Vitamin D level and its determinants among Sudanese Women: Does it matter in a sunshine African Country?

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Abstract

Background: Vitamin D deficiency is a worldwide concern. The aim of the current study was to determine the vitamin D level and its contributing factors in Sudanese women. **Methods:** In this cross-sectional study, 251 Sudanese women attending Family Health Centers in Khartoum, Sudan were interviewed. Following the exclusion of confounding factors, samples from 190 women were analzsed. Serum 25 hydroxyvitamin D "25(OH) D" was quantified using competitive electrochemiluminescence immunoassay. **Results:** Participants' age ranged from 18 to 85 years with a mean age (±SD) of 40.2 (±14.06) years. The mean (±SD) vitamin D level was 13.4 (±6.72) ng/ml, ranged 3.00–36.5 ng/ml and the median was 12.7 ng/mL. In total, 157 out of 190 (82.6%) had vitamin D serum levels below 20 ng/ml (deficient); of whom, 52 (27.4%) were in the age group 21–30 years (*P* value = 0.228). The correlation between vitamin D level and residence outside Khartoum, sun-exposed face and hands, and face and limbs in comparison with being completely covered were found to be statistically significant (*p* values 0.008, 0.023, and 0.036). **Conclusion:** This study displayed a high percentage (82.6%.) of vitamin D deficiency among women in Sudan, and this in part may indicate that sunshine alone cannot guarantee vitamin D sufficiency in the tropics. Family physicians in tropical countries should screen those with clinical presentations related to vitamin D deficiency.

Keywords: Dietary intake, menopausal state, PHC, reproductive health, Sudan, sun exposure, Vitamin D, Women

Introduction

Vitamin D (D2, D3, or both) is a secosterol produced inside the body in the sun-exposed skin or obtained from vitamin D-rich foods. Vitamin D proved to have many metabolic and

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biological functions. One of the chief physiologic functions of vitamin D is to sustain serum calcium and phosphorus levels in a healthy physiologic range to conserve a diversity of metabolic functions, transcription regulation, and bone metabolism.[1] Many studies have shown skeletal and non-skeletal health benefits of vitamin D.[2-4]

Serum 25 hydroxyvitamin D [25(OH)D] -though not the active metabolite- is the best estimate of the status of a person's serum vitamin D level. It has a longer serum half-life (-3 weeks) than 1, 25(OH)D (4 h) and is independent of the unstable calcium requirements of the skeletal system.[5] Recently, a dramatic increase in the diagnosis of vitamin D deficiency was observed, the cause of which is not apparent.[6] Several studies have been published on the 25(HO) D level worldwide, but only limited data are available from African countries including Sudan.[7,8]

Vitamin D proved to have many biological activities, and its deficiency not only leads to bone mineralization disorders but also other metabolic, autoimmune, musculoskeletal, mental, infectious, and neoplastic conditions were related to vitamin D deficiency.[2-4] Moreover, vitamin D plays a part in the female reproductive function through its regulation of the follicular stimulating hormone, anti-mullerian hormone, regulation of different genes in the genital system, and sex hormones. Furthermore, it has been involved in the pathogenesis of various female genital tract and reproductive disorders.[9,10]

Up to our knowledge, and as stated by Cashman *et al.* in a recently published review article, there are no published studies about the prevalence of 25(HO)D and its determinants among Sudanese women.[11] The current study meant to determine the serum level of 25(OH)D among Sudanese apparently-healthy women and find out its determinants.

Materials and Methods

This descriptive cross-sectional study intended to measure the serum levels of 25(HO) D3 among Sudanese women attending the Family Health Centers (FHC) in Khartoum State. Samples were taken in summer and autumn because studies showed that the vitamin D level is prejudiced by seasonal variation; it is slightly low in winter but does not differ in summer and autumn.[12]

The sample size was determined by Fischer's formula.[13] using a prevalence rate of 14.86% according to a pilot study.[7] Approximately, 20% of the calculated sample size was added to cater for incomplete and non-responses. The minimum sample size calculated was 194. A stratified sampling method was utilized to select 20 FHCs from the list of 41 FHCs in Khartoum state. Within each FHC, the study subjects were recruited randomly from the attendants. Population resident in Khartoum State represent all states of Sudan.

