Study Tools

To accomplish the study objectives, we developed a questionnaire to collect data on the incidence of VD deficiency in adolescent females. This questionnaire was adapted from a prior study and tailored to our particular aims.[1] Initially drafted in English, it was subsequently translated into Kurdish. To ensure its accuracy and appropriateness for our target population, we enlisted the assistance of professionals to evaluate the translation. The first part of the questionnaire was on participants' sociodemographic features, including age, education level, skin colour, menstrual status, marital status, and body mass index (BMI). Whereas the second part examined associated risk factors and dietary intake. It included 11 items on risk. The questionnaire was administered through face-to-face interviews, and blood samples were analyzed to determine VD levels.

Blood Sampling and Preparation

A 5.0 mL blood was collected from each participant, centrifuged to separate the serum, and stored at −20°C. The Elecsys Vitamin D total II kit (Roche Diagnostics, Germany) was used to quantify VD levels. The reference range for VD was established as 30–40 ng/mL, while <10 ng/mL classified as severe deficiency, 10–20 ng/mL as moderate deficiency, and 21–29.9 ng/mL as mild deficiency.[15]

Validity and Reliability

The study instrument's validity and reliability were evaluated to ensure accuracy and consistency. To assess validity, 15 experts from various universities and health organizations reviewed the questionnaire. This expert review confirmed that the questionnaire items were clear, relevant, and sufficient for the study objectives. A pilot study was conducted with 30 female adolescents from the target population to enhance reliability. The instrument proved acceptable internal consistency, as indicated by a Cronbach's alpha coefficient of 0.784, ensuring reliable measurement of the study variables.

Ethical Approval

The Ethics Committee of the College of Medicine, University of Sulaimani, Sulaimaniyah, Iraq approved the study protocol (No. 35, on March 3, 2022). All procedures used were in accordance with the Helsinki Declaration.

Data Analysis

Statistical analyses were conducted using Statistical Package for Social Science, version 25 (IBM, Chicago, USA). A *P*-value of <0.05 was considered statistically significant. The normality of the data was assessed using the Kolmogorov-Smirnov test. Associations were examined using Spearman correlation, Kruskal-Wallis and Mann-Whitney U tests.

Results

Regarding the age distribution, most (n = 107, 31.5%) were 16 years old, and the least (n = 17, 5.0%) were 14 years old. Regarding academic level, most participants (n = 129, 37.9%) were in 10 and the least were in 9 (n = 52, 15.3%). Regarding employment status, 29 participants (8.5%) were employed, while the majority (n = 311, 91.5%) were unemployed. Regarding the distribution of skin colour, 76 (22.4%) had dark skin, 166 (48.8%) had medium skin, 88 (25.9%) had light skin, and 10 (2.9%) had fair skin. Most participants (n = 115, 33.8%) had menarche at age 12 (1.8%) and least (n = 5, 1.5%) at age 10. Menstruation was reported as regular by 74 participants (21.8%), irregular by 92 (27.1%), and sometimes irregular by 174 (51.2%). Regarding marital status, most participants (n = 334, 98.2%) were single, and 6 (1.8%) were married. Income levels were reported as very good by 34 participants (10%), good by 177 (52.1%), fair by 124 (35.6%), and bad by 5 (1.5%). BMI classifications indicated that 5 participants (1.5%) were underweight (<18.5 kg/m^2), 280 (82.4%) were average weight (18.5–24.9 kg/m^2), 52 (15.3%) were overweight (25.0–29.9 kg/m^2), and 3 (0.9%) were obese (30.0+ kg/m^2). Regarding the season of blood sampling, 82 participants (24.1%) had blood in spring, 42 (12.4%) in summer, 87 (25.6%) in autumn, and 129 (37.9%) in winter (Table 1).

A significant proportion had levels below the normal reference range. Specifically, 134 participants (39.4%) were found to have severe VD deficiency (<10 ng/mL). Moderate deficiency (10–20 ng/mL) was observed in most participants (n = 142, 41.8%). Additionally, 64 participants (18.8%) had mild deficiency (21 to 29.9 ng/mL) (Table 2).

According to Table 3, the participants had a mean age of 16 ± 1.1 years, experienced menarche at around 12 ± 1.27 years old, with a mean weight of 60 ± 8.0 kg and a mean height of 162 ± 6.0 cm. The mean BMI was 22.62 ± 2.52 kg/m², and the mean VD level was 13.29 ± 6.45 ng/mL.

