RESEARCH ARTICLE

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Impact of Nutritional and Environmental Factors on Vitamin D Deficiency

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Abstract

Background: Vitamin D can be obtained through a variety of food sources; however, ultraviolet rays in the sunlight can convert a natural substance in the skin known as ergosterol to vitamin D. **Aim:** This study aims to investigate the prevalence and risk factors linked to vitamin D deficiency among a group of apparently healthy young male and female Tabuk citizens in Saudi Arabia. **Methods:** A cross-sectional study that comprised a convenience sampling method of 350 male and female Tabuk citizens. **Results:** The results indicated a generalized vitamin D deficiency and severe deficiency among the participants, where 74.57% of the population had vitamin D deficiency, and 25.43% reported vitamin D sufficiency. There was a significant positive correlation among the BMI, exercise, exposure to sunlight, vitamin D intake, and calcium intake with vitamin D status (r = 0.574,** 0.525,** 0.515,** 0.466 and 0.465** at p-value < 0.001, respectively). **Conclusion:** The present study indicates vitamin D deficiency to be relatively common even among the population of Saudi Arabia, a country receiving adequate sunlight. Also, Vitamin D and calcium supplementation can prove to be beneficial in correcting the deficiency. Moreover, the individuals at a higher risk of vitamin insufficiency, such as women, need to be educated on the health benefits of vitamin D and calcium supplementation.

Keywords: Vitamin D deficiency- nutritional and environmental factors- Tabuk citizens

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Introduction

Vitamins are organic compounds that lack a definite pattern of synthesis. These neither act as energy providers or nor as body-building foods; yet, they are required in small quantities by living beings for their normal health and development (McDowell, 2012). Vitamin D can be obtained through a variety of food sources; however, ultraviolet rays in the sunlight can convert a natural substance in the skin known as ergosterol to vitamin D. Therefore, intake of vitamin D-fortified foods and adequate exposure to sunlight are considered vital for keeping a healthy vitamin D status. Nutritional complements might be essential to meet the daily requirement for vitamin D status (Dietary supplement fact sheet, 2016; Nair and Maseeh, 2012).

Vitamin D and its metabolites decrease the rate of several cancer types by restraining tumor angiogenesis, inciting mutual adherence of cells, and improving intercellular communication throughout gap junctions, whereby strengthening the inhibition of proliferation that occurs from tight physical association with adjacent cells inside a tissue (contact inhibition) (Garland et al., 2006).

Vitamin D promotes absorption of calcium and phosphorus compounds from the intestines, thereby maintaining the bones in a healthy state (Christakos et al., 2011). However, insufficient intake of vitamin D commonly leads to tooth decay and rickets in growing children. Moreover, in adults, deficiency of vitamin D could lead to osteoporosis and osteomalacia (Carmeliet et al., 2015; Christodoulou et al., 2013). Moreover, it’s recently realized relation with risk of many cancer types is getting substantial attention (Guyton et al., 2001). Other diseases caused due to a deficiency of vitamin D include diabetes mellitus, tension, cancer of lungs, colon or breast, chronic diseases, and cardiovascular diseases (Wang et al., 2017).

Globally, vitamin D deficiency affects around half of the population (Holick, 2007). A systematic review of vitamin D deficiency conducted by Bassil et al., (2013) inferred vitamin D deficiency to occur predominantly (30 to 90%) in the Middle East and North Africa despite exposure to high levels of sunlight and grown-up risks, including female sex, multiparty, period of the year, apparel style, financial status and habitation- urban instead of country.

The Middle East area receives a significant amount of sunlight to allow for sufficient synthesis of vitamin D

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consistently. However, low levels of vitamin D have been recorded among the population in the region (BinSaeed et al., 2015; Nair and Maseeh, 2012). Moreover, women are majorly found to suffer from vitamin D deficiency. A previous study demonstrated that females who are of reproductive age with inadequate vitamin D intake are susceptible to medical conditions, including pregnancy-initiated hypertension, vaginosis, and low newborn birth weight (Nichols et al., 2012). Besides, vitamin D deficiency among the Middle Eastern women has been affirmed by an expanding range of research and ascribed to the popular local traditions that restrict skin exposure to sunlight (Allali et al., 2009).

