RESEARCH ARTICLE

Poor dietary consumption and limited sun exposure are risk factors for vitamin D deficiency in premenopausal Kuwaiti women: A cross-sectional study

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ABSTRACT

Background: Low serum vitamin D levels are reported constantly among females living in the Arabian Gulf countries, presumably due to their lifestyle, which limits direct sun exposure. Because Vitamin D deficiency has been implicated in a wide range of ailments, healthy females with the deficiency might be at risk for developing many health problems. Thus, the aim was to assess lifestyle risk factors for vitamin D deficiency in healthy women in Kuwait.

Methods: A total of 104, disease-free, premenopausal women were recruited for assessment of their serum 25OHD and intact PTH levels. Physical examination, blood withdrawal and interviewer-administered questionnaires were used to collect the relevant data. Associations were detected statistically using nonparametric tests and logistic regression was used to identify risk factors for vitamin D deficiency.

Results: Vitamin D deficiency ($<$ 25 nmol/L) occurred in 84.6%, and hyperparathyroidism ($\geq$ 6.9 pmol/L) occurred in 25% of women, among which all were vitamin D deficient. Significant risk factors of vitamin D deficiency were nondaily milk intake (OR:25, CI%:4.2 – 147), no fish intake (OR:5, CI%:1 – 22.8), and no weekend sun exposure (OR:8.2, CI%:1.28 – 52.6). Having PTH $\geq$ 6 pmol/L was also associated with a higher likelihood of having vitamin D deficiency.

Conclusion: Vitamin D deficiency is very common in disease-free, premenopausal Kuwaiti women and can be avoided by improving food consumption and obtaining more sun exposure.

BACKGROUND

Vitamin D deficiency is considered a global health dilemma, and intensive research is being conducted to investigate the latitude of this problem. As a result, a number of risk factors have been associated with vitamin D deficiency. For example, studies have shown that Black, Hispanic, and Asian individuals have a higher risk of vitamin D deficiency than White Caucasian individuals.[1–2] Vitamin D deficiency has also been shown to occur more frequently in winter and spring versus summer and fall.[1,3] Higher rates of vitamin D deficiency have been found in obese and overweight individuals than in normal weight individuals.[1,4] Dress type and the amount of skin area covered has also been associated with lower serum levels of vitamin D and higher rates of vitamin D deficiency.[5–7] Hyperparathyroidism has been frequently demonstrated as a significant risk factor in vitamin D deficiency,[8] and low consumption of certain foods has also been reported to predict vitamin D deficiency, with low milk consumption being the most common predictor.[9]

Middle Eastern populations have been shown to obtain the lowest serum vitamin D levels,[10] and vitamin D deficiency has been reported repeatedly in many parts of the region. Low serum vitamin D levels have been reported in Jordanian[11] and Iranian adults.[12] Populations of the Arabian Gulf seem to have even lower levels of vitamin D. Levels below 25 nmol/L have been found commonly in around 79% of UAE women,[13] 81% of Saudi adolescent females,[14] 78.4% of Kuwaiti adolescent females,[7] 51.4% of Qatari females[15] and in almost 50% of Bahraini men and women.[3] Generally, females seem to have a higher risk for deficiency.[3,16]

Risk factors of vitamin D deficiency in the Kuwaiti population have been studied recently. Risk factors found in 5–11-year-old schoolchildren were age ≤ 8.5 years, female, hyperthyroidism, overweight, and obesity.[17] Risk factors found in 11–16-year-old adolescents were female gender, age, governorate, parental education, BMI, vitamin D supplementation, and the number of times the student walks to school.[18] To our knowledge, no published studies have been conducted on premenopausal women to investigate the influence of lifestyle factors such as food intake, sun exposure, and physical activity on vitamin D levels. Thus, the aim of this study was to assess vitamin D deficiency and its associated lifestyle risk factors in disease-free, supplement-free, premenopausal Kuwaiti women.

METHODS

This observational, cross-sectional study was approved by the Joint Committee for the Protection of Human Subjects in Research by the Kuwait Institute for Medical Specialization, Ministry of Health and AbdulMihsin Al-Abdulrezzag Health Sciences Centre, Health Sciences Centre- Kuwait University. The study was conducted in accordance with the Declaration of Helsinki.

Participant inclusion

The majority of participants were recruited by phone. Many of them were female relatives of students who had participated in a previous study.[17] The previous study included students from 16 different elementary schools covering all governorates of Kuwait.
In addition, female students from the college of Basic Education, Public Authority for Applied Education and Training (PAAET) were also approached during cafeteria hours and invited to participate. Those who were interested were given an invitation letter that included simple questions for exclusion purposes and were asked to return the letters with their contact details.

Accordingly, menopausal, non-Kuwaiti, pregnant, and breastfeeding women were excluded. Women with a medical diagnosis or taking medication or vitamin/mineral supplements were excluded. It was required that a history of supplementation had ceased at least six months prior to participation, and no vitamin D injection had ever been administered previously. Only eligible participants were later recalled for examination.

