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Prevalence of Vitamin D Deficiency and its Association with Age, Sex and Ethnicity in Albaha, Saudi Arabia

Abdulmajeed Abdulghani A Sindi[1*], Mohammad A Albanghali[2], Mohammad A Izhari[3], Saleh Alghamdi[4], Fayez S Alghamdi[5], Mohammed A Shanawaz[2], Raed A Alharbi[3], Abdullah S Alsulaiman[6], Osama Abdulaziz[7], Naseem Akhter[3]

[1]Department of Basic Medical Sciences, Faculty of Applied Medical Sciences, Albaha University, Albaha, Saudi Arabia

[2]Department of Public Health, Faculty of Applied Medical Sciences, Albaha University, Albaha, Saudi Arabia

[3]Department of Laboratory Medicine, Faculty of Applied Medical Sciences, Albaha University, Albaha, Saudi Arabia

[4]Department of Clinical Pharmacy, Faculty of Clinical Pharmacy, Albaha University, Albaha, Saudi Arabia

[5]Department of Academic Affairs, King Fahad Hospital, Albaha, Saudi Arabia

[6]Molecular Pathology Genetic Division, Alhada Armed Forces Hospital, Defence Ministry, Taif, Saudi Arabia

[7]Department of Clinical Laboratory Sciences, Faculty of Applied Medical Sciences, Taif University, Taif, Saudi Arabia

ABSTRACT

Hypovitaminosis D is a rising public health concern, rendering a billion people at risk of multiple health issues globally. The present study aimed to assess the prevalence of vitamin D deficiency and its association with age, sex and ethnicity in the population of Albaha, Saudi Arabia. A retrospective study was performed involving 10,070 subjects from Albaha. The demographics and laboratory results of the subjects were retrieved from hospital records. The mean age (SD) of all subjects was 39 (± 19). The mean vitamin D level (SD) of all Saudis was 24.7 ng/ml (± 14), while that of non-Saudis was 23.4 ng/ml (± 13). The mean ± SD vitamin D level of Saudi males or females was 25 ± 14 ng/ml, while the level of non-Saudi males (25 ± 13 ng/ml) and non-Saudi females was 23 ± 13 ng/ml. Of all subjects, 45.9% (n=4,624), 26.3% (n=2,645) and 27.8% (n=2,801) were vitamin D deficient, insufficient and sufficient, respectively. Regarding sex, the prevalence of vitamin D deficiency was slightly higher in females (males: 45.2%, females: 46.2%, OR=0.97, p=0.6), whereas females were less likely to be vitamin D insufficient (OR=0.88, p=0.038). Non-Saudi subjects (48.8%) showed higher prevalence of vitamin D deficiency (OR=1.26, p=0.04) compared to Saudi subjects (45.78%). In children (categorized as <2, 2–6, 7–11 and 12–18 years), vitamin D deficiency increased with age (9.6%, 14.7%, 37.6% and 54.0%, respectively). Children aged 2–6 years (OR=0.35, p=0.001) and <2 years were less likely to be vitamin D deficient than children aged 12–18 years. The incidence of vitamin D insufficiency also correlated with increasing age in children aged up to 7–11 years. However, the prevalence of vitamin D deficiency was found to decrease with age in the adult groups [19–39 (57.3%), 40–59 (42.9%) and >60 (36%)]. A similar trend was observed in the male, female and Saudi age categories. Saudi's aged between 19 and 39 years (OR=3.3, p<0.001) were more likely to be vitamin D deficient than those aged >60 years. Hypovitaminosis D in subjects from Albaha was found to be around 72%, with it being more prevalent in children aged 12–18, adults aged 19–39 and non-Saudis. Health education, regular health screening, vitamin D fortification by regular sun exposure and supplementation policy could be worthwhile to address vitamin D deficiency-related health problems, especially for high-risk groups.

Key words: Hypovitaminosis D, Deficiency, Vitamin D, Albaha, Prevalence

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Corresponding author: Abdulmajeed Abdulghani A Sindi
e-mail ✉ :asindi@bu.edu.sa
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INTRODUCTION

Hypovitaminosis D, either vitamin D deficiency or insufficiency, is a serious public health concern worldwide, including in South Asia and the Middle East [1-4]. Regardless of ethnicity, approximately a billion people are at risk of Hypovitaminosis D globally [5,6]. This issue impacts all age groups and sex to varying degrees of deficiency [1,7-11].