A cross-sectional study was conducted by Hasanato et al. in 2015 to analyze the vitamin D status and the impact of nutritious and ecological elements on vitamin D level among young female medical students of the King Saud University, Riyadh, Saudi Arabia. The study demonstrated a high prevalence of vitamin D deficiency among female medical students that could be attributed to social and natural elements. Studies of these kinds have been undertaken owing to the outcomes of research conducted in North America, Europe, and Australia that indicate a deficiency of vitamin D among youngsters and grown-ups (Prentice, 2008; Zgaga et al., 2011). However, these circumstances are not distinctive to sunny nations such as the gulf area where the prevalence of vitamin D deficiency has been accounted to be high (Mahdy et al., 2010). Additionally, research into the vitamin D status of young females in Saudi Arabia has been rare, and a few studies conducted in the field have failed to recognize the risk factors associated with vitamin D status that include different lifestyles and dietary intake of vitamin D and calcium (Al Asoom and Ibrahim, 2016; Sulimani et al., 2016).

A systematic review of vitamin D status in connection to cancer risk was conducted by Garland and his colleagues in 2006, comprising 30 of the colon, 13 of the breast, 26 of the prostate, and 7 of ovarian cancer and many that evaluated the relationship of vitamin D receptor genotype with risk of cancer. Age-adjusted death rates for both Breast and colon cancers led to be higher in cities with low-level of sunlight and lessen in sunshiny cities. Residents of sunny areas such as Tabuk in the Saudi Arabia and those with a history of exposure to substantial sunlight levels had a lower risk of prostate cancer (Garland et al., 2006).

In light of this gap in the earlier research, the present study mainly aimed to investigate the prevalence and risk factors linked to vitamin D deficiency among a group of apparently healthy young male and female Tabuk citizens in Saudi Arabia. In addition, we believe that the results of the current study will support the plan of general well-being by providing a comprehensive view of risk factors, which, in turn, might assist in directing the decision and advanced methods to lessen the vitamin D deficiency.

Materials and Methods

Study Design and Participants

The current study was a cross-sectional study that comprised a convenience sampling method of 350 male and female Tabuk citizens aged from 20 to 40 years at the Tabuk City, Saudi Arabia, the biggest city in Northwest Saudi Arabia and capital of the Tabuk area (Labour Force Survey, 2014). Data were gathered at the big major mall in Tabuk and at the University of Tabuk campus between March 15, 2017, and April 30, 2017, to guarantee the portrayal of the populace. The period for data gathering was selected owing to a temperature of around 86 Fahrenheit (^{o}F) when the climate in Tabuk is for the most part sunny with clear skies. The sample size was calculated by the Slovin equation with an alpha estimation of 0.05. The population size (N) was 591,000. The required sample size was at least 337 participants; the researchers involved 350 participants in compensating for any restriction faced during the process of data gathering.

Inclusion criteria included young male and female citizens, between 20 and 40 years old and staying in the Tabuk City. The exclusion criteria included members with a history of diabetes, hypertension, liver or renal illnesses, endocrine diseases, pregnancy, or lactation; individuals who had received medication that influenced vitamin D levels or bone digestion; and individuals who had taken any vitamin or mineral supplements within nine months preceding the study.

Data Collection

A vitamin D survey was conducted to collect the socio-demographic data from the participants, such as gender, age, income, marital status smoking status, and frequencies of exposure to sunlight and physical activity. Moreover, the survey investigated whether the participants had knowledge of vitamin D source and its connection to the risk of osteoporosis, cardiovascular disease, diabetes mellitus, and cancer. The survey also addressed the recurrence, length, and contributing factors to exposure to sunlight and highlighted the intake of dairy products and other nutritious components. The survey also covered the pertinent medical history of the participants and side effects associated with the musculoskeletal system. Vitamin supplementation and utilization of different pharmaceuticals were also taken into consideration.

The height and weight of every participant were measured by a staff nurse according to the conventions set by the institute. A wall-mounted stadiometer was utilized to quantify participants' height to the closest 0.5 cm, whereas their weight was recorded through calibrated scales to the closest 0.1 kg. The body mass index (BMI) of every participant was calculated using the following equation: height (m^2)/weight (kg) (World Health Organization, 2000).

All participants were categorized as underweight body mass index (BMI < 18.5 kg/m^2), typical weight (BMI: 18.5–24.9 kg/m^2), overweight (BMI: 25–29.9 kg/m^2), or obese (BMI: 30 kg/m^2) on the basis of their weight in accordance with the World Health Organization's rules.

Their vitamin D status was studied by utilizing distinctive shorts of 25(OH)D levels as follows: vitamin D sufficiency: 30 ng/mL; vitamin D deficiency: 10–30 ng/mL; and severe vitamin D deficiency < 10 ng/mL. Along these lines, vitamin D deficiency was recognized as 25(OH) D levels under 30 ng/mL (Bassil et al., 2013).