As shown in Table 4, there were no significant correlations in VD levels based on working status. Both working and non-working participants had similar mean VD levels (13.357 vs. 13.279, P = 0.923). However, skin colour was a significant factor, with lighter skin tones associated with higher mean VD levels (P = 0.020). Participants with fair skin had the highest mean level (18.626 ng/mL), while those with dark skin had the lowest (12.411 ng/mL). The regularity of menstruation did not significantly impact VD levels (P = 0.542) nor marital status, although single participants had a higher mean level than married ones (13.367 vs. 8.780, P = 0.056). Income level also did not significantly differ in VD levels across categories (P = 0.904). Additionally, BMI did not substantially affect VD levels, as similar mean levels were observed across different BMI categories (P = 0.718). The season of VD collection emerged as a highly significant factor (P = 0.001), with the highest levels recorded in summer (24.447 ng/mL) and the lowest in winter (10.900 ng/mL).

The duration of sun exposure per day did not show significant correlations with VD levels. This was supported by non-significant across different exposure durations. However, the use of sunscreen had a notable impact. In cases where SPF 15 was used, there was a positive correlation (r = 0.132,

Table 1. **Sociodemographic characteristics of female adolescents.**

Variable	Frequency	Percentage
Age (Years)		
14	17	5.0
15	62	18.2
16	107	31.5
17	99	29.1
18	55	16.2
Level		
9	52	15.3
10	129	37.9
11	95	27.9
12	64	18.8
Working Status		
Working	29	8.5
Not working	311	91.5
Colour of skin		
Dark	76	22.4
Medium	166	48.8
Light	88	25.9
Fair	10	2.9
Age of menarche (Years)		
9	6.0	1.8
10	5.0	1.5
11	33	9.7
12	115	33.8
13	103	30.3
14	50	14.7
15	21	6.2
16	7.0	2.1
Regularity of menstruation		
Regular	74	21.8
Irregular	92	27.1
Sometime irregular	174	51.2
Marital Status		
Single	334	98.2
Married	6.0	1.8
Income		
Very good	34	10
Good	177	52.1
Fair	124	35.6
Bad	5.0	1.5
Body mass index (kg/m²) groups		
<18.5 = underweight	5.0	1.5
18.5–24.9 = normal weight	280	82.4
25.0–29.9 = overweight	52	15.3
30.0+ = obese	3.0	0.9
Season of blood collection		
Spring	82	24.1
Summer	42	12.4
Autumn	87	25.6
Winter	129	37.9

Table 2. **Distribution of the female adolescents according to the level of vitamin D deficiency:**

Levels of vitamin D (reference range 30–40 ng/mL)	Frequency	%
Severe (below ten ng/mL)	134	39.4
Moderate ((10–20 ng/mL)	142	41.8
Mild (21–29.9 ng/mL)	64	18.8

Table 3. **Mean and standard deviation of weight, height, and vitamin D level.**

Items	Mean	Standard Deviation
Age (Years)	16	1.1
Age of Menarche (Years)	12	1.27
Weight (kg)	60	8
Height (cm)	162	6.0
Body Max Index	22.62	2.52
Vitamin D Level (ng/mL)	13.29	6.45

P = 0.015) with VD levels, while SPF 50 (r = −0.114, P = 0.036) and SPF 100 (r = −0.106, P = 0.052) were associated with lower VD levels. Furthermore, the presence of diseases did not display significant correlations with VD levels. However, dietary intake variables showed positive correlations with VD levels, including milk consumption (r = 0.138, P = 0.011) and cheese intake (r = 0.135, P = 0.013). Additionally, the duration of outdoor activity and dressing style, especially when <27% of the body was uncovered, showed a significant association with higher VD levels (r = 0.263, P = 0.001). Conversely, more excellent coverage displayed a negative correlation (r = −0.242, P = 0.001). Physical activity, frequency and location of sunscreen use did not significantly correlate with VD levels. The only exception was using sunscreen 3 times a day, which exhibited a negative correlation (r = −0.166, P = 0.002) (Table 5).