Hypovitaminosis D eventuates as a consequence of multiple factors: decreased endogenous synthesis or bioavailability, enhanced metabolic need and enhanced loss of vitamin D via urine [12]. Vitamin D is a fat-soluble vitamin with unique metabolic and physiological features. It plays a significant role in calcium homeostasis and in the process of skeletal mineralization [13]. Biological demand for vitamin D in humans is met by either exogenous sources (dietary supplements) or through *de novo* synthesis aided by exposure to ultraviolet light (90% of the total requirement) [14-16]. Both forms of vitamin D, cholecalciferol (vitamin D3) and ergocalciferol (D2), are initially metabolized in the liver in similar ways [17]. Hepatic hydroxylation of vitamin D gives rise to 25-hydroxyvitamin D [25(OH)D], which is converted by the 1α-hydroxylase enzyme in the kidneys into a physiologically active form: 1,25hydroxyvitamin D [1,25(OH)2D] [18]. Serum calcium and phosphorus and fibroblast growth factor-23 play important roles in this renal production [19].

In combination with multiple physiological factors, vitamin D regulates calcium and phosphorous metabolic processes and consequently plays a vital role in maintaining neuromuscular and skeletal health in the human body [20,21]. Vitamin D also enhances insulin production by pancreatic β cells [22]; it indirectly impacts insulin production and activity by increasing the cellular calcium level [23]. Vitamin D has immune modulatory functions and regulates cell proliferation and differentiation. Therefore, Hypovitaminosis D has various impacts on health and may increase the risk of chronic clinical illness, including autoimmune disorders, cancers and cardiovascular diseases [24].

Decreased cancer incidence and mortality have been reported in individuals with higher levels of vitamin D [25]. Various systematic reviews have reported an association of vitamin D deficiency with arterial hypertension [26], the role of an increased vitamin D level in reducing blood pressure [27] and an increased prevalence of cases of hypertension in individuals with low levels of vitamin D. Together, these reports indicate that Hypovitaminosis D contributes to hypertension and therefore cardiovascular conditions [28]. Association of Hypovitaminosis D with psychological disorders, diabetes, impaired epithelial function, exaggerated risk of lethal infectious diseases (e.g., tuberculosis and acquired immunodeficiency syndrome) and compromised regulatory processes have also been reported [28-32]. A higher risk of anaemia in childhood and old age with chronic kidney and heart condition co-morbidities has also been associated with Hypovitaminosis D [33,34].

Humans are highly dependent on exposure to sunlight to meet their vitamin D biological requirements. Despite the sunny climate in the Kingdom of Saudi Arabia (KSA), paradoxically, the prevalence of Hypovitaminosis D has been reported to be much higher across different age groups, particularly in females, in comparison to countries with less sunny climates [35-37]. In many neighbouring countries, such as the United Arab Emirates, Egypt and Qatar, Hypovitaminosis D and its serious health impacts have been extensively reported in the literature. This compelled the researchers involved in the current study to further investigate the prevalence of Hypovitaminosis D in the Middle East, particularly in the KSA [38-40]. In view of the greater prevalence of vitamin D deficiency in some KSA cities [41], inconsistent scientific findings and the lack of community-based Hypovitaminosis D prevalence studies in the KSA, this study aimed to investigate vitamin D deficiency in the population residing in the Albaha region of the KSA.

MATERIALS AND METHODS

Study design

A retrospective study was conducted to collect data to evaluate the prevalence of Hypovitaminosis D. Data were collected from patients visiting multiple primary healthcare centres and general hospitals in Albaha city, KSA, over a period of 22 months between January 2019 and October 2020. The data were anonymized and included information on: sex; age; nationality; sample day and time; location and clinic; and 25 (OH) D concentrations (ng/ml).

Data collection

A total of 10,070 subjects were included in this study. The cut-offs values for serum vitamin D levels were adjusted in accordance with the Endocrine Society Clinical Practice Guideline. The levels were set as: sufficient (30 ng/ml), insufficient (20–29.9 ng/ml) and deficient (< 20 ng/ml) [42-44]. In addition, patients were stratified according to sex, nationality (Saudi and non-Saudi) and age [child ≤18 years (sub classified into <2, 2–6, 7–11 and 12–18) and adult >18 years (sub classified into 19–39, 40–59 and ≥ 60)].

Statistical analysis

The data were analysed using the Statistical Package for the Social Sciences software (SPSS) version 20.0 (IBM, Armonk, NY). Both the mean ± standard deviations (SD) and median ± interquartile range (IQR) were computed for continuous variables. Descriptive statistics are presented in tables and figures. For identifying the risk factors that might be associated with vitamin D deficiency or insufficiency, a multivariate logistic regression analysis was performed providing odds ratios

(OR) and 95% confidence intervals (CI). The level of significance was adjusted at p values=0.05.

RESULTS

Subjects' characteristics

A prospective observational investigation was conducted to determine the prevalence of Hypovitaminosis D in Albaha in the KSA. The 25(OH)D levels of 10,070 subjects were examined. The mean ± SD age of the subjects was 39 ± 19 and the mean ± SD vitamin D concentration was 24.7 ± 14 ng/ml (Table 1). The demographic characteristics of the subjects are summarised in Table 1.

