Prevalence and Predictors of Hypovitaminosis D Among Female University Students in Tabuk, Saudi Arabia

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ABSTRACT

BACKGROUND: A high hypovitaminosis D prevalence has repeatedly been reported in Middle Eastern countries. Previous data regarding the vitamin D status of young women in Saudi Arabia and the related hypovitaminosis D risk factors are scarce, so this research assessed hypovitaminosis D prevalence and its risk factors among apparently healthy female university students in Tabuk, Saudi Arabia.

METHODS: This cross-sectional research used a convenience sample of healthy female students (n = 180) aged between 19 and 25 years in May 2016. Information was gathered on the participants' sociodemographics, health, lifestyle, dietary intakes, anthropometry, and serum 25-hydroxyvitamin D (25(OH)D), and a logistic regression analysis was performed to assess hypovitaminosis D risk factors.

RESULTS: The sample's hypovitaminosis D prevalence (25(OH)D <30 ng/mL) was 80.6%. The main determinants of hypovitaminosis D were as follows: urban residence (odds ratio [OR] = 6.54; 95% confidence interval [CI], 2.74-5.63), rare sun exposure (OR = 6.14; 95% CI, 2.15-17.55), and insufficient vitamin D intake (OR = 2.50; 95% CI, 1.07-5.81).

CONCLUSIONS: The findings emphasize that despite plentiful sunshine, Saudi Arabia and the Middle East face a vitamin D deficiency epidemic. Vitamin D status must therefore be assessed at the national level so that strategies aimed at boosting vitamin D levels can be instigated.

KEYWORDS: hypovitaminosis D, prevalence, predictors, female university students, Saudi Arabia

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Introduction

Vitamin D (or 25-hydroxyvitamin D, 25(OH)D) is a multifunctional prohormone.[1] Scientific understanding of its role has developed from regarding it as a simple vitamin to recognizing its qualities as a steroid prohormone.[2] Vitamin D has a key part to play in human calcium and phosphorus metabolism and consequently in maintaining healthy bones.[3] Vitamin D deficiency has previously been linked to rickets among children and to osteoporosis and osteomalacia among adults.[4,5] Various recent epidemiologic research papers have also identified associations between vitamin D shortages and nonskeletal chronic diseases, such as diabetes mellitus, cardiovascular diseases, hypertension, and autoimmune diseases, and also with cancers of the lung, breast, and colon.[6–9] It has been established that the body's vitamin D is derived from a combination of exposure to sunlight leading to synthesis in the skin and the dietary consumption of ergocalciferol (vitamin D_2) and cholecalciferol (vitamin D_3), the 2 most important vitamin D metabolites in the human diet.[10]

Hypovitaminosis D is a widespread, and increasingly prevalent, health condition affecting around 1 billion people globally.[3,11] The Middle East region enjoys high levels of sunshine which should enable vitamin D synthesis to occur throughout the year, but low levels of vitamin D have been recorded among populations in the region.[12–16] Bassil et al[17] recently conducted a systematic review of work on hypovitaminosis prevalence and predictors in the Middle East and North Africa region, concluding that hypovitaminosis D is extremely common despite the region's high sunshine levels, with a prevalence of between 30% and 90%, and adult risk factors, including older age, female sex, multiparty, season of the year, style of clothing, socioeconomic status, and residence (urban rather than rural). Moreover, an increasing amount of research is confirming widespread vitamin D deficiency among Middle Eastern women[12,13,16,17] and is attributing this to the dominant local cultural traditions which limit skin exposure to sunlight.[18] A prior study has also observed that women of reproductive age who are vitamin D deficient may face an increased risk of reproductive complications and issues, such as preeclampsia, pregnancy-induced hypertension, obstructed labor, vaginosis, and low infant birth weight.[19]

Previous research into the vitamin D status of young women in Saudi Arabia has been scarce, and the few studies which have been conducted in this context have neglected to consider the previously identified risk factors related to vitamin D status, which include various sociodemographic and lifestyle factors, and individuals' dietary intakes of vitamin D and calcium.[20–24] Because of this gap in the prior research, this investigation was specifically designed to explore the prevalence and risk factors previously identified in relation to hypovitaminosis D among a sample of apparently healthy female students enrolled at the University of Tabuk, Saudi Arabia. It is believed that the study's findings will support the design of public health policy by providing a more in-depth understanding of the risk factors and guiding the choice and development of appropriate intervention strategies to reduce the prevalence of hypovitaminosis D.