An expert medical laboratory technologist collected 3 mL blood from each participant, which was then transferred to the clinical laboratory of the University of Tabuk for measuring serum 25 (OH)D and studying bone profile (serum calcium, magnesium, phosphorous, and basic phosphatase) using electrochemiluminescence immunoassay (Modular Analytics E170; Roche Diagnostics GmbH). The results of these tests were reported in nanogram per milliliter.

Statistical Analysis

We utilized the SPSS for Windows program (adaptation 23.0; SPSS, Chicago, IL, United States) to analyze the collected data. The statistical significance level of the outcomes was set at p-value < 0.05. As an elementary investigation, we performed a chi-square and linear regression analyses to set up the statistically significant indicators for vitamin D deficiency. The important indicator factors demonstrated by these statistical tests were then incorporated into independently predicted case models to distinguish the individual factors that could be utilized to freely anticipate the cases of vitamin D deficiency in the study sample. Moreover, Spearman rho correlation was employed to analyze the strength and direction of relationship that existed between the socio-demographic and lifestyle variables and vitamin D status.

Changes were made in the food intake database to ensure that it contained all appropriate recipes, commercial products, and contemporary manufacture's data, reflecting the correct information about the food that the participants must have recently taken in 24 hours. Experts kept a watch on the dietary intake of vitamin D and calcium for 24 hours which were related to the previous 24 hours. The results were checked by the Tinuviel software (WISP), a program containing data from the sixth edition tables of the McCance and Widdows on food intake (Tinuviel software: WISP User's Manual., 2003). All this was done so that the data was available on research sample's nutrient consumptions.

Ethical Consideration

The ethical approval was provided by the University of Tabuk (Committee of Research Ethics, number: TU-1437-1030). Written informed consent was submitted by the eligible participants. However, they were provided with the right to withdraw from the study at any time.

Results

The study population was grouped into 11 variables to enable efficient interpretation of the results. The participants aged 20 years and above and the factors investigated included residential area, marital status, age, gender, smoking status, exposure to sunlight, BMI, vitamin D intake, calcium intake, and exercise. The dependent variables were vitamin D sufficiency, vitamin D deficiency, and vitamin D severe deficiency. In the current study, the participants' duration of exposure to sunlight was characterized for no less than 15 minutes with no less than three times every week so that at least 15% of their skin (e.g., their face, arms, and hands) got exposed to direct sunlight. While surveying the participants for their level of physical exercise, those involved in the regular physical movement (e.g., jogging) for no less than 60 minutes and no less than three times each week, twice or once or less were characterized as practicing regular, rare, or uncommon, respectively (Al-Faris, 2016).

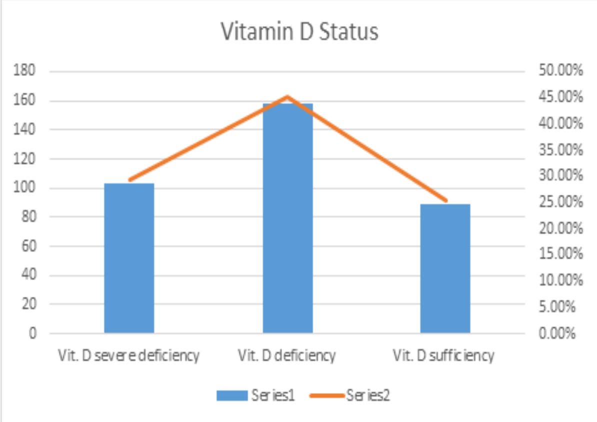

Figure 1. Vitamin D Status among Participants.

A total of 350 healthy males and females participated in this study. Figure 1 displays the frequency of vitamin D deficiency (158 participants among the total sample). A total of 103 participants reported severe vitamin D deficiency (25(OH)D < 10 ng/mL). Moreover, the results indicated a generalized vitamin D deficiency and severe deficiency among the participants, where 74.57% of the population had vitamin D deficiency, and 25.43% reported vitamin D sufficiency.

Table 1 shows socio-demographic and lifestyle features associated with vitamin D deficiency in the study population analyzed using chi-square test. There was a significant difference based on gender (χ^2 = 14.51), smoking (χ^2 = 59), exposure to sunlight (χ^2 = 128.23), BMI (χ^2 = 182.33), exercise (χ^2 = 160.93), vitamin D intake (χ^2 = 128.68), and calcium intake (χ^2 = 111.5) at a p-value of > 0.001* on vitamin D status. Other detailed socio-demographic and lifestyle data are displayed in Table 1.