Table 1: Demographic characteristics and vitamin D status of the subjects.

Categories		N	%	Variables			
				Age (years)		Vitamin D (ng/ml)	
				Mean ± SD	Median (IQR)	Mean ± SD	Median (IQR)
All subjects		10,070	100	39 ± 19	39 (25-54)	24.7 ± 14	21 (14-31)
Male		2,890	28.7	37 ± 22	36 (18-54)	24.7 ± 13	21 (15-31)
Female		7,180	71.3	40 ± 18	40 (28-53)	24.7 ± 14	21 (14-32)
Saudi		9,611	95.4	39 ± 20	39 (25-54)	24.7 ± 14	21 (14-32)
Non-Saudi		459	4.6	39 ± 14	37 (30-48)	23.4 ± 13	20 (14-29)
Saudi male		2,807	29.2	37 ± 23	35 (18-54)	25.0 ± 14	21 (15-31)
Saudi female		6,804	70.8	40 ± 18	40 (30-47)	25.0 ± 14	21 (14-29)
Non-Saudi male		83	18.1	39 ± 18	41 (29-53)	25.0 ± 13	21 (15-30)
Non-Saudi female		376	81.9	39 ± 13	36 (27-54)	23.0 ± 13	20 (14-32)
Age categories							
Child	<2	104	1.03	-	-	41.3 ± 17	40 (28-53)
	2-6	375	3.73	4 ± 1	3 (2-5)	34.7 ± 15	31 (23-44)
	7-11	434	4.31	9 ± 1	9 (8-11)	24.6 ± 11	23 (17-29)
	12-18	698	6.93	15 ± 2	15 (13-17)	21.8 ± 12	19 (13-27)
Adult	19-39	3,512	34.9	30 ± 6	30 (25-35)	21.7 ± 13	18 (12-27)
	40-59	3,306	32.8	49 ± 6	49 (44-54)	25.1 ± 13	22 (15-32)
	≥60	1,641	16.3	69 ± 8	67 (63-74)	27.7 ± 15	24 (16-36)
Male in age categories							
Child	<2	51	1.8	-	-	39 ± 16	37 (26-53)
	2-6	211	7.3	4 ± 1	3 (2-5)	35 ± 15	32 (24-44)
	7-11	196	6.8	9 ± 1	9 (8-10)	26 ± 11	24 (18-31)
	12-18	291	10.1	15 ± 2	14 (13-16)	23 ± 12	20 (15-28)
Adult	19-39	846	29.2	29 ± 6	30 (24-34)	21 ± 12	17 (13-26)
	40-59	740	25.6	49 ± 6	48 (44-54)	24 ± 13	21 (15-29)
	≥ 60	555	19.2	70 ± 9	69 (63-77)	26 ± 14	23(16-33)
Female in age categories							
Child	<2	53	0.7	-	-	43 ± 18	44 (29-55)
	6-Feb	164	2.3	4 ± 1	3 (2-5)	34 ± 15	31 (23-44)
	11-Jul	238	3.3	9 ± 1	9 (8-11)	24 ± 11	21 (16-28)
	12-18	407	5.7	15 ± 2	15 (13-17)	21 ± 12	18 (12-26)
Adult	19-39	2,666	37.1	30 ± 6	30 (2635)	22 ± 14	18 (12-28)
	40-59	2,566	35.7	49 ± 6	49 (44-54)	26 ± 14	23 (15-33)
	≥ 60	1,086	15.1	69 ± 8	66 (62-73)	28 ± 16	25 (17-37)

Overall vitamin D status

The overall prevalence of Hypovitaminosis D in the population of the Albaha region was 72.2%; 45.9% (n=4,624) of the subjects were found to be vitamin D deficient (13.6 ± 4 ng/ml) and 26.3% (n=2,645) were found to be vitamin D insufficient (24 ± 3 ng/ml, Table 2). Only 27.8% (n=2,801) of the subjects had sufficiency of vitamin D (43 ± 12 ng/ml, Table 2 and Figure 1).

Table 2: Overall prevalence of vitamin D status among Albaha's population.