Methods

Study design and participants

A cross-sectional research study was undertaken using a convenience sample of 180 healthy female students aged between 19 and 25 years at the University of Tabuk, Saudi Arabia, which is a government university in Tabuk City, the largest city in Northwest Saudi Arabia and capital of the Tabuk region. The data were collected at various locations on the University of Tabuk campus, each of which was chosen because of its convenience in allowing students from all the university's various colleges to participate. The data collection took place between May 1, 2016, and May 31, 2016, a month with an average temperature of approximately 32°C, when the weather in Tabuk is generally sunny with clear skies. The final study sample excluded participants with personal medical histories of diabetes, hypertension, liver or renal diseases, endocrine diseases, pregnancy, or lactation; those who had used medication which affects vitamin D levels or bone metabolism; and those who had taken any vitamin or mineral supplements within the 6 months prior to the study. All the individuals who were confirmed as eligible to participate gave their written informed consent after the study objectives and procedures, and their right to withdraw from the research at any time had been explained to them. Approval for the research protocol was sought and obtained from the University of Tabuk's Committee of Research Ethics.

Data collection

Questionnaires were administered by individual interviewers to gather general data on sociodemographics (each participant's age, marital status, and income), residence information (urban or rural), smoking status (smoker or a nonsmoker), and the participants' frequencies of sun exposure and physical activity.

Each participant's height and weight were measured by a nurse as per standardized protocols. A wall-mounted stadiometer was used to measure their height to the nearest 0.5 cm, and their weight was recorded via calibrated scales to the nearest 0.1 kg. Each participant's body mass index (BMI) was then calculated from the measurements taken (weight [kg]/height [m^2]).[25]

The study participants' dietary consumption of vitamin D and calcium was established by deploying a single 24-hour dietary recall survey relating to the previous 24 hours, which was administered by a trained researcher. The resulting dietary intake data were analyzed using WISP (Tinuviel Software), a program which contains data from the sixth edition of the McCance and Widdowson food composition tables, to generate data on the research sample's nutrient intakes.[26] Some customization was performed on the food composition database to ensure that it contained recipes for composite dishes, commercial products (such as newly released foods), and accurate and recent manufacturers' information on foods that the participants had reportedly consumed in their 24-hour recall responses.

Levels of serum 25(OH)D were measured via the collection of blood samples by a registered nurse between 8:00 AM and 11:00 AM in the morning under standardized conditions after the subject had fasted overnight. Blood samples were delivered to the University of Tabuk's clinical laboratory for testing serum 25(OH)D concentrations using electrochemiluminescence immunoassay (Modular Analytics E170; Roche Diagnostics GmbH, Mannheim, Germany). The results generated were expressed in nanogram per milliliter.

Definitions

In this study, the participants' sun exposure was defined as frequent, infrequent, or rare, based on whether they had exposed a minimum of 15% of their skin (eg, their face, arms, and hands) to direct sunlight for at least 15 minutes at least 3 times, twice, or once or less per week, respectively.[27] In assessing their levels of physical exercise, participants taking part in moderate physical activity (eg, walking) for at least 60 minutes at least 3 times per week, twice, or once or less were defined in the research as practicing frequent, infrequent, or rare daily exercise, respectively.[27] Each participant's weight status was categorized in line with the World Health Organization's guidelines as underweight (BMI: <18.5 kg/m^2), normal weight (BMI: 18.5-24.9 kg/m^2), overweight (BMI: 25-29.9 kg/m^2), or obese (BMI: ⩾30 kg/m^2). Their vitamin D status was described using different cutoffs of 25(OH)D levels as follows: vitamin D sufficiency: ⩾30 ng/mL; vitamin D insufficiency: 20-30 ng/mL; vitamin D deficiency: <20 ng/mL; and severe vitamin D deficiency: <10 ng/mL. Therefore, hypovitaminosis D or vitamin D insufficiency was identified as 25(OH) D levels less than 30 ng/mL.[17,24]

Statistical analyses

The SPSS for Windows program (version 23.0; SPSS, Chicago, IL, USA) was used to analyze the data gathered by this study. The statistical significance level of the results was set at $P < .05$. As a preliminary investigation, a univariate logistic regression analysis of the data was performed to establish the statistically significant predictors for hypovitaminosis D. The significant predictor variables indicated by the univariate analysis were

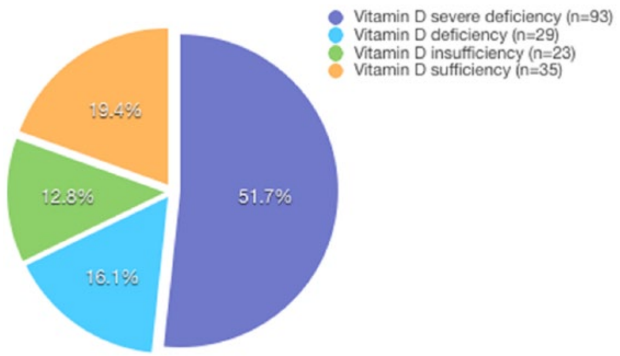

Figure 1. Vitamin D status of the sample (n = 180).

then included in a multiple logistic regression model to identify which of the individual variables could independently predict instances of hypovitaminosis D in the study sample. Calculations of the odds ratio (OR) and their 95% confidence interval (CI) were also performed.