Table 2 displays the unstandardized regression coefficient (b), standard error, standardized regression coefficient (beta), and t-statistics for each variable, a linear regression analysis was established that demonstrated the relationship between age and vitamin D status; a significant effect of age (t = -2.505, p < 0.013) was reported, the R2 for the model was 0.018 and adjusted R^2 was 0.015.

Table 3 reveals a Spearman's rho correlation amongst

Table 1. Socio-demographic and Lifestyle Features Associated with Vitamin D Deficiency Using Chi-square Analysis

Variables	Vitamin D Sufficiency	Vitamin D Deficiency	Vitamin D Severe Deficiency	Chi-square	P-value
Gender					
Male	50 (33.3%)	70 (46.7%)	30 (20%)	14.51	0.001*
Female	39 (19.5%)	88 (44%)	73 (36.5%)		
Marital status					
Single	43 (26.1%)	74 (44.8%)	48 (29.1%)	0.06	0.96
Married	46 (24.9%)	84 (45.4%)	55 (29.7%)		
Residential area					
Urban	79 (25.8%)	137 (44.8%)	90 (29.4%)	0.21	0.89
Rural	10 (22.7%)	21 (47.8%)	13 (29.5%)		
Income					
> 6,000 SR	38 (32.7%)	51 (44%)	27 (23.3%)	6.07	0.19
6,000-12,000 SR	37 (22.4%)	75 (45.5%)	53 (32.1%)		
< 12000 SR	14 (20.3%)	32 (46.4%)	23 (33.3%)		
Smoking					
Smoker	32 (13.3%)	127 (53%)	81 (33.7%)	59.00	< 0.001*
Non-smoker	57 (51.8%)	31 (28.2)	22 (20%)		
Sun exposure					
Frequently	62 (67.4%)	23 (25%)	7 (7.6%)	128.23	< 0.001*
Sometimes	23 (17%)	72 (53.3%)	40 (29.6%)		
Rarely	4 (3.2%)	63 (51.2%)	56 (45.6%)		
BMI					
<24.9	74 (74%)	18 (18%)	8 (8%)	182.33	< 0.001*
25–29.9	15 (10%)	88 (58.3%)	48 (31.7%)		
≥ 30	0 (0%)	52 (52.5%)	47 (47.5%)		
Exercise					
Frequently	67 (74.4%)	15 (16.7%)	8 (8.9%)	160.93	< 0.001*
Sometimes	19 (12.1%)	90 (57.3%)	48 (30.6%)		
Rarely	3 (2.9%)	53 (51.4%)	47 (45.6%)		
Vitamin D intake					
≥ DRI	73 (62.9%)	26 (22.4%)	17 (14.7%)	128.68	< 0.001*
< DRI	16 (6.8%)	132 (56.4%)	86 (36.8%)		
Calcium intake					
≥ DRI	71 (59.7%)	30 (25.2%)	18 (15.1%)	111.50	< 0.001*
< DRI	18 (7.8%)	128 (55.4%)	85 (36.8%)		

Abbreviations, BMI, body mass index; DRI, Dietary Reference Intake; a 600 I U/d according to DRI for vitamin D. b 1000 mg/d according to DRI for calcium.

Table 2. Age Associated with Vitamin D Status Using Linear Regression Analysis

Coefficients[a]					
Model	Unstandardized Coefficients		Standardized Coefficients	t	P-value
	B	Std. Error	Beta		
(Constant)	2.371	0.138		17.188	< 0.001
Age	-0.010	0.004	-0.133	-2.505	0.013

R^2, 0.018; adjusted R^2, 0.015; a. Dependent Variable, Vitamin D Status. b. Predictors, (Constant); Age

the socio-demographic and lifestyle variables with vitamin D status using Pearson's product–moment correlation. There was a significant positive correlation among the BMI, exercise, exposure to sunlight, vitamin D intake, and calcium intake with vitamin D status (r = 0.574,** 0.525,** 0.515,** 0.466 and 0.465** at p-value < 0.001, respectively). Adversely, smoking was found to have a significant negative relationship with the vitamin D status (r = − 0.328** at p-value < 0.001). Other detailed correlations are presented in Table 3.