N		%	Age (years)							
			Vitamin D (ng/ml)		All		Child ≤ 18		Adult >18	
			Mean ± SD	Median (IQR)	Mean ± SD	Median (IQR)	Mean ± SD	Median (IQR)	Mean ± SD	Median (IQR)
Sufficient	2,801	27.8	43 ± 12	40 (34-49)	41 ± 21	43 (27-58)	7 ± 5	5 (2-16)	49 ± 16	49 (36-60)
Insufficient	2,645	26.3	24 ± 3	24 (22-27)	39 ± 20	40 (25-54)	10 ± 5	10 (6-13)	46 ± 15	45 (34-57)
Deficient	4,624	45.9	13.6 ± 4	14 (11-17)	38 ± 17	36 (25-50)	12 ± 4	13 (10-11)	42 ± 16	39 (29-52)

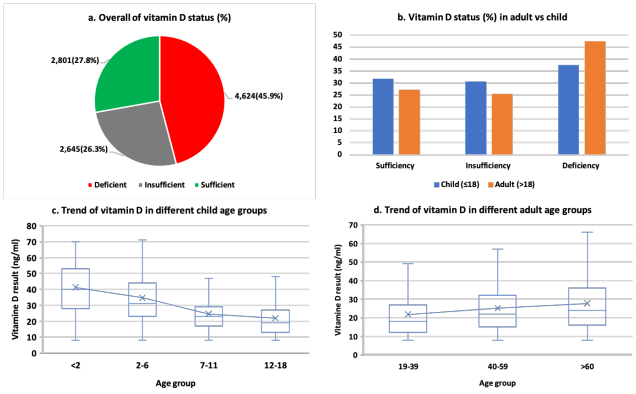

Figure 1: Vitamin D status of all subjects and in the child and adult categories. (A) Pie chart showing the overall prevalence of vitamin D deficiency, insufficiency and sufficiency in all subjects. (B) Bar chart showing the prevalence of each vitamin D status according to the two main age groups: child (18) and adult (18). Boxplots showing the trends in vitamin D concentration across the different age groups of children (C) and adults (D). Vitamin D results (concentration, ng/ml) are depicted on the y-axes, and age groups on the x-axes for the child category (<2, 2–6, 7–11, 12–18) and adult category (19–39, 40–59 and 60).

Vitamin D status by age

Comparative assessment of Hypovitaminosis D was accomplished between two age categories: child (≤ 18 years) and adult (>18 years).

Vitamin D deficiency was higher in the adult group and vitamin D sufficiency was higher in the child group (Figure 1b).

The mean vitamin D concentrations in different child and adult sub-categories are shown in Figures 1c and 1d, with opposite trends observed in these two groups. In the child group, vitamin D was found to decrease with age, while in the adult sub-categories, the vitamin D level was found to consistently increase with age.

In the child age subgroups, vitamin D deficiency was the most prevalent (54%) in the 12–18 group (Table 3) and then in the 7–11 group (37.6%).

The prevalence of vitamin D deficiency in the 2–6 and <2 groups was approximately 15% and 10%, respectively.

In contrast to the 12–18 group, the 7–11, 2–6 and <2 groups were 50%(OR=0.5, p=0.001), 92% (OR=0.08, p=0.001) and 96%(OR=0.04, p=0.001) less likely to be vitamin D deficient.

The child group with the greatest vitamin D insufficiency was the 7–11 group, and the <2 group had the lowest vitamin D insufficiency (17.3%).

Indeed, compared with the 12–18 group, the 2–6 and <2 groups showed lower probability of being vitamin D insufficient by a factor of 0.35 (p=0.001) and 0.15 (p=0.001), respectively.

In the adult category, the 19–39 groups exhibited the highest level of vitamin D deficiency (57.3%), followed by the 40–59 groups (42.9%) (Table 3). The adult group with the greatest vitamin D insufficiency was the 40–59 groups.

The ≥ 60 group was found to have the greatest vitamin D sufficiency (37%). The 19–39 group was 3.3 times (OR=3.3, p<0.001) and 1.5 times (OR=1.5, p<0.001) more likely to be deficient and insufficient, respectively, with respect to the 60 group (Table 3).

The 40–59 group showed 70% (OR=1.7, p<0.001) and 30% (OR=1.3, p=0.001) higher probability of being vitamin D deficient and insufficient, respectively, compared to the ≥ 60 group.

Table 3: Associations between Vitamin D status and sex, nationality and age.

