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Vitamin D Status in Jordan: Dress Style and Gender Discrepancies

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Key Words
Dress style · Gender · Jordan · Parathormone · UV radiation · Vitamin D deficiency

Abstract
Background/Aims: Vitamin D deficiency is highly prevalent worldwide and has been linked to many diseases. The aims of the present study were to assess the vitamin D status of Jordanians at the national level and to identify groups of the population at high risk for vitamin D deficiency. ***Methods:*** Vitamin D status was assessed in a national sample of 5,640 subjects aged ≥7 years. The study involved interviews, laboratory measurements of 25(OH)D and others, and physical measurements. The present report deals, exclusively, with subjects aged >18 years. ***Results:*** The prevalence of low vitamin D status [25(OH)D <30 ng/ml] was 37.3% in females compared to 5.1% in males. Dress style in females was independently related to low vitamin D status; women wearing 'Hijab' (adjusted OR = 1.7, p = 0.004) or 'Niqab' (adjusted OR = 1.5, p = 0.061) were at a higher risk for low vitamin D status than were western-dressed women. ***Conclusion:*** The high prevalence of low vitamin D status in females in contrast with a low prevalence in males, together with a higher prevalence in women wearing Hijab or Neqab, calls for action to increase the population's awareness and to develop strategies to reduce this risk among women, particularly those wearing dress styles that cover most or all of their skin.

Introduction

Vitamin D deficiency is currently recognized as a global epidemic despite the worldwide success achieved against rickets. Rickets can be viewed as the tip of the iceberg and other forms of vitamin D deficiency remain highly prevalent in many parts of the world. It is well known that nobody is immune against vitamin D deficiency, irrespective of geography, age, or race/ethnicity.

A major cause of vitamin D deficiency is inadequate exposure to sunlight. Very few foods naturally contain vitamin D, and foods that are fortified with vitamin D are often inadequate [1, 2]. The recommendation to avoid all sun exposure to protect from skin cancer has put the world's population at risk for vitamin D deficiency [3]. The unfortunate outbreak of hypercalcemia in the 1950s in Great Britain was blamed on the overfortification of milk with vitamin D even though there was little evidence for this [4].

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Despite the ongoing controversy regarding the definition of vitamin D deficiency, the most widely accepted definition is a serum level of 25(OH)D <20 ng/ml; levels between 20 and 29 are considered insufficient, and levels ≥30 are considered sufficient. This definition is based on the facts that: (1) serum 25(OH)D levels are inversely associated with parathyroid hormone levels until the former reach 30–40 ng/ml, at which point parathyroid hormone levels begin to level off [5], and (2) intestinal calcium transport increased 45–65% in women when 25(OH)D levels increased from an average of 20 ng/ml to an average of 32 ng/ml [6].

Vitamin D deficiency or insufficiency affects 1 billion people worldwide, as deduced from several studies [7–12]. Vitamin D deficiency is highly prevalent in the United States and in Europe. For example, 32% of healthy students, physicians, and residents at a Boston hospital were found to be vitamin D deficient [9]. Even in sunny countries, vitamin D deficiency is common when people cover most of their skin. About 30–50% of children and adults in Saudi Arabia, the United Arab Emirates, Australia, Turkey, India, and Lebanon had vitamin D deficiency below 20 ng/ml [13–16].

A hospital-based study in Saudi Arabia of 100 healthy male medical students, interns, residents, physicians, and employees aged 25–35 years and 100 healthy male visitors of the same hospital aged ≥50 years reported low vitamin D levels, i.e. <20 ng/ml, in 28% of the first group and in 37% of the second group [17].

The Institute of Medicine of the United States has stated that all children and adults up to the age of 50 years require 200 IU of vitamin D daily, while adults aged 51–70 and ≥71 years need 400 and 600 IU vitamin D daily, respectively [18]. It has been suggested, however, that both children and adults consume 800–1,000 IU vitamin D daily from dietary and supplemental sources when sunlight is unable to provide it [19]. Several factors have been shown to be associated with vitamin D deficiency, including latitudes >30°N and >30°S [20], winter season [20], low altitude [21], skin pigmentation [22], use of sunscreen [23], indoor work, living in urban apartments [21], dressing styles covering most of the body [12, 13], older age [24], and obesity [25].