Table 3. Spearman's rho Correlation Analysis of the Variables Associated with Vitamin D Status

	Vitamin D Status	
	Correlation Coefficient	P-value
Sun Exposure	0.515**	< 0.001*
BMI	0.574**	< 0.001*
Exercise	0.525**	< 0.001*
Vitamin D Intake	0.466**	< 0.001*
Vitamin D Intake	0.465**	< 0.001*
Smoking	-0.328**	< 0.001*
Age	-0.133*	0.013
Income	0.118*	0.027

Discussion

The current study investigated the prevalence and risk factors associated with vitamin D deficiency among a group of apparently healthy young male and female Tabuk citizens in Saudi Arabia. The results indicate vitamin D deficiency to be common among male and female citizens residing in Tabuk City, the biggest city in the Northwest Saudi Arabia region. The percentage of participants having vitamin D insufficiency was at an alarming 74.57%. We used vitamin sufficiency: 30 ng/mL; vitamin D deficiency: 10–30 ng/mL; and severe vitamin D deficiency < 10 ng/mL as the references. Therefore, 74.57% of the respondents had serum levels of 25(OH)D of less than 30 ng/mL.

Vitamin D is synthesized by the skin upon exposure to direct rays. Vitamin D can also be taken as part of the diet and can, therefore, be sourced from specific foods. These two sources of vitamin D are sufficient to keep serum levels within the recommended range. However, unavailability of one of the sources reduces the serum levels of the vitamin, resulting in its deficiency. Insufficiency of the vitamin is associated with defects in bone formation.

Vitamin D facilitates the intestinal absorption of calcium. The mechanism involves the biosynthesis of calbindin, responsible for transporting calcium through the brush border of the intestine (Heaney, 2008). Also, both calcium and vitamin D are important for the formation of healthy bones. In the present study, vitamin D and calcium intake correlated with vitamin D insufficiency. Previous studies have indicated vitamin D and calcium supplementation to be useful in correcting vitamin D insufficiency (Thacher and Clarke, 2011). Bone diseases, such as rickets and osteomalacia, are the most common consequences of vitamin D insufficiency.

A direct relationship exists between exercise and BMI. A lack of exercise is likely to result in a higher than normal BMI; a higher BMI is an indicator of lack of good health. The present study reported a high percentage of participants with unhealthy BMI to suffer from vitamin D deficiency. However, those in the normal BMI range also reported vitamin D insufficiency. Smoking is another factor that can be used to determine the overall health of an individual. Our study found that both smokers and non-smokers displayed a high percentage of participants with vitamin deficiency.

Despite it being a sunny country, the high prevalence of vitamin D insufficiency in Saudi Arabia is in line with the findings of previous research. For instance, a study on the status of female students in the University of Tabuk (Alzaheb and Al-Amer, 2017) revealed 12.8% of the respondents to have vitamin D insufficiency, and 67.8% were deficient in the vitamin. In our findings, insufficiency of vitamin D was highest among the urban population and in individuals who reported minimum exposure to sunlight. The benefits of sunlight on vitamin D sufficiency were reported by Hovsepian et al., (2011), who analyzed the prevalence of insufficiency among males and females in a sunny city in Iran. They found a high vitamin insufficiency among females, despite the availability of abundant sunlight in the region. They associated the finding with the culture that requires women to wear scarfs and clothing that essentially covers parts of the body such as hands, legs, and neck.

In connection with Hovsepian's report, the current study reported a significant difference in the prevalence of vitamin D insufficiency between male and female participants. The prevalence among males and females was 66.7 and 80.5%, respectively. Saudi Arabia is a Muslim-dominated country, and the law requires women to be covered in abayas, clothing that covers all parts of the body. Therefore, despite the availability of abundant sunlight in Saudi Arabia, women suffer from vitamin D deficiency.

Along similar lines, a study by Hasanato et al., (2015) reported deficiency of vitamin D in 70.8% of a group of young female medical students in a university in Saudi Arabia owing to low exposure to sunlight. The low exposure to sunlight was associated with lack of open spaces and excessive heat. The study findings are consistent with the findings of the present study, where 80.5% of females suffered from vitamin D insufficiency, which was (similar to Hasanato et al., (2015) study) attributed to a lack of exposure to the sunlight.

In conclusion, the results of the present study indicate vitamin D deficiency to be relatively common even among the population of Saudi Arabia, a country receiving adequate sunlight. The factors contributing to the deficiency, as identified by this study, include gender, vitamin D and calcium intake, and sunlight exposure. Vitamin D and calcium supplementation can prove to be beneficial in correcting the deficiency. Moreover, the individuals at a higher risk of vitamin insufficiency, such as women, need to be educated on the health benefits of vitamin D and calcium supplementation.

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