A trained investigator interviewed a total of 251 females after introducing herself and explaining the purpose of the study. Patients' weight and height were measured at the Health Center, and the BMI was calculated. Women with chronic illness, endocrine or autoimmune disease, current or history of cancer, use of drugs, use of alcohol or smoking, use of vitamin D, calcium or multi-vitamin supplements were excluded. Non-Sudanese nationality, pregnant, and lactating women at the time of enrolment were also excluded. Hemolyzed samples were also excluded leaving data of 190 healthy subjects for final statistical analysis. Following the signing up of the informed consent, subjects were kindly asked to donate 3 ml of venous blood. Serum 25(OH)D was measured using the analyzer Cobas e411, Roche Diagnostics, Germany. This analyzer uses the immunological reaction for the in-vitro quantitative determination according to electrochemiluminescence immunoassay. The test principle is a competitive one, and the total duration of the assay is 18 min. Vitamin D levels were determined according to the Endocrine Society's Clinical Guidelines.[14]

Data were analyzed using the R-Statistical Software version 3.4.1. Categorical data (such as Employment and marital status) were summarized using frequencies and displayed using tables and bar-graphs. Continuous numerical data (such as age and number of previous pregnancies) were summarized using median, range, mean, and standard deviation (SD). The main outcome variable (Vitamin D level in ng/mL) was considered normally distributed as per normality testing. Categorical and continuous data were displayed in tables and graphs. The effect of categorical and continuous variables on the outcome variable was determined using linear regression, ANOVA, and t test as appropriate. The level of significance was set at $P \leq 0.05$.

Results

Out of 251 interviewed women, 190 were included; their socio-demographic characteristics, obstetric history, and variables are shown in Table 1.

The levels of vitamin D varied considerably among participating women. The range was between 3.0 and 36.5 ng/mL. The mean value was 13.4 ng/mL (Standard Deviation SD = 6.72 ng/mL), and the median value was 12.7 ng/mL. Figure 1 displays the distribution of the study contributors according to vitamin D level groups. Correlation between vitamin D levels and some risk factors is shown in Table 2.

Upon adjusted multiple linear modeling, residence outside Khartoum was statistically significant in terms of effect on vitamin D levels ($P = 0.008$) [Figure 2] and sun-exposed skin (Face and Hands) and sun-exposed skin (Face and Limbs) in comparison with being completely covered ($P = 0.023$ and $P = 0.036$) as shown in Figures 3 and 4.

Discussion

In this study, the serum level of 25 (OH)D was measured for 190 healthy Sudanese females, 80% of whom were below

Table 1: Socio-demographic characteristics, obstetric history, and some variables of women included in the study (*n*=190)

Characteristic	Category	Vitamin D level	Count (%)	*P*
Vitamin D	Sufficient	32.8 ng/mL	3 (1.6%)	NA
	Insufficient	23.3 ng/mL	30 (15.8%)	
	Deficient	11.1 ng/mL	157 (82.6%)	
Age	mean (SD)	40.2 years (14.06)		0.222
Employment	Unemployed	14.1 ng/mL	82 (43.2%)	0.182
	Employed	12.8 ng/mL	108 (56.8%)	
Education level	Illiterate	13.5 ng/mL	24 (12.6%)	0.014*
	Primary school	16.0 ng/mL	43 (22.6%)	
	Secondary school	13.2 ng/mL	50 (26.3%)	
	University	11.8 ng/mL	73 (38.4%)	
Residence	Khartoum	13.2 ng/mL	187 (98.4%)	0.022*
	States	22.2 ng/mL	3 (1.6%)	
Marital Status	Married	13.2 ng/mL	118 (62.1%)	0.0496*
	Single	12.6 ng/mL	42 (22.1%)	
	Divorced	12.1 ng/mL	13 (6.8%)	
	Widowed	17.6 ng/mL	17 (8.9%)	
Menarche	mean (SD)	14.0 years (1.99 years)		0.414
Parity	mean (SD)	5.5 (3.27)		0.839
Pills Use	Yes	13.9 ng/mL	15 (7.9%)	0.767
	No	13.3 ng/mL	175 (92.1%)	
Family History of Cancer	Yes	14.3 ng/mL	18 (9.5%)	0.519
	No	13.3 ng/mL	172 (90.5%)	
Menopause	Yes	14.4 ng/mL	52 (27.4%)	
	No	13.0 ng/mL	138 (72.6%)	
Socioeconomic status	Low	13.6 ng/mL	160 (84.2%)	0.939
	Moderate	11.8 ng/mL	27 (14.2%)	
	High	12.4 ng/mL	3 (1.6%)	
	Total	75	233	
Sun Exposed Area	Covered	12.6 ng/mL	7 (3.7%)	0.767
	Face and hands	12.4 ng/mL	7 (3.7%)	
	Face, hands, and legs	12.3 ng/mL	37 (19.5%)	
	Face and limbs	13.7 ng/mL	139 (73.2%)	
BMI	Mean (SD)	26.2 (4.67)		0.753
Use of Sun Protection creams	Yes	10.6 ng/m	12 (6.3%)	0.252
	No	13.5 ng/mL	178 (93.7%)	
Sun Exposure	Before 10 am	13.6 ng/mL	122 (64.2%)	0.377
	10 am to 2 pm	13.2 ng/mL	64 (33.7%)	
	After 3 pm	8.9 ng/mL	4 (2.1%)	