Discussion

This study underscores the significant public health concern posed by VD deficiency among female adolescents in Sulaimaniyah, Iraq. The results indicate a profound deficiency, with 39.4% of the participants severely deficient and 42.6% classified as inadequate. The mean serum VD level was notably low (13.29 ng/mL), with a pronounced deficiency during winter. These findings align with global trends, where VD deficiency has reached epidemic levels, affecting approximately one billion individuals across various demographics, as reported in numerous studies.[1,16]

The study's sociodemographic analysis revealed that most participants were 16 years old, consistent with similar studies conducted in China and Norway, where the average age of participants was 15–16 years.[17,18] This consistency underscores adolescence as a critical period for assessing VD status, given the rapid physiological and hormonal changes occurring during this developmental stage. The sample's predominance of level 10 students reflects the educational structure in Sulaimaniyah, where higher-grade students are preoccupied with intensive academic preparations, potentially limiting

Table 4. **Comparative differences between vitamin D deficiency and the demographic characteristics.**

Variable	No.	Mean	Standard deviation	*t*- statistic	*P*-value
Working status					
Working	29	13.357	6.558	4460.5[a]	0.923
Not working	311	13.279	6.446		
Colour of skin					
Dark	76	12.411	5.914		
Medium	166	12.819	6.362	9.787[b]	0.020*
Light	88	14.316	6.486		
Fair	10	18.626	8.514		
Regularity of menstruation					
Regular	74	13.216	5.432		
Irregular	92	12.805	6.351	1.224[b]	0.542
Sometime irregular	174	13.570	6.896		
Marital status					
Single	334	13.367	6.472	545.5[a]	0.056
Married	6	8.780	1.808		
Income					
Very good	34	13.238	6.057		
Good	177	13.157	6.405	0.565[b]	0.904
Fair	124	13.389	6.605		
Bad	5	15.608	8.034		
Body mass index (kg/m^2)					
<18.5 = underweight	5	13.916	2.641		
18.5–24.9 = normal weight	280	13.193	6.407	1.347[b]	0.718
25.0–29.9 = overweight	52	13.793	7.028		
30.0+ = obese	3	12.163	5.710		
Season of vitamin D collection					
Spring	82	12.920	5.714		
Summer	42	24.447	3.380	98.432[b]	0.001*
Autumn	87	11.780	5.419		
Winter	129	10.900	4.214		

*: Significant difference, a = Mann-Whitney U, b = Kruskal-Wallis H

their outdoor activities and exposure to sunlight, a primary source of VD synthesis.

Skin colour emerged as a significant determinant of VD levels, with most participants having a wheat-coloured (medium) skin tone, characteristic of Middle Eastern populations. This finding corroborates the study by Oliosa et al., which reported a similar skin colour distribution among their sample.[19] Melanin, which provides skin pigmentation, acts as a natural sunscreen, reducing the skin's ability to synthesize VD from sunlight. Thus, individuals with darker skin tones, such as those with medium or dark skin, are at a higher risk of VD deficiency, particularly in areas with partial sunlight exposure during some seasons.

Table 5. **Correlation between level of vitamin D and associated risk factors.**

Associated risk factors		Spearman correlation	*P*-value
Sun exposure time per day (Minutes/day)	<5	−0.062	0.257
	5–15	0.003	0.960
	16–30	−0.035	0.520
Using a type of sunscreen	SPF15	0.132	0.015*
	SPF 30	−0.035	0.517
	SPF 50	−0.114	−0.036
	SPF100	−0.106	0.052
Having chronic diseases	Diabetic	0.102	0.061
	Cancer	0.058	0.286
	Kidney disease	−0.066	0.227
	Liver disease	0.036	0.504
	Congenital Blood Disorder	0.071	0.194
	Thyroid disease	−0.027	0.613
	Hormonal Disorder	−0.023	0.675
	Gastrointestinal Disorder	−0.056	0.303
	Asthma	−0.004	0.943
	Other	0.053	0.327
Dietary intake	Milk by cup/day	0.138	0.011
	Milk beverage (yoghurt, buttermilk, cream)	0.041	0.454
	Cheese	0.135	0.013*
	Dairy dessert	0.061	0.265
	Dairy ice cream	0.101	0.064
Used medication	Anti-seizure Drug	−0.035	0.523
	Antidepressant Drug	0.021	0.701
Length of outdoor activity (Minutes/week)	<60	0.067	0.220
	>60	0.004	0.944
Dressing style	<27% uncovered	0.263	0.000*
	≥ 27% uncovered	−0.242	0.000*
Physical activity	Daily	0.087	0.108
	Weekly	−0.073	0.176
Where do you use sunscreen?	Only Face	−0.017	0.755
	Face & Hand	−0.079	0.144
	Most of the Body	−0.029	0.598
How often do you use sunscreens?	Only Morning	−0.041	0.453
	Twice a Day	0.004	0.948
	Thrice a Day	−0.166	0.002*
	Every 2 hour	0.011	0.837
In which season do you use sunscreen?	Only Summer	0.032	0.561
	Spring & Summer	−0.017	0.759
	All Season	−0.106	0.052