Vitamin D deficiency causes rickets in children and precipitates and exacerbates osteopenia, osteoporosis, and fractures in adults. It has also been associated with an increased risk of common cancers, autoimmune diseases, hypertension, and infectious diseases [2].

Worldwide, a few studies have attempted to assess vitamin D status at the national level. Some studies have been hospital based, recruiting patients, visitors, or employees, while others have targeted specific groups of the population. In Jordan, to our knowledge, the only published study on vitamin D status targeted Islamic Hospital employees and trainees aged 18–45 years. Results showed that over 62% of the 146 participants had low serum 25(OH)D, i.e. <30 ng/ml [12]. Women wearing Hijab or Neqab were at a higher risk for low vitamin D than were women with a western dress style. Hijab or Purdah is a dress style covering the whole body but sparing the face and hands while Neqab is a dress style that covers the whole body including the face and hands. In the present study, we used a national community-based approach to enroll a representative sample of the entire Jordanian population. The purpose of the study was to assess the vitamin D status of Jordanians and to identify any discrepancies at the regional and governorate levels. To this end, the study was national and recruited population samples from all governorates in Jordan, i.e. a total of 12 governorates.

Jordan lies between latitudes 29°19′N and 32°35′N (southern region up to 31°12′N, middle region up to 32°05′N, and northern region up to 32°35′N). The solar zenith angle at noon in summer ranges from 8.5° to 31.3° and in autumn from 31.3° to 55.4°. Jordan is generally a sunny country throughout the year, except in winter. However, the vast majority of women are either veiled (wearing Neqab) or wear Hijab for religious or cultural reasons; the remainder has a western dress style. Women are also likely to be homebound and consequently have restricted exposure to sunlight. Given the lack of population-based data on vitamin D status, the present report has the following specific objectives: (1) to determine the prevalence of vitamin D deficiency in the Jordanian population, both male and female, aged >18 years and (2) to identify groups of the population at a higher risk for vitamin D deficiency.

Methods

Sampling

A national population-based household sample was selected from the 12 governorates of Jordan. These 12 governorates belong to the 3 regions of the country, i.e. the north, middle, and south. A complex multistage sampling technique was used to select the households, taking into consideration the geographic distribution of the population as well as urban-rural residence. As the population is covered by an extensive network of health centers and because the study procedures have to take place in a medical setting, the selection of the household population sample was health center-oriented. The health director in each governorate was contacted and asked to identify at least 2 health centers in which the study procedures could be conducted. He was asked to select the health centers so that urban and rural areas in each governorate are represented and the selected centers have enough space to host the study team, participants, and equipment. A total of 31 health centers were identified and people served by these centers were targeted. A systematic sample of households was selected from the population served by the selected health centers. The number of selected households was approximately proportional to the population in each region.

In each selected area, 1 day before data collection, 2-membered teams (a male and a female in each) visited the selected households, explained the purpose of the study, and invited all members aged ≥7 years to report to the health center the next day after an overnight fast. Subjects on regular medications were asked not to take their medications early on that day and to bring all of their medications with them to the survey site. To encourage participation, the study team worked on all weekdays, including official holidays, except Fridays. Of the 9,000 subjects invited to participate 5,640 responded (1,607 males and 4,033 females). The overall response rate was 63% (36% in males and 90% in females). The main reason for no response was lack of time because of work.

Ethical Issues

The study was approved by the Ethical Committee for Research on Humans of the National Center for Diabetes, Endocrinology, and Genetics, and it was supported by the Ministry of Higher Education. Informed consent was obtained from all participants or their guardians if the participants were children. Blood sampling was carried out by skilled laboratory technicians or nurses with adherence to a standard protocol. Physical measurements and interviews were carried out by trained personnel. The privacy of participants was respected. Identifying information was kept strictly confidential and the data were used only for scientific purposes. Each participant was privately informed about all of his/her laboratory measurements and, in case of the presence of abnormal findings, was referred to his/her doctor for any necessary intervention.