		Sufficiency			Insufficiency					Deficiency				
		N	%	Mean ± SD (ng/ml)	N	%	Mean ± SD (ng/ml)	OR (95%CI)	p value	N	%	Mean ± SD (ng/ml)	OR (95%CI)	p value
Overall		2,801	27.8	43 ± 12	2,645	26.3	24 ± 3			4,624	45.9	13.6 ± 4		
Sex														
Male		779	27	42.9 ± 11	803	27.8	24.2 ± 2	1		1,308	45.2	14.1 ± 3	1	0.6
Female		2,022	28.2	43 ± 11	1,842	25.6	24.5 ± 2	0.88 (0.7-0.9)	0.038*	3,316	46.2	13.4 ± 3	0.97 (0.8-1.1)	
Nationality														
Saudi		2,693	28.02	43 ± 11	2,518	26.2	24.4 ± 2	1		4,400	45.78	13.6 ± 3	1	0.04*
Non- Saudi		108	23.53	41 ± 12	127	27.67	24.4 ± 2	1.2 (0.9-1.6)	0.08	224	48.8	14.2 ± 3	1.26 (1-1.6)	
Age														
Child	<2	76	73.1	48.9 ± 13	18	17.3	24.6 ± 3	0.15 (0.08-0.2)	0.001*	10	9.6	13.6 ± 4	0.04 (0.02-0.08)	0.001*
	6-Feb	208	55.5	45.3 ± 12	112	29.9	24.6 ± 3	0.35 (0.4-0.6)	0.001*	55	14.7	15.5 ± 3	0.08 (0.06-0.1)	0.001*
	11-Jul	101	23.3	40.1 ± 11	170	39.2	24.4 ± 3	1.1 (0.7-1.5)	0.62	163	37.6	15.2 ± 3	0.5 (0.4-0.7)	0.002*
	18-Dec	127	18.2	42.0 ± 11	194	27.8	24.2 ± 3	1		377	54	13.8 ± 3	1	
Adult	19-39	714	20.3	43.5 ± 12	786	22.4	24.3 ± 3	1.5 (1.2-1.7)	0.001*	2,012	57.3	13.2 ± 3	3.3 (2.9-3.8)	0.001*
	40-59	968	29.3	42.4 ± 11	921	27.9	24.5 ± 3	1.3 (1.1-1.5)	0.001*	1,417	42.9	13.8 ± 3	1.7 (1.5-2)	0.001*
	>60	607	37	43.6 ± 12	444	27.1	24.3 ± 3	1		590	36	13.9 ± 3	1	0.001*
Male in different age groups														
Child	<2	37	72.5	46.6 ± 11	8	15.7	23.8 ± 2	0.1 (0.05-0.3)	0.001*	6	11.8	13.2 ± 4	0.07 (0.02-0.2)	0.001*
	6-Feb	120	56.9	45.3 ± 12	62	29.4	24.3 ± 3	0.3 (0.2-0.5)	0.001*	29	13.7	15.3 ± 3	0.1 (0.05-0.2)	0.001*
	11-Jul	58	29.6	38.9 ± 10	76	38.8	24.4 ± 3	0.8 (0.5-1.3)	0.4	62	31.6	15.3 ± 3	0.4 (0.2-0.7)	0.001*
	18-Dec	58	19.9	41.5 ± 11	92	31.6	24.3 ± 3	1		141	48.5	14.6 ± 3	1	
Adult	19-39	143	16.9	43.6 ± 12	190	22.5	24.0 ± 3	1.6 (1.2-2.1)	0.004*	513	60.6	13.8 ± 3	3.2 (2.4-4.1)	0.001*
	40-59	177	23.9	42.9 ± 11	217	29.3	24.1 ± 3	1.4 (1.1-1.9)	0.01*	346	46.8	14.1 ± 3	1.7 (1.3-2.2)	0.001*
	>60	186	33.5	41.7 ± 11	158	28.5	24.1 ± 3	1		211	38	13.9 ± 3	1	
Female in different age groups														
Child	<2	39	73.6	51.1 ± 14	10	18.9	25.1 ± 3	0.17 (0.8-0.3)	0.001*	4	7.5	14.1 ± 4	0.03 (0.01-0.08)	0.001*
	6-Feb	88	53.7	45.5 ± 12	50	30.5	25.0 ± 3	0.38 (0.2-0.6)	0.001*	26	15.9	15.6 ± 4	0.09 (0.05-0.1)	0.001*
	11-Jul	43	18.1	41.7 ± 13	94	39.5	24.3 ± 3	1.4 (0.9-2.3)	0.1	101	42.4	15.2 ± 3	0.6 (0.4-1.1)	0.09