*Statistically significant Pearson Chi-Square test at 0.05 or less.

50 years. The majority (82.6%) of them show levels of 25 (OH) D below 20 ng/ml (deficient). A previous study reported a high frequency of vitamin D deficiency among apparently healthy blood donors, especially males.[7] Another study revealed that 72.5% of the 40 post renal transplant patients and 5% of the 40 healthy controls were vitamin D deficient. However, only 35% of the whole group were females.[15] Currently, we found that 55% of the vitamin D-deficient women were in the reproductive age group (21–40 years). Vitamin D deficiency has been described to be prevalent among healthy women at reproductive age in different countries including Pakistan (73%), Jordan (76%), and Saudi Arabia (80.6%).[16-19]

Studies from China reported 84.9% of urban women of child-bearing age,[20] 85.3% of lactating women,[21] and 67% of multiethnic Asian population to have suboptimal 25(OH)D serum levels.[22] Furthermore, the median serum 25(OH)D concentration was found to be below 20 ng/ml in 56.7% of Belgian pregnant women, notably in the first trimester.[23] Similarly, the assembled estimation of pre-existing vitamin D values of 14 population-based studies revealed a prevalence of 40.4% of the studied European individuals[24] and 39% among healthy American volunteers aged 18–50 years with an augmented risk in Black and Asian adults.[25]

Although, both black and white Northern American women had low levels of vitamin D (29.2%),[26] African Americans women showed lower levels of vitamin D than European Americans women. However, both groups have similar vitamin D-binding protein concentrations, signifying that African Americans harbor

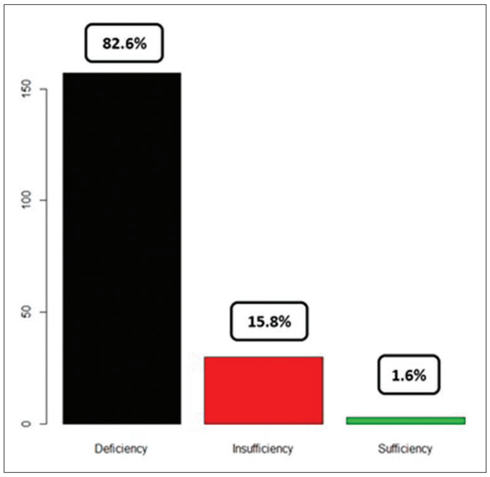

Figure 1: The distribution of the study contributors according to vitamin D level groups

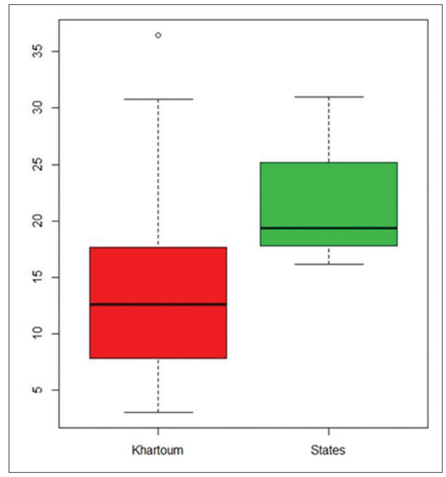

Figure 2: The difference in mean vitamin D levels according to residence of the studied women. The mean for women from Khartoum was 13.2 ng/mL compared to the mean level for women from outside Khartoum, which was 22.2 ng/mL ($P = 0.022$)