Data Collection

All of the field work, including the obtainment of blood samples, was carried out between July 1 and November 30, 2009. Because of Ramadan (the fasting month for Muslims) and the following holidays, field work stopped for about 6 weeks during the period of August 20 to September 30, 2009. Thus, data collection was carried out during summer and autumn. Participants attended the health centers in the morning (8:00 a.m. to 11:00 am) with a minimum fasting time of 10 h. A total of 5,640 subjects aged between 7 and 90 years were included in the study. The present report deals, exclusively, with participants >18 years of age. There was a total of 4,590 subjects, i.e. 1,128 males and 3,462 females.

Interview

A pilot-tested structured questionnaire was prepared and administered by trained interviewers to collect relevant information. The questionnaire sought information about sociodemographic factors and factors potentially influencing serum 25(OH)D concentrations, such as exposure to sunlight, sunscreen use, clothing and coverage of body parts (head and face, arms, hands, and legs), skin color, and others. In addition, extensive data were collected on psychological status, comorbidities, and nutrition.

Physical Measurements and Laboratory Analysis

Anthropometric measurements including weight, height, and hip and waist circumferences were obtained with the subjects wearing light clothing and no shoes. Waist circumference was measured to the nearest centimeter using a nonstretchable tailor measuring tape at the narrowest point between the iliac crest and the rib cage, and hip circumference was measured at the widest part of the body below the waist [26]. The body mass index (BMI) was calculated as the ratio of weight in kilograms to the square of height in meters. Readings of systolic and diastolic blood pressure were taken with the subject seated and the arm at heart level, after at least 5 min of rest, using a standardized mercury sphygmomanometer.

For laboratory analysis and all biochemical measurements, 2 sets of fasting blood samples were drawn via a canula inserted into the antecubital vein into sodium fluoride potassium oxalate tubes for glucose and lithium heparin vacuum tubes for lipids. Samples were centrifuged within 1 h at the survey site, and plasma was transferred to separate labeled tubes and transported immediately in cold boxes filled with ice to the central laboratory of the National Center for Diabetes, Endocrinology, and Genetics. All biochemical measurements were carried out by the same team of laboratory technicians and the same method was used throughout the study period. Serum 25(OH)D concentrations were determined using radioimmunoassay (BIOSOURCE Europe S.A., Nivelles, Belgium). Laboratory analysis was also performed for several blood constituents but will not be described here because they are irrelevant to the current report. These include parathormone, vitamin B12, creatinine, lipids (total cholesterol, HDL, LDL, and triglycerides), glucose, alkaline phosphatase, albumin, calcium, magnesium, phosphorous, and hemoglobin. All assays were conducted according to the manufacturers' instructions.

Data Management and Statistical Analysis

Data were entered into a computer and statistically analyzed using SPSS-PC software [27]. The data were initially checked for errors by performing range and logical checks. Detected errors were corrected by returning to the original data forms. Suspicious laboratory measurements were remeasured by the same laboratory.

The prevalence rate of low vitamin D status [25(OH)D <30 ng/ml] by age and gender was obtained. An overall gender-adjusted prevalence rate was obtained using the entire Jordan population as a standard. Separate estimates of the prevalence rates of low vitamin D status in the 3 regions were also obtained. The pattern of female dress was assessed in relation to vitamin D status. Bivariate analyses were carried out to identify relevant variables related to vitamin D status. Mean values of 25(OH)D were obtained by age, gender, and dress style. A χ^2 test was used to assess the statistical significance of observed differences in vitamin D status for categorical variables while an independent samples t test was used when vitamin D level was treated as a continuous variable.

Multivariate logistic regression models were fit to examine the association of low vitamin D status with a number of variables while simultaneously controlling for potential confounders. For this purpose, vitamin D status was dichotomized, using 30 ng/ml as the cutoff point, and entered in the model as the dependent variable. All other relevant variables were treated as independent variables. Variables showing no relationship to vitamin D status were excluded from the model and the process was repeated until the most parsimonious model was obtained. The most parsimonious model is that which explains most of the variability in vitamin D status with the least number of explanatory variables. Effect modification was assessed by introducing interaction terms in the model as relevant.

Results

The present report is based on a national community-based sample of 4,590 participants aged >18 years, i.e. 1,128 males and 3,462 females. Because children ≤18 years of age can be viewed as a special group, they were not dealt with in this report and their results will be reported separately. This report is focused on the distribution and determinants of vitamin D status in the population.