	18-Dec	69	17	42.5 ± 12	102	25	24.0 ± 3	1		236	58	13.4 ± 3	1	
Adult	19-39	571	21.4	43.4 ± 12	596	22.4	24.3 ± 3	1.5 (1.2-1.8)	0.001*	1,499	56.2	12.9 ± 3	2.9 (2.4-3.4)	0.001*
	40-59	791	30.8	42.3 ± 11	704	27.4	24.6 ± 3	1.3 (1.1-1.5)	0.003*	1,071	41.7	13.7 ± 3	1.5 (1.2-1.7)	0.001*
	>60	421	38.8	44.4 ± 12	286	26.3	24.4 ± 3	1		379	34.9	13.8 ± 3	1	
	Saudi in different age groups													
Child	<2	75	72.8	49.2 ± 13	18	17.5	24.6 ± 3	0.15 (0.08-0.2)	0.001*	10	9.7	13.6 ± 4	0.04 (0.02-0.09)	0.001*
	6-Feb	203	55.2	45.5 ± 13	110	29.9	24.6 ± 3	0.3 (0.2-0.4)	0.001*	55	14.9	15.5 ± 3	0.1 (0.06-0.1)	0.001*
	11-Jul	99	23.4	40.1 ± 11	165	39	24.4 ± 3	1.1 (0.8-1.5)	0.6	159	37.6	15.2 ± 3	0.5 (0.3-0.7)	0.002*
	18-Dec	125	18.2	41.9 ± 11	194	28.3	24.2 ± 3	1		367	53.5	13.8 ± 3	1	
Adult	19-39	677	20.6	43.6 ± 12	732	22.3	24.2 ± 3	1.5 (1.3-1.8)	0.001*	1,879	57.1	13.1 ± 3	2.8 (2.4-3.2)	0.001*
	40-59	922	29.4	42.5 ± 11	869	27.7	24.5 ± 3	1.3 (1.1-1.5)	0.001*	1,348	42.9	13.7 ± 3	1.5 (1.3-1.7)	0.001*
	>60	592	36.9	43.7 ± 11	430	26.8	24.3 ± 3	1		582	36.3	14.9 ± 3	1	
	Non-Saudi in different age groups													
Child	<2	1	100	30	0	0	-	-	-	0	0	-	-	-
	6-Feb	5	71.4	39.8 ± 14	2	28.6	23.0 ± 4	-	-	0	0	-	-	-
	11-Jul	2	18.2	39.5 ± 7	5	45.5	24.0 ± 1	-	-	4	36.4	15.3 ± 3	-	-
	18-Dec	2	16.7	47.5 ± 19	0	0	-	-		10	83.3	14.1 ± 3	-	
Adult	19-39	37	16.5	41.2 ± 11	54	24.1	24.3 ± 3	1.6 (0.6-3.6)	0.3*	133	59.4	13.7 ± 3	6.7 (2.6-17.1)	0.001*
	40-59	46	27.5	41.4 ± 12	52	31.1	24.5 ± 3	1.2 (0.5-2.7)	0.6	69	41.3	14.9 ± 3	2.8 (1.1-7.1)	0.3
	>60	15	40.5	41.3 ± 13	14	37.8	24.2 ± 2	1		8	21.6	14.5 ± 4	1	

Vitamin D status by sex

The prevalence of vitamin D deficiency was slightly higher in females (46.2%, n=3,316) compared to males (45.2%, n=1,308). However, male subjects were 1.12 times (OR=0.88, 95%CI=0.7–0.9, p=0.083) and 1.031 times (OR=0.97, 95%CI=0.8–1.1, p=0.6) more likely to be vitamin D insufficient and deficient compared to female subjects (Table 3).

Vitamin D status by nationality

The prevalence of vitamin D deficiency was slightly higher in non-Saudi subjects (48.8%, n=224) compared to Saudi subjects (45.78%, n=4,400) (Table 3). In total, 27.67% (n=127) and 26.2% (n=2,518) of non-Saudi and Saudi subjects, respectively, were found to be vitamin D insufficient. The probability of Hypovitaminosis D (deficiency and insufficiency) was assessed to compare the two ethnic groups. Non-Saudi subjects exhibited a 26% (OR=1.26, p=0.04) and 20% (OR=1.2, p=0.08) higher chance of being vitamin D deficient and insufficient, respectively, in comparison to Saudi subjects.

Vitamin D status and interaction between variables

When sex and age were analysed, for both the male and female child categories, the eldest age group [12–18] was found to have the highest vitamin D deficiency, with 48.5% and 58% prevalence, respectively (Table 3). Prevalence of vitamin D insufficiency was found to be approximately 39% in the 7–11 group of both male and female children. The most impacted age group in both nationality categories (Saudi child and non-Saudi child) was the 12–18 group, and the deficiency prevalence was 83.3% in non-Saudi children and 53.5% in Saudi children. In adults, the 19–39 group showed the greatest

level of vitamin D deficiency for both males (60.6% deficient) and females (56.2% deficient). Males and female adults showed equal levels of vitamin D insufficiency (28%) in the 40–59 groups. Saudi (57.1%) and non-Saudi (59.4%) adults showed almost equal levels of vitamin D deficiency in the most affected age group (19–39). The same mean ± SD (25 ± 14 ng/ml) vitamin D level was recorded for Saudi males, Saudi females and non-Saudi males, while that of non-Saudi females was slightly lower (23 ± 13 ng/ml). All males, all females and all Saudis were found to have almost the same mean ± SD vitamin D level (24.7 ± 14 ng/ml), whereas that of all non-Saudis was slightly lower (23.4 ± 13 ng/ml). The probability of a male adult, male child, female adult and female child being vitamin D deficient or insufficient was almost similar to that of all adults and children (Table 3). When compared to the >60 years age group, the 19–39 group of non-Saudi adults exhibited a greater likelihood of being deficient and insufficient by a factor of 6.7 (p=0.001) and 1.6 (p=0.001), respectively (Table 3). However, when compared to the >60 years age group, the 19–39 and 40–59 groups of Saudi adults were deficient by a factor of 2.8 (p=0.001) and 1.5 (p=0.001), respectively (Table 3). Lastly, in comparison to the 12–18 years age group, all other groups of Saudi children were less likely to have Hypovitaminosis D (deficiency and insufficiency) to a greater extent.