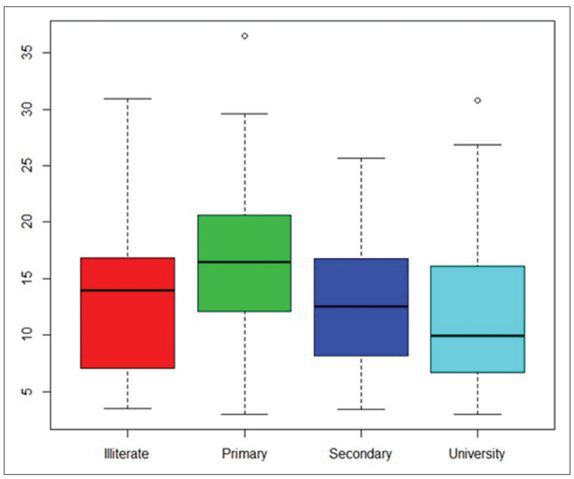

Figure 3: The association between vitamin D and education levels among the study participants. Vitamin D levels were far less in university graduates (mean = 11.8 ng/mL) than in primary school graduates (mean = 16.0 ng/mL), $P = 0.006$

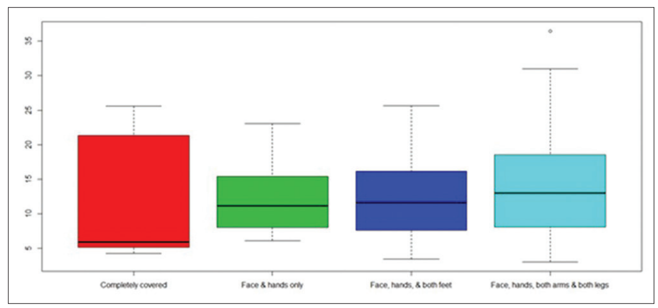

Figure 4: The correlation between exposed areas to the sun light and vitamin D level among the studied Sudanese women

lower levels of free 25(OH)D.[27] The same results were obtained following the control of lifestyle and demographic factors suggesting different ethnicity-specific genetic determinants.[27] Approximately, 37% of Mexican older adults showed levels below 20 ng/L, 65% of whom were women.[28] In Kenya, the prevalence of vitamin D deficiency in healthy women was estimated to be 79.4%.[29] While both the 118 clinically diagnosed with Type 2 diabetes mellitus and the matched hundred healthy non-diabetic individuals resident in Nkawie district, Ghana, showed deficient levels of vitamin D.[30]

Our results are comparable to those reported from Saudi Arabia and China.[19,20] However, they are slightly higher than those reported from Pakistan, Jordan, multiethnic Asian population, and the Kenyan obstetric patients and far higher than the percentages reported among European and American women.[16,19,22,28,29] Surprisingly, vitamin D levels in tropical or sunshine countries are lower than template countries. These low levels could be attributed to the scarcity of naturally inclosing vitamin D foods in these countries in addition to the lack of awareness that sun exposure is the primary source of vitamin D.[31]

Exposure to adequate ultraviolet-B radiation (UV-B, 280–315 nm) is the chief source of vitamin D followed by its synthesis in human skin.[1-13] However, this is reduced during winter and spring especially in far North countries. Additionally, lifestyle and terror of skin cancers may further reduce sun exposure leading to vitamin D deficiency.[32] These two factors may justify the low vitamin D level in people resident in template countries. Unexpectedly, this study did not reveal sun exposure as a determinant of vitamin D level among Sudanese women (p 0.767). However, an Irish study on 5,138 elderly populations; 67% of them were females proved that ambient UV-B dose and sun enjoyment are strongly positively associated with serum 25(OH) D (beta = 6.6; $P < 0.001$).[33]