Characteristics of the Study Population

Table 1 shows the sociodemographic characteristics of the study population. The mean age was 41.9 years (SD = 13.4). Subjects ≥60 years of age constituted 12% of the sample. Males were grossly underrepresented, accounting for about one fourth of the sample. The extent of skin coverage was rated as high and moderate in 8.5 and 60.8% of the population, respectively. The average family size was 5.8 (SD = 2.5). The prevailing skin color was wheatish (about 59%); dark or black subjects constituted 12% of the sample, and the rest were whites or blonds.

Vitamin D Status of the Study Population by Age and Gender

Table 2 shows that 94.9% of males were vitamin D sufficient, 3.6% were insufficient, and only 1.5% were deficient. Much higher rates of vitamin D insufficiency (23.1%) and deficiency (14.2%) were observed in females compared to males (p = 0.00). The sex-adjusted rate of low vitamin D status [25(OH)D <30 ng/ml] was 22.2% (adjusted to the total Jordanian population). The prevalence of low vitamin D status (deficiency and insufficiency combined) was highest in men ≥60 years of age, as expected, but in women it was highest in the age group of 19–39 years. Table 2 shows the mean values of serum 25(OH)D by age (separately for males and females). The mean values were significantly higher in males than in females across all age groups (p = 0.000). The mean values were 73.3 ng/ml for males and 39.8 ng/ml for females.

Table 1. Distribution of the study population by sociodemographic characteristics (Jordan, 2009)

Variable	n	%
Age, years (mean = 41.9, SD = 13.4)		
19–39	2,099	45.7
40–59	1,939	42.2
60+	552	12.0
Gender		
Male	1,128	24.6
Female	3,462	75.4
Monthly family income, JOD		
<300	2,051	45.2
300+	2,483	54.8
Education, years of completed formal schooling		
Illiterate	420	9.2
1–11	1,470	32.2
12	1,133	24.9
>12	1,536	33.7
Extent of skin coverage		
Large	390	8.5
Moderate	2,791	60.8
Low	1,409	30.7
Marital status		
Single	644	14
Married	3,624	79.0
Divorced	67	1.5
Widowed	255	5.6
Family size (mean = 5.8, SD = 2.5)		
<5	1,396	31.0
5–7	2,017	46.0
8+	1,038	23.0
Smoking status		
Current smoker	689	15.1
Ex-smoker	215	4.7
Never-smoker	3,674	80.3
Employment		
Unemployed	2,944	64.4
Indoor job	1,329	29.1
Outdoor job	300	6.6
Skin color		
Blond and white	1,244	29.4
Wheatish	2,678	58.6
Dark or black	548	12.0
Type of residence		
Separate house	2,618	57.4
Other	1,944	42.6
Altitude, meters		
<700	1,747	38.1
700–900	1,709	37.2
900+	1,134	24.7
Region		
North	1,680	36.6
Middle	2,164	47.1
South	746	16.3

Table 2. Vitamin D status by age and gender (Jordan, 2009)

Age, years	n	25(OH)D (ng/ml)	25(OH)D level (ng/ml)			p value
		mean ± SD	<20	20–29.9	≥30	
Male						0.03
19–39	408	73.2 ± 28.9	3 (0.7)	11 (2.7)	394 (96.6)	
40–59	504	75.9 ± 29.3	6 (1.2)	19 (3.8)	479 (95.0)	
≥60	216	67.3 ± 29.4	8 (3.7)	10 (4.6)	198 (91.7)	
Total	1,128	73.3 ± 29.3	17 (1.5)	40 (3.5)	1,071 (94.9)	
Female						0.000
19–39	1,691	37.3 ± 18.8	273 (16.1)	418 (24.7)	1,000 (59.1)	
40–59	1,435	42.4 ± 21.9	180 (12.5)	299 (20.8)	956 (66.6)	
≥60	336	41.9 ± 22.7	39 (11.6)	82 (24.4)	215 (64.0)	
Total	3,462	39.8 ± 20.7	492 (14.2)	799 (23.1)	2,171 (62.7)	

Consistent with the prevalence of low vitamin D status mentioned above, men aged ≥60 years and women 19–30 years of age also had the lowest mean values of 25(OH)D.

The prevalence of serum levels of 25(OH)D <40 ng/ml were 11.9% in males and 58.5% in females; the corresponding rates for levels <50 ng/ml were 22.3 and 74.2% (not shown in tables).