DISCUSSION

Addressing health disparities has been the principal focus of recent public health endeavours [45]. To that end, many essential micronutrients and their deficiency-related health issues have become a major point of discussion in the community of biochemical research; vitamin D and its deficiency in the global population have attracted the attention of the scientific community in recent years [46]. This retrospective observational study examined the prevalence of Hypovitaminosis D, specifically 25(OH)D levels, in the Albaha population in the KSA. Even though vitamin D status has been investigated in other regions of the KSA, this is the first time a study has been conducted on Hypovitaminosis D in Albaha. Previous studies revealed that demographic factors (age, sex and ethnicity) are major determinants of 25(OH)D concentration level [4,47]. Association of vitamin D status with major demographic determinants of vitamin D concentration levels in the Albaha population has been identified in the present study. The prevalence of vitamin D deficiency, insufficiency and sufficiency was determined by analysing 25(OH)D levels in 10,070 study subjects. The average concentration of vitamin D was approximately 25 ng/ml, suggesting that Hypovitaminosis D is prevalent in the population. Of all subjects, 45.9% were found to be deficient in vitamin D and 26.3% were found to have vitamin D insufficiency. The prevalence of Hypovitaminosis D (vitamin D deficiency and insufficiency altogether) was 72.2%, commensurate with the reported prevalence of Hypovitaminosis D in different KSA regions, which is 28–75% [10,48,49]. After conducting a meta-analysis (2008–2015), Al-Alyani et al. reported the prevalence of vitamin D deficiency in the KSA to be around 65% [44]. Although, because of the lack of uniformity in cut-off values applied to differentiate vitamin D deficiency from sufficiency, it is difficult to definitively compare rates of deficiency and sufficiency reported in different studies [50]; 27.8% vitamin D sufficiency was observed in the present study.

The prevalence of vitamin D deficiency in non-Saudi and Saudi subjects was 48.8% and 45.78%, respectively, while that of vitamin D insufficiency in non-Saudi and Saudi subjects was 27.67% and 26.2%, respectively. These results suggest that vitamin D deficiency and insufficiency are more prevalent in the non-Saudi population compared to the Saudi population in the region, which is in contrast to the findings of a cross-sectional study of the population of Al-Madinah Munawara, KSA [51]. This could be due to higher altitude and genetic, nutritional, socioeconomic and environmental factors. Non-Saudi subjects exhibited a 26% (OR=1.26, p=0.04) and 20% (OR=1.2, p=0.08) higher chance of being vitamin D deficient and insufficient, respectively, than Saudi subjects. Although both Saudi and non-Saudi populations living in Albaha experience low sun exposure due to the high altitude climate zone, the higher incidence of Hypovitaminosis D in non-Saudis may be attributed to their genetics and poor socioeconomic status and thereby the insufficient dietary supplementation of vitamin D, which is a major predictor of vitamin D deficiency [52,53].

The prevalence of vitamin D deficiency was marginally higher in females (46.2%) compared to males (45.2%). A higher prevalence of vitamin D deficiency in females in the KSA has been reported previously [41,54,55], however, few other studies have described a higher prevalence of vitamin D deficiency in males too [7,9]. This finding (a higher prevalence of vitamin D deficiency in females in the KSA) is in accordance with those emanating from a cross-sectional multi-stage survey report [2]. Since vitamin D deficiency is a multi-factorial phenomenon, it is important to determine the associated risk factors, particularly those for females, to manage and reduce vitamin D deficiency-related health issues in vulnerable populations.

In the overall child, male child and female child categories, the 12–18 age groups exhibited the lowest vitamin D status (21–23 ng/ml). A higher prevalence of vitamin D deficiency was observed in the 12–18 group (54%) compared to the 7–11 groups (37.6%) in child category. The prevalence of vitamin D deficiency in the male and female 12–18 groups was 48.5% and 58%, respectively. The same group (12–18) also showed the highest prevalence of vitamin D deficiency for Saudi (53.5%) and non-Saudi children (83.3%). In contrast to the 12–18 group, the 7–11, 2–6 and <2 groups were determined to be 50% (OR=0.5, p=0.001), 92% (OR=0.08, p=0.001) and 96% (OR=0.04, p=0.001) less likely to be vitamin D deficient.