Results

In all, 180 healthy women who were enrolled as students at the University of Tabuk at the time of the study participated in this research. Figure 1 shows that hypovitaminosis D (25(OH)D <30 ng/mL) prevalence was 80.6% (12.8% were insufficient and 67.8% were deficient) among the sample. Furthermore, 51.7% female students had severe vitamin D deficiency (25(OH)D <10 ng/mL).

The univariate logistic regression analyses (Table 1) established that the only variables which were significantly associated with a heightened risk of hypovitaminosis D (25(OH)D <30 ng/mL) were living in urban areas (OR = 4.71; 95% CI, 2.17-10.24), rare sun exposure (OR = 4.38; 95% CI, 1.17-11.14), and insufficient dietary intake of vitamin D (OR = 2.27; 95% CI, 1.06-4.85).

The multivariate logistic regression analysis (Table 2) revealed that the independent risk factors which had associations with hypovitaminosis D were the same 3 variables found by the univariate logistic regression analyses: living in urban areas (OR = 6.54; 95% CI, 2.74-15.63), rare sun exposure (OR = 6.14; 95% CI, 2.15-17.55), and insufficient dietary intake of vitamin D (OR = 2.50; 95% CI, 1.07-5.81).

Discussion

This cross-sectional research found a high prevalence of hypovitaminosis D among its sample of apparently healthy female university students. About 12.8% of the participants had vitamin D insufficiency, and a further 67.8% had vitamin D deficiency. These findings refute the assumption made in some prior studies that people who live in a country like Saudi Arabia, which has abundantly high levels of year-round sunshine, face a lower risk of vitamin D deficiency.[22,28] Moreover, the worryingly high prevalence of hypovitaminosis D observed here is in line with the findings of some previous studies in the Middle Eastern context, and specifically in Saudi Arabia, which also identified a high prevalence.[17] For example, a recent cross-sectional research in Saudi Arabia using a sample of healthy female subjects aged 15 to 24 years revealed that 56.6% had vitamin D insufficiency.[29] Along similar lines, a cross-sectional research in Qatar which used a sample of healthy female university students concluded that almost all the participants had vitamin D insufficiency (more precisely, the sample had a strikingly high prevalence of 97.2%).[30] When taken together, these results indicate that hypovitaminosis D has a high worldwide prevalence and that Saudi Arabia and other Middle Eastern countries are not exempt from this risk despite their high levels of sunshine.

Various risk factors have previously been associated with vitamin D insufficiency or deficiency in different populations.[12] This research has identified 3 factors as statistically significantly associated with the high prevalence of hypovitaminosis D among the study sample of female students. The first factor, living in an urban area, was linked to a 6.5-fold increase in the risk of hypovitaminosis D. To the best of the present authors' knowledge, only 1 study in Saudi Arabia has previously explored the impact of a person's place of residence (ie, urban vs rural) on their vitamin D levels.[24] It found levels of serum 25(OH) vitamin D to be notably higher among rural/semiurban resident populations than among urban ones (28.9 and 26.6 ng/mL, respectively). Other investigations in Middle Eastern contexts have arrived at similar findings[19,31,32]; for example, a cross-sectional research examining a sample of non-pregnant Jordanian women of reproductive age found that in comparison with women living rurally who had attained at least secondary education, the deficiency prevalence was 1.30 times greater for urban women with the same level of education and 1.18 times greater for urban women who had attained a level of education below secondary.[19] These differences in risk levels might be because the UV-B radiation from sunlight is the main human source of vitamin D, so urban residents face a greater risk of vitamin D deficiency because the areas in which they live tend to have higher levels of air pollution which can partially block ultraviolet B photons.[33] This study also proposes that urban Saudi Arabian women generally spend a greater proportion of their time indoors than rural woman do, and they also have different clothing styles, sun protection habits, and sun avoidance attitudes, all of which could contribute to their apparently widespread vitamin D deficiency. There is a need for more research in the Saudi Arabian context to further investigate how individuals' residence status (rural or urban) influences their vitamin D status.