For further presentation of the results, vitamin deficiency and insufficiency were combined and referred to as 'low vitamin D status', reflecting a serum 25(OH)D level <30 ng/ml.

Prevalence of Low Vitamin D Status by Selected Variables

The overall crude prevalence of low vitamin D status [25(OH)D <30 ng/ml] was 29.4%. The prevalence rates of low vitamin D status by selected variables are shown in table 3. Subjects with less coverage of their skin were significantly less likely to have low vitamin D status (11.9%) compared to subjects with a higher extent of coverage (p = 0.00). Married subjects were less likely to have low vitamin D status (28.1%) than were single, divorced, or widowed subjects (p = 0.00). Never-smokers had a significantly higher prevalence (32.1%) than did current smokers and ex-smokers (p = 0.00). Working outdoors was associated with a low prevalence (7.3%) compared to working indoors or being unemployed (p = 0.00). Those living in a separate house were less likely to have low vitamin D status (27.2%) than were those living in apartments or other housing (p = 0.00). Subjects living at altitudes 700–900 meters above sea level were less likely to have low vitamin D status (26.9%) than were subjects living at a lower or higher altitude (p = 0.00). Significant regional differences in the prevalence of low vitamin D status were observed (p = 0.00), the highest rate being in the middle region which includes Amman, the capital of Jordan (34.7%). Monthly family income, education, family size, and skin color were not significantly associated with low vitamin D status.

Table 4 shows the mean serum 25(OH)D values and the prevalence rates of low vitamin D status [25(OH)D <30 ng/ml] in women according to their dress style. Women wearing western dress styles (at least exposing the head and face) had a significantly higher mean value of 25(OH)D than did women wearing Hijab (p = 0.000) or Neqab (p = 0.000). However, women wearing Hijab and Neqab did not differ significantly in their mean serum 25(OH)D values (p = 0.419). Consistent with the results mentioned above, women wearing western dress styles were less likely to have low vitamin D status (29.4%) compared to women wearing Hijab or Neqab. The association, however, did not reach statistical significance (p = 0.07); this is probably because of the relatively small number of women in western-style dress (183 out of 3,462 women, i.e. 5.3%). It is interesting to note that 9.5% of the women were veiled (wore Neqab) and the vast majority wore Hijab (85.2%).

Factors Independently Related to Low Vitamin D Status

To identify the factors related to low vitamin D status after controlling for potential confounders, we performed multivariate logistic regression. In the first model, all of the variables in table 3 were initially entered as independent variables while vitamin D was, of course, the dependent variable. The model included all subjects, males and females, >18 years of age; results are shown in table 5. Many of the variables which showed a relationship with low vitamin D status in the bivariate analyses were excluded from the model via the stepwise procedure. The second model was similar to the first but was exclusively performed for females. Results of this analysis are shown in table 6.

Living in the middle region (adjusted OR = 1.8, p = 0.00) and the south (adjusted OR 1.3, p = 0.01) was significantly associated with low vitamin D status compared to living in the north after adjustment for family income and gender. A better monthly family income, i.e. ≥300 JOD, was associated with low vitamin D status (adjusted OR = 1.2, p = 0.00) after adjustment for region and gender. Females were more than 11 times more likely to have low vitamin D status than were males (p = 0.00) after adjustment for region and income (table 5).

As shown in table 6, similar results were observed when logistic regression analysis was carried out separately for females. The only difference is that dress style showed a statistically significant association with low vitamin D status. Women wearing Neqab were 1.5 times more likely to have low vitamin D status than were women wearing western styles and the difference was close to statistical significance (p = 0.061). Similarly, Hijab was associated with lower vitamin D status (adjusted OR = 1.7, p = 0.004).

Parathormone Level by Age and Gender

The mean values of parathormone levels by age and gender are shown in table 7. The values increased significantly with age in both genders (p = 0.00). At each age, females had significantly higher values of parathormone than did males.

Discussion

The success against rickets in different parts of the world was followed by a declining interest in vitamin D deficiency. However, it has been quickly recognized that rickets is just the tip of the iceberg, and interest in the wide range of health problems posed by vitamin D deficiency have regained momentum. Of particular importance is the link between vitamin D deficiency and chronic diseases, including cancer and cardiovascular diseases, which are currently responsible for most of the global disease burden.