Compared with the 12–18 group, the 2–6 and <2 groups showed a lower probability of being vitamin D insufficient by a factor of 0.35 (p=0.001) and 0.15

(p=0.001), respectively. These findings suggest that vitamin D deficiency/insufficiency is chiefly prevalent in adolescent children aged 12–18 years across various categories, which is in agreement with the observations reported in other studies [56,57]. Gordan et al. and Dyson et al. also reported a higher prevalence of vitamin D deficiency in children and adolescents [58,59]. The higher prevalence in non-Saudi children compared with Saudi children may be because of their genetic and socioeconomic status, reflecting insufficient dietary supplementation and limited outdoor activities and sun exposure.

In adults, 57.3% in the 19–39 age group and 42.9% in the 40–59 group were found to have vitamin D deficiency. In the overall adult, male adult (60.6%) and female adult (56.2%) categories, the 19–39 group exhibited the highest prevalence of vitamin D deficiency. The 19–39 group was found to be 3.3 times (OR=3.3, p<0.001) and 1.5 times (OR=1.5, p<0.001) more likely to be deficient and insufficient, respectively, with respect to the >60 group. The second highest degree of prevalence of Hypovitaminosis D was found in the 40–59 group, with 70% (OR=1.7, p<0.001) and 30% (OR=1.3, p=0.001) higher probability of being vitamin D deficient and insufficient, respectively, in comparison to the >60 group. A similar finding of a significantly higher risk of vitamin D deficiency (almost twice) in women aged 30–49 years compared with women aged 50–65 years (OR=2.01, p=0.03) has been reported in a study of Riyadh, KSA [60]. Tuffaha et al. reported a prevalence of vitamin D deficiency of 62.65% and 40% in Saudi adult females and males older than 15 years [2]. The prevalence of vitamin D sufficiency was 37% in the >60 age group (Table 3). This observation aligns with the finding of Naugler et al. who reported a lesser degree of prevalence of vitamin D deficiency in old age categories [61]. A similar degree of vitamin D deficiency was recorded in both Saudi (57.1%) and non-Saudi adults (59.4%) in the 19–39 age groups. In contrast with the >60 group, the 19–39 group of non-Saudi adults exhibited a greater likelihood of being deficient and insufficient by factors of 6.7 (p=0.001) and 1.6 (p=0.001), respectively. Whereas, compared with the >60 group, the 19–39 and 40–59 groups of Saudi adults were deficient by factors of 2.8 (p=0.001) and 1.5 (p=0.001), respectively. Previous studies have demonstrated a higher prevalence of vitamin D deficiency in the Saudi population [46,62]. The documented greater prevalence of vitamin D deficiency in the Saudi population across age groups could be due to genetics, urbanization of lifestyles and changes in dietary habits. Compared to the 12–18 age group, all other Saudi child groups were less likely to develop Hypovitaminosis D to a greater extent.

CONCLUSION

Overcoming health disparities has been a topic of discussion among the scientific community in recent years. Hypovitaminosis D is a common health-related problem both nationally and globally. In conclusion, the current study revealed that vitamin D deficiency and insufficiency were marginally greater in non-Saudis compared to Saudis. Vitamin D deficiency was found to be comparatively more prevalent in females. Males, females, Saudis and non-Saudis aged 19–39 exhibited a significantly higher prevalence of vitamin D deficiency in comparison to those aged >60 years. This study also suggests a higher prevalence of vitamin D deficiency and insufficiency in children and adolescents, especially those aged 12–18 years, compared to those of younger ages. The present study also suggests that the highest prevalence of vitamin D sufficiency is found in children aged <2 years (compared to all other child age groups) and in adults aged >60 years (compared to all other adult age groups). This indicates that individuals in the early and advanced stages of life in Albaha are comparatively less impacted by Hypovitaminosis D. Raising nationwide awareness about vitamin D fortification and supplementation and adequate sun exposure and outdoor activities among adolescents and adults may be worthwhile to reduce Hypovitaminosis D.

SUPPLEMENTARY MATERIALS

Not applicable.

AUTHOR CONTRIBUTIONS

Conceptualization: AS and MA

Methodology: AS and MA

Formal analysis: AS and MA

Investigation: AS, SA, RA, FA, MA

Data curation: AS, MA, MS

Writing-Original draft preparation: AS, MI, NA

Writing, Review and Editing: AA, OS

Visualization: AS, AA, OS

Project administration: AS

Funding acquisition: AS

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INSTITUTIONAL REVIEW BOARD STATEMENT

The study was conducted according to the guidelines of the Saudi Ministry Health, and approved by the Deanship of Scientific Research at Albaha University (1441-28-41206495-2) and the Scientific and Research Committee of King Fahad Hospital, Albaha, Saudi (protocol code 6972).

INFORMED CONSENT STATEMENT

Not applicable.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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