Cutaneous vitamin D3 production is affected by different factors comprising season, altitude, latitude, time of day, air pollution, skin pigment, and use of sun protection creams.[12] The longer the path of the solar UV-B photons through the ozone layer which efficiently absorbs them, the lesser the beneficial UV-B photons to the earth. An escalation in the peak angle of the

Table 2: Vitamin D levels according to individual risk factors among studied Sudanese women using linear logistic regression model

Covariate	Estimate	Standard Error	*P*
Age	–0.086	0.052	0.100
Employment (Unemployed)	0.292	1.215	0.810
Education (Primary)	3.548	1.799	0.051
Education (Secondary)	0.235	1.925	0.903
Education (University)	–0.189	2.223	0.932
Residence (States)	18.722	6.966	0.008*
Married	1.670	2.187	0.447
Widow	4.954	2.790	0.078
Parity	0.080	0.196	0.684
Sun Exposure time 10 am to 2 pm	–1.357	1.710	0.429
Sun exposed skin (Face and Hands)	–13.196	5.714	0.023*
Sun exposed skin (Face, Hands, and Feet)	–8.269	4.370	0.061
Sun exposed skin (Face and Limbs)	–8.749	4.122	0.036*
Use of Sun Protection creams	–10.886	7.254	0.136
Menarche Age	0.016	0.328	0.962
Pregnancy Age 20–24	1.305	2.644	0.623
Pregnancy Age 25–29	2.211	3.830	0.565
Pregnancy Age 30–34	1.872	5.630	0.740
Pregnancy Age over 35	0.020	7.763	0.998
BMI	–0.068	0.134	0.613
Pills	2.155	2.415	0.374
Family History of Cancer	0.620	2.029	0.761
Menopause	0.491	1.349	0.717
Low Socioeconomic Status	–.450	7.124	0.533
Moderate Socioeconomic Status	–5.663	7.225	0.435

*Statistically significant Pearson Chi-square test at 0.05 or less

sun during winter, in addition to the early morning and the late afternoon, results in a longer path. In addition, it can justify why at the equator and in the far northern and southern regions of the world in summer, where the sun shines almost 24 h a day -vitamin D3 synthesis occurs only between approximately 10:00 am and 3:00 pm.[1]

In the current study, although the sun-exposed area did not show significant association with vitamin D deficiency, nevertheless, when multiple linear regression was applied, sun-exposed skin (Face and Hands) and (Face and Limbs) were found to be statistically significant when compared with being completely covered (beta =-13.196; *P* 0.023 and beta = –8.749; *P* 0.036). This is in concordance with a study done in urban mid-western obstetric Michigan Hospital in which ladies who wore the "hijab or niqab" (A Muslim female's dressing that covers the whole body) were more probably liable to have vitamin D deficiency (89.5% vs. 68.7; $P < 0.0001$) and insufficiency (98.8% vs. 91.4%; $P < 0.0001$) when matched with women who did not wear the hijab.[34]

Part of the limitations of this study was owing to the fact that women recruited from FHC and not a community-based survey, which would have identified the Sudanese population directly. In addition to the inherent drawbacks of the cross-sectional study, among the limitations of this study is the lack of concomitant measuring of parathyroid hormone and serum calcium and phosphate levels. Furthermore, genetic testing of vitamin D receptors (VDR) variants would have empowered the study. In spite all these limitations, the study is novel and one of the few studies conducted in Sudan showing high prevalence of vitamin D in women.

Conclusions

This study revealed a high percentage of vitamin D deficiency (82.6%) among apparently-healthy Sudanese women. Rural residence and sun-exposed skin were found to be significantly associated with vitamin D serum levels. Community-based investigations with larger sample size are expected to affirm these findings additionally and will also allow reference values of vitamin D levels in general Sudanese population to be determined.

Declarations

Ethics approval and consent to participate

Ethical clearance was attained from the Ethical Committee of the Ministry of Health, Khartoum State. Permission was taken from the Administrative of the seven localities and heads of the referral FHCs in Khartoum State for data and sample collection. Informed written consent was obtained from each candidate, and participants' information was kept confidential.

Availability of data and materials

All data generated or analyzed during this study are included in this published article and its supplementary information files.

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Conflicts of interest

There are no conflicts of interest.

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