Table 3. Prevalence of low vitamin D in the study population by selected variables (Jordan, 2009)

Variable	Prevalence of low 25(OH)D <30 ng/ml (%)	p value
Total	29.4	
Age, years		0.000
19–39	33.6	
40–59	26.0	
60+	25.2	
Gender		0.000
Male	5.1	
Female	37.3	
Monthly family income, JOD		0.077
<300	28.0	
300+	30.4	
Education, years of completed formal schooling		0.096
Illiterate	28.8	
1–11	27.0	
12	30.0	
>12	31.1	
Extent of skin coverage		0.000
Large	38.2	
Moderate	36.9	
Low	11.9	
Marital status		0.000
Single	34.3	
Married	27.8	
Divorced	35.8	
Widowed	37.3	
Family size		0.066
<5	29.7	
5–7	28.1	
8+	32.1	
Smoking status		0.000
Current smoker	19.4	
Ex-smoker	15.3	
Never-smoker	32.1	
Employment		0.000
Unemployed	31.9	
Indoor job	29.0	
Outdoor job	7.3	
Skin color		0.154
Blonde and white	30.9	
Wheatish, dark, or black	28.8	
Type of residence		0.000
Separate house	27.2	
Other	32.3	
Altitude, meters		0.007
<700	31.8	
700–900	26.9	
900+	29.5	
Region		0.000
North	23.6	
Middle	34.7	
South	27.1	

Table 4. Prevalence of low vitamin D [25(OH)D <30 ng/ml] by female dress style (Jordan, 2009)

Variable	Total	Mean ± SD	p value	Low vitamin D, n	Prevalence of low vitamin D	p value
Dress style			0.000			0.072
Neqab	329	37.8 (17.9)		120	36.5%	
Hijab	2,950	39.4 (20.2)		1,117	37.9%	
Western	183	51.2 (27.9)		54	29.5%	
Total	3,462	39.8 (20.7)		1,291	37.3%	

The mean serum 25(OH)D of western dress style differed significantly from that of Neqab (p = 0.000) and Hijab (p = 0.000), but the mean levels of Neqab and Hijab did not differ from each other significantly (p = 0.419).

Table 5. Factors independently related to low vitamin D using multivariate logistic regression analysis

Variable	OR	p value
Region		0.000
North	1	
Middle	1.8	0.000
South	1.3	0.012
Monthly income (≥300 vs. <300 JOD)	1.2	0.000
Gender (female vs. male)	11.4	0.000

Each variable is adjusted for all other variables in the table.

Table 6. Factors independently related to low vitamin D in females using multivariate logistic regression analysis

Variable	OR	p value
Region		0.000
North	1	
Middle	1.8	0.000
South	1.3	0.013
Monthly income (≥300 vs. <300 JOD)	1.2	0.000
Dress style		0.011
Western	1	
Hijab	1.7	0.004
Neqab	1.5	0.061

Table 7. Mean parathormone values by age and gender

Age, years	Mean ± SD	p value
Males		
<40	20.7 (13.5)	0.00
40–59	23.1 (11.4)	
60+	29.0 (20.4)	
Total	23.4 (14.5)	
Females		
<40	28.7 (18.9)	0.00
40–59	29.5 (17.8)	
60+	34.6 (26.0)	
Total	29.6 (19.3)	

The mean parathormone values differed significantly by gender (p = 0.00).

The present study attempted to assess the magnitude of vitamin D deficiency at the national level in a relatively large representative sample of the population. Most previous studies conducted in different parts of the world targeted patients, hospital visitors or employees, or special population groups. Due to the small sample size generally employed by these studies, generalization of the findings to the wider population is problematic. Consequently, the findings of such studies can hardly form a firm basis for evidence-based interventions at the population level.