The second risk factor identified in this research as a predictor of hypovitaminosis D among the sample of female students was rare exposure to sun. This finding confirms those of previous studies conducted in Saudi Arabia[24,27,34] and in other Middle Eastern countries[19,32,35,36] by identifying a positive association between an individual's 25(OH)D concentration and their exposure to sunshine. Prior research has emphasized that it is vital that individuals allow themselves sufficient exposure to

Table 1. Univariate logistic regression analysis of the variables associated with hypovitaminosis D (25(OH)D level <30 ng/mL) for the sample (n = 180).

VARIABLES	VITAMIN D STATUS		UNADJUSTED	
	HYPOVITAMINOSIS D (n = 145, 80.6%)	VITAMIN D SUFFICIENCY (n = 35, 19.4%)		
	No. %	No. %	OR	95% CI
Age group, y				
19–22	75 (80.6)	18 (19.4)	1	Ref.
>22–25	70 (80.5)	17 (19.5)	0.99	0.47–2.07
Marital status				
Single	64 (81.0)	15 (19.0)	1	Ref.
Married	81 (80.2)	20 (19.8)	0.95	0.45–2.00
Residential area				
Rural	35 (62.5)	21 (37.5)	1	Ref.
Urban	110 (88.7)	14 (11.3)	4.71	2.17–10.24
Accommodation type				
Flat	41 (89.1)	5 (10.9)	1	Ref.
House	104 (77.6)	30 (22.4)	0.42	0.15–1.17
Monthly household income, SR				
<5000	32 (76.2)	10 (23.8)	1	Ref.
5000–15 000	87 (83.7)	17 (16.3)	1.60	0.66–3.86
>15 000	26 (76.5)	8 (23.5)	1.02	0.35–2.94
BMI status, kg/m²				
<24.9	29 (76.3)	9 (23.7)	1	Ref.
25–29.9	52 (83.9)	10 (16.1)	1.61	0.59–4.43
⩾30	64 (80.0)	16 (20.0)	1.24	0.49–3.14
Smoking status				
Nonsmokers	7 (70.0)	3 (30.0)	1	Ref.
Smokers	138 (81.2)	32 (18.8)	1.85	0.45–7.54
Sun exposure				
Rarely	70 (89.7)	8 (10.3)	4.38	1.17–11.14
Infrequently	41 (80.4)	10 (19.6)	2.05	0.83–5.06
Frequently	34 (66.7)	17 (33.3)	1	Ref.
Usual time of day of sun exposure				
Morning	45 (76.3)	14 (23.7)	0.69	0.29–1.68
Midday	49 (83.1)	10 (16.9)	1.06	0.41–2.71
Evening	51 (82.3)	11 (17.7)	1	Ref.
Daily exercise				
Rarely	62 (86.1)	10 (13.9)	1.73	0.69–4.36
Infrequently	40 (75.5)	13 (24.5)	0.86	0.35–2.10
Frequently	43 (78.2)	12 (21.8)	1	Ref.

Table 1. (Continued)

VARIABLES	VITAMIN D STATUS		UNADJUSTED	
	HYPOVITAMINOSIS D (n = 145, 80.6%)	VITAMIN D SUFFICIENCY (n = 35, 19.4%)		
Dietary vitamin D intake, IU/d[a]				
<DRI	83 (86.5)	13 (13.5)	2.27	1.06–4.85
⩾DRI	62 (73.8)	22 (26.2)	1	Ref.
Calcium intake, mg/d[b]				
<DRI	56 (76.7)	17 (23.3)	0.67	0.32–1.40
⩾DRI	89 (83.2)	18 (16.8)	1	Ref.

Abbreviations: BMI, body mass index; CI, confidence interval; DRI, Dietary Reference Intake; OR, odds ratio; Ref., reference; SR, Saudi Riyal (≈$0.266).
[a]600 IU/d according to DRI for vitamin D.
[b]1000 mg/d according to DRI for calcium.

Table 2. Multivariate logistic regression analysis of the variables associated with hypovitaminosis D (25(OH)D level <30 ng/mL) for the sample (n = 180).

VARIABLES	ADJUSTED	
	OR	95% CI
Residential area		
Rural	1	Ref.
Urban	6.54	2.74–15.63
Sun exposure		
Rarely	6.14	2.15–17.55
Infrequently	2.52	0.93–6.88
Frequently	1	Ref.
Dietary vitamin D intake, IU/d[a]		
<DRI	2.50	1.07–5.81
⩾DRI	1	Ref.