When the participants presented for examination, the study and methods, as well as what was expected from the participants, were explained once again. Consent forms were signed accordingly. The study was carried out between December 2011 and March 2012.

The sample size needed to assess the risk factors of vitamin D deficiency was based on the equation $(N > 50 + 8m)$, where (N) is the sample size and (m) is the number of independent variables.[19] Using the results of a previous study,[7] 82–90 samples were estimated to use 4–5 independent variables in

the analysis. The sample size obtained for this study was 104.

Examination and interview

Anthropometric measurements and a 15 ml blood sample were collected. Weight was measured on the same balance for all the women to the nearest 0.1 kg, whereas height was measured with a stadiometer to the nearest 0.5 cm. The body mass index (BMI) was calculated. Waist and hip circumferences were measured with a measuring tape to the nearest 0.5 cm to calculate the waist hip ratio (WHR). Skin color was assessed using the Fitzpatrick skin color classification.[20] Age was calculated according to the participant's registered date of birth as of the examination date.

Serum samples were separated and shipped to the investigators' laboratory (TDL, UK) on dry ice for the analysis of 25-hydroxyvitamin-D (25OHD) and intact parathyroid hormone (iPTH). The Elecsys total Vitamin D assay using an immunoassay analyzer E170 (Roche diagnostics, USA) was used to quantify 25OHD, with inter- and intra-assay CV%s of 3.43% and 5.44%, respectively. Intact PTH was measured using an electrochemiluminescence immunoassay (Roche, USA) with inter- and intra-assay CV%s of 1.6% and 3.9%, respectively.

Self-reported questionnaires were administered by a dietician during a 20-minute interview to gather information about participants' lifestyle, socioeconomic status, and food frequency consumption. The interview and examination were carried out by three trained dieticians. The data used in this presentation included governorate of residence, occupation, education level, dress code, minutes of physical activity per week, and minutes of sun exposure per day on the weekend (without the application of sunscreen). The food frequency questionnaire addressed the frequency of general food consumption, with a focus on dairy foods. The participants were reminded to report the frequency of consumption based on the standard serving sizes of different foods. Foods included in this presentation were milk, yogurt, cream (gaimer), lebna, cheese, meat, chicken, fish, eggs, legumes, nuts and seeds, vegetables, leafy vegetables, and fruits. Responses to the frequency of food consumption were daily, 3 – 5 times/week, 1 – 2 times per week, 1 – 2 times per month, and not consumed. To strengthen the correlations, these responses were later rescaled to daily, weekly (1 – 5 times a week), and rarely (never to 1 – 2 times a month).

Statistics

Normality was assessed using the Kolmogorov-Smirnov test. Due to the lack of normal distribution in the majority of variables, nonparametric tests were used. Continuous variables are reported in median and interquartile range (IQR). Spearman's correlation was used to assess the associations between continuous variables. The Kruskal-Wallis test was used to assess serum vitamin D levels across categorical variables. Vitamin D deficiency was determined as 25OHD levels < 25 nmol/L since the majority of samples were below 25 nmol/L.[21] The potential risk factors of vitamin D deficiency were assessed using a univariate binary logistic regression analysis. The same potential variables were re-tested following conversion into binary variables to increase the number of samples in each group. Accordingly, the variables that were significant or showed a trend towards significance were included in the multivariate binary logistic regression analysis. In this analysis, a stepwise approach was used to avoid model overload, and this reduced the number of variables included in the model to four, which was enough to support a meaningful outcome.[19] Statistical analysis was carried out using SPSS, version 22.

RESULTS

Sample characteristics

A total of 104 apparently healthy premenopausal women, free of disease, aged 19 – 47 years were recruited. The women were mostly Caucasian (94.2%) with a medium-toned skin color (63.5%) (Table 1). Around 61.5% were either overweight or obese, and 15% had WHR ≥ 0.86. Recruitment was from all governorates in Kuwait. Nearly 54% were married and 52% had children. Around 67% of the women held a Bachelor's degree (or were about to achieve one at the time of this study). Sixty-four percent reported a sedentary lifestyle, and nearly 50% obtained up to five minutes per day of direct sun exposure on weekends (Table 1). A good proportion of women in this study reported consuming milk, cheese, and leafy vegetables daily, while other vegetables, legumes, nuts, seeds, and fish, were generally consumed less often (Table 2).

Table 1. Demographics and lifestyle characteristics of the study sample (n = 104).

Variable	Groups	Frequency	%
Residence (Governorate)	Asma	19	18.3
	Hawally	24	23.1
	Farwania	13	12.5
	Mubarak Al-Kabir	20	19.2
	Ahmadi	18	17.3
	Jahra	10	9.6
Education	Secondary	3	2.9
	High school	5	4.8
	Diploma	21	20.2
	Bachelor's	70	67.3
	Master's	5	4.8
Occupation	Unemployed	23	22.1
	Employed	44	42.3
	Student	37	35.6
Skin color	Light	28	26.9
	Medium	66	63.5
	Dark	10	9.6
Dress code	Unveiled	2	1.9
	Hejab	82	78.8
	Niqab	20	19.2
Physical activity	None	64	61.5
	1 – 3 days a week	20	19.2
	4 – 7 days a week	20	19.2
Weekend sun exposure	none	31	29.8
	5 minutes a day	16	15.4
	15 minutes a day	22	21.2
	30 minutes a day	35	33.7

Table 2. Food intake frequency (%) among the study sample (n = 104).