*: Significant difference

The timing of menarche occurs at an average age of 12 among 33.8% of participants, consistent with global trends, where early pubertal onset is increasingly observed.[20] The timing of puberty is influenced by a complex interplay of genetic, environmental, and nutritional factors, including VD status. Research has suggested that VD plays a critical role in regulating the endocrine system and reproductive health, potentially influencing puberty's timing and adolescents' overall health.[21] This study's findings contribute to the growing body of evidence suggesting that VD deficiency may be associated with earlier menarche and irregular menstrual cycles, as observed in 51.2% of participants.

The prevalence of menstrual irregularities is parallel to that of Peña et al., who highlight the importance of monitoring menstrual health as an indicator of overall adolescent well-being.[22] Menstrual irregularities can be a manifestation of underlying hormonal imbalances,[23] which may be exacerbated by VD deficiency. The high percentage of single participants (98.2%) reflects the sociocultural norms in the region, where marriage is typically delayed until after the completion of higher education. The financial stability of the participants reported that 52.1% had good income that may provide some buffer against the adverse effects of VD deficiency.

The findings regarding BMI revealed that 82.4% of participants had a normal BMI, while 15.3% were overweight. These results are consistent with the literature, which indicates that while BMI is a helpful indicator of nutritional status, it does not fully capture the complexities of VD metabolism. For instance, adipose tissue can sequester VD, lowering bioavailability in overweight and obese individuals.[24] This study's findings suggest that even normal-weight adolescents are not immune to VD deficiency, highlighting the need for targeted interventions that address dietary intake and lifestyle factors beyond weight management alone.

Seasonal variation in VD levels was a significant finding, with the lowest levels observed during winter. This pattern is well-documented in the literature, with numerous studies demonstrating that reduced sunlight exposure during winter is a critical factor in the widespread deficiency observed during this season.[25,26] The winter months in Sulaimani, characterized by shorter daylight hours and colder temperatures, likely contribute to reduced outdoor activity and lower VD synthesis. This study reinforces the importance of seasonally adjusted public health strategies, such as advocating for VD supplementation during the winter months, to mitigate the seasonal decline in VD levels.

The study also found significant correlations between dietary intake of VD-rich foods, outdoor activity, and VD levels. These findings are consistent with existing research emphasizing the importance of a balanced diet and adequate sun exposure in maintaining optimal VD status[27]. However, cultural practices, such as clothing that limits skin exposure to sunlight and dietary patterns that may not include sufficient VD-rich foods, can exacerbate the risk of deficiency. Public health interventions should, therefore, not only focus on increasing awareness of the importance of VD but also address cultural and lifestyle barriers to adequate sun exposure and dietary intake.

This study has some limitations, such as its cross-sectional design, which provides a snapshot of data simultaneously, limits the ability to establish causal relationships between VD deficiency and its associated factors. Moreover, the reliance on self-reported data for dietary intake and lifestyle factors introduces the possibility of recall bias, potentially affecting the accuracy of the findings. The exclusion of students who took VD supplements or multivitamins may also limit the generalizability of the findings. While this was done to focus on the natural prevalence of deficiency, it excludes a potentially significant portion of the population actively managing their VD levels. Finally, the study did not explore the potential long-term health consequences of VD deficiency during adolescence, such as its impact on bone health, mental health, and chronic disease risk.

Conclusions

The study highlights a high prevalence of VD deficiency (primarily moderate to severe) among female adolescents. The analysis emphasizes the significant impact of seasonal variations on VD levels. Specifically, it shows that levels are considerably higher during the summer and significantly lower in winter. Skin colour is also a notable factor, with lighter skin tones being associated with higher VD levels. Dietary factors, particularly milk and cheese consumption, have a positive correlation with VD status. This suggests that nutritional interventions could be a practical approach. Surprisingly, sun exposure, a well-known factor, did not significantly correlate with VD levels. The study also reveals that body coverage significantly influences VD levels, with less coverage associated with higher VD status. These findings indicate that addressing seasonal fluctuations, enhancing dietary intake, and considering lifestyle factors could be essential strategies in tackling VD deficiency among adolescents.

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Conflict of interest

Not declared.

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