Abbreviations: CI, confidence interval; DRI, Dietary Reference Intake; OR, odds ratio; Ref., reference.
[a]600 IU/d according to DRI for vitamin D.

sunlight to avoid vitamin D deficiency.[37] On average, 5 to 10 minutes of direct exposure of limbs to sunlight (half the minimal erythema dose) produces approximately 3000 IU of vitamin D_3[3]; however, the surface area of a person's body exposed to direct sunlight depends on their choice of clothing, deployment of sunscreen, and general lifestyle.[38] The high prevalence of vitamin D deficiency among Middle Eastern women has previously been associated with inadequate exposure of their skin to sunlight because of their countries' conservative clothing customs, which specify that when outside they should wear items (eg, niqab, hijab) that cover most of their bodies.[12,16,18] In relation to this, previous research which used a sample of women of various nationalities of childbearing age living in the United Arab Emirates[39] found that the mean serum 25(OH)D was 8.6 ng/mL among Emiratis, 12.6 ng/mL among non-Gulf Arabs, and 64.3 ng/mL among Europeans. This research reported the variable of wearing a veil as an independent predictor of hypovitaminosis D. Because the regional culture and religious customs inhibit women in the Middle Eastern region from exposing much of their skin to direct sunlight, it suggested that they should try to increase the amount of time they are partially exposed to sunlight to prevent vitamin D deficiency,[40] an objective which could perhaps be achieved through community or national government projects which create private female-only outdoor spaces for meeting and/or exercising.

Understanding the influence of vitamin D intake on overall vitamin D status is limited in the Saudi Arabian context. The findings of this research indicate that among the sample of female students, insufficient dietary intake of vitamin D was the third independent risk factor associated with hypovitaminosis D. This finding is in line with prior studies in Saudi Arabia[24,41] and in the wider Middle Eastern region.[18,42,43] The dietary sources of vitamin D are quite limited, but seafood is generally regarded as effective regarding this issue.[3] More specifically, higher consumptions of fatty fish and cod liver oil have been identified as responsible for the higher serum vitamin D concentrations among individuals in Norway and Sweden (northern countries with low levels of sunlight) than in Spain and Italy, which are sunny countries.[44] However, seafood is not popular in Saudi Arabia, as highlighted in research by Al-Mogbel[45] which used a sample of 353 Saudi women aged 19 to 40 years and which concluded that most participants (61%) rarely, or never, ate seafood. Along similar lines, research in Jordan also observed that 75% of the Jordanian women in the sample never, or rarely, ate fresh fish or sardines.[38] Other sources of dietary vitamin D include fortified foods (usually milk and other dairy products, margarine and spreads, and some breakfast cereals) and dietary supplements.[46] However, prior research suggests that the fortification level present in dairy products is insufficient to prevent vitamin D deficiency,[47] and that Saudi women rarely consume vitamin D supplements.[29] Therefore, the design of effective policies able to encourage intakes which will support a healthy vitamin D status represents a strategic challenge for government.

As with most population-based studies, this research has several inherent limitations. The first of these is its cross-sectional design, which meant that no conclusions could be drawn in relation to the causal relationships between hypovitaminosis D and the risk factors identified by the study. Second, convenience sampling contains potential bias because it cannot guarantee that all the eligible individuals within a population are equally likely to be included in the study sample. Third, no data were available on participants' protective actions (eg, their habitual avoidance of direct sun exposure and/or their sunscreen use) or on their skin color. Fourth, data on some of the variables presumed to be risk factors, such as exposure to sunlight and levels of physical activity, were only indirectly gathered by the questionnaires, so there is a possibility that recall bias may have been present. The final limitation which must be mentioned here is that reporting a single day of a person's dietary intake might not capture a normal day for them. The 24-hour dietary recall method was carefully designed to gather detailed data on an individual's food and drink intake over one 24-hour period, but it cannot guarantee that this day is typical.

Conclusions

Although Saudi Arabia receives abundant sunshine which should enable year-round vitamin D synthesis, this research identified a high level of hypovitaminosis D prevalence in its sample of healthy female university students. It also found the following independent risk factors for hypovitaminosis D: rare sun exposure, insufficient dietary consumption of vitamin D, and living in urban areas. There is therefore a need at the national level to assess the population's vitamin D status in order that appropriate targeted strategies aiming at vitamin D fortification and supplementation can be put in place.

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Author Contributions

RAA and OA-A designed this research. RAA conducted the analyses of the data which were gathered in the course of the study and drafted the final manuscript, whereas OA-A designed the study protocol and conducted the fieldwork. The authors worked together to interpret the results and agree with the findings and to finalize, check, and approve the manuscript.

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