Among the most important findings of the present study is the high rate of low vitamin D status in adult females (37.3%), which contrasts markedly with a relatively low rate in adult males (5.1%). An explanation for such a finding may point to important clues for the etiology of vitamin D deficiency in Jordan and probably similar populations in the Eastern Mediterranean region and abroad. It is evident, from the outset, that dietary factors are difficult to incriminate in this regard since it is unlikely that the food consumed within the same family differs between males and females. The focus should be on factors and behaviors that discriminate between males and females. Jordan is a sunny country most of the year and sufficient exposure to sunlight is guaranteed for those who seek it. So, the question should be 'why do adult females not receive enough exposure to sun?' Two behaviors pertaining specifically to women could explain most of the discrepancy in vitamin D status between males and females: first, the dress style of the majority of women and second, the prevailing social norms that women should stay indoors and leave the house only when necessary, often with permission from their husbands or guardians. In support of the first explanation, our data showed that about 95% of women were either veiled wearing Neqab (which covers the whole body including the face and hands) or wearing Hijab (which covers the whole body but spares the face and hands). Our data also showed that wearing Neqab and Hijab were independent risk factors for low vitamin D status with an excess risk of 50–70% compared to western-dressed women. With regard to the second explanation, we have no data to support this claim as we did not collect data on social norms or on the actual practices of women regarding the time they usually spend indoors or outdoors. It is true that a lot of progress has been achieved with regard to women's situation in Jordan and that women nowadays enjoy rights almost equal to those of men. However, as Jordanians know, in our population we believe that there are still social barriers that push women to stay at home most of the time. We also believe that women wearing Neqab or Hijab are more likely to be influenced by social barriers and, thus, be homebound.

The finding of a higher prevalence of low vitamin D status in women wearing Neqab or Hijab compared to women wearing western dress styles is consistent with the only previous study of vitamin D in Jordan [12]. However, the prevalence of low vitamin D status reported by that study in women during summer (31% in western-dressed women, 55% in women wearing Hijab, and 83% in women wearing Neqab) was much higher than that in the present study. This was also true for men, where the prevalence of low vitamin D status was 18% compared to 5.1% only in the present study. This cannot be attributed to season as our study was also conducted in summer and early autumn, but it is likely to be due to differences in the study populations. While the present study targeted a nationally representative sample of the population, the other study enrolled 146 employees and trainees of the Islamic Hospital in Amman, Jordan. The reported prevalence of low vitamin D status in men was also higher in a recent study conducted in eastern Saudi Arabia (28% in men aged 25–35 years and 37% in men ≥50 years [17]. However, the sample in the Saudi study consisted of hospital employees (aged 25–35 years) or visitors (aged ≥50 years) and, thus, it may not be representative of the general population.

The present study provided an opportunity to assess several factors, many of which were reported to have a relationship with vitamin D status in some previous studies. Among these were altitude from sea level, dress style, use of sun screen, skin color, obesity, income, type of housing, education, and occupation. Several of these factors showed significant associations with vitamin D status in bivariate analyses. However, after adjustment for the effects of a number of potential confounders by multivariate stepwise logistic regression, a few of these associations retained their statistical significance. In addition to gender, these included dress style in women, region, and income. Subjects from the middle region which includes Amman, the capital of Jordan, had an 80% increased risk of suffering from low vitamin D status compared to subjects from the north. Limited exposure to sun within and outside the house is expected in large cities such as Amman and can provide an explanation for the observed low vitamin D status in this region. The increased risk of low vitamin D status for subjects with a relatively better income (>300 JOD) was modest (20%); this finding, however, was difficult to explain. Residual confounding by factors that were not completely accounted for cannot be ruled out.

The lack of a relationship between low vitamin D status and skin color is consistent with evidence from studies in African-American blacks and Indians which suggests that there is no difference in the total capacity of cutaneous vitamin D synthesis between individuals with different skin types [28, 29].

The observed higher mean parathormone level in females is generally consistent with their lower level of 25(OH)D.

In conclusion, the present study revealed a high prevalence of low vitamin D status in Jordanian women >18 years of age in contrast to a relatively low prevalence in men of the same age. Certain dress styles, i.e. Hijab and Neqab, were very common in adult women and were found to be associated with low vitamin D status. Regional differences in low vitamin D status among the 3 regions in Jordan were documented; the highest rates were in the middle region (including Amman, the capital) and lowest rates were in the north.

The findings of the present study call for action at the national level to increase the awareness of the population and to develop strategies to reduce this risk, particularly among women wearing dress styles that cover most or all of their skin. Social barriers that prevent women from having enough sun exposure should also be targeted.

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