Food	Rarely	Weekly	Daily
Milk	16 (15.4)	43 (41.3)	45 (43.3)
Yogurt	37 (35.6)	51 (49)	16 (15.4)
Cheese	5 (4.8)	60 (57.7)	39 (37.5)
Lebna	44 (42.3)	51 (49)	9 (8.7)
Gaimer (cream)	72 (69.2)	31 (29.8)	1 (1)
Eggs	27 (26)	69 (66.3)	8 (7.7)
Meat	31 (29.8)	73 (70.2)	0 (0)
Chicken	9 (8.7)	81 (77.9)	14 (13.5)
Fish	62 (59.6)	41 (39.4)	1 (1)
Legumes	47 (45.2)	56 (53.8)	1 (1)
Nuts & seeds	41 (39.4)	56 (53.8)	7 (6.7)
Vegetables (nonstarch)	52 (50)	51 (49)	1 (1)
Leafy vegetables	16 (15.4)	47 (45.2)	41 (39.4)
Fruits	27 (26)	55 (52.9)	22 (21.2)

Table 3. Clinical and anthropometric characteristics of the study sample (n = 104).

Measures*	Median	IQR	Min	Max	Groups	Frequency	%
Age	27.0	22.0 – 39.5	19.0	47.0	19 – 29.99	63	60.6
					30 – 39.99	15	14.4
					40 – 47	26	25.0
Body mass index (BMI)	26.3	23.6 – 32.25	17.5	48.7	<25	40	38.6
					≥25	64	61.5
Waist hip ratio (WHR)	0.8	0.73 – 0.82	0.7	1.0	<0.86	88	84.6
					≥0.86	16	15.4
Serum vitamin D (25OHD)	16.0	12.0 – 20.0	8.0	85.0	<25	88	84.6
					25 – 49.99	8	7.7
					≥50	8	7.7
Intact Parathyroid hormone (iPTH)	5.2	3.77 – 6.97	1.8	14.0	1.06 – 6.89	78	75.0
					>6.89	26	25.0

*Age in years, BMI in kg/m^2, 25OHD in nmol/L, iPTH in pmol/L.

Vitamin D deficiency and associated factors

Median serum 25OHD was 16.0 nmol/L (IQR: 12.0 – 20.0) (Table 3). No correlation was found between 25OHD and BMI or WHR, but a positive correlation was found with age ($r = 0.22, p = 0.024$), and a negative correlation was found with iPTH ($r = -0.29, p = 0.003$). Median iPTH was 5.2 pmol/L (IQR: 3.77 – 6.97), and 25% had hyperparathyroidism (≥6.9 pmol/L) (Table 3). No significant correlation in vitamin D deficiency or hyperparathyroidism between different age groups was found; however, both were more frequent in younger women (<30 years old).

In the univariate analysis, no significant correlation was found between vitamin D deficiency and physical activity, skin color, dress code, residence, or education. No significant association was found across groups by age, BMI, WHR, or PTH (Table 3), however, PTH at the ≥6 pmol/L cutoff was significantly associated with vitamin D deficiency (Table 4). No significant association was found across occupations, yet students had a significantly higher

Table 4. Univariate and multivariate analysis of the risk factors of vitamin D deficiency in the study sample (n = 104) using binary logistic regression.

Independent variable		Univariate analysis			Multivariate analysis*		
						95% C.I. for OR		
	Freq	%	p value	Odds ratio	Lower	Upper	p value
Milk intake			0.001	24.9	4.22	147	0.001
Daily	45	43.3					
Nondaily	59	56.7					
Weekend sun exposure			0.087	8.2	1.28	52.6	0.026
Yes	73	70.2					
No	31	29.8					
Fish intake			0.047	4.99	1.01	22.8	0.038
Yes	42	40.4					
No	62	59.6					
iPTH			0.029	0.187	0.035	1	0.052
<6 pmol/L	63	60.6					
≥6 pmol/L	41	39.4					

*(Omnibus test: Chi-square = 34 with four degrees of freedom ($p = 0.001$), Hosmer and Lemeshow test: Chi-square = 7.8 ($p > 0.05$), Cox & Snell, and Nagelkerke $R^2 = 0.279 – 0.484$).

frequency of vitamin D deficiency when compared with the rest of the study sample. Weekend sun exposure showed a trend in significance following conversion into a binary variable (Table 4).

Milk intake was the only dietary factor with a significant association with vitamin D deficiency. Those who reported rare consumption of milk did not obtain 25OHD levels above 25 nmol/L, while daily consumption was correlated with the highest frequency of levels above 25 nmol/L. After food intake variables were converted into binary variables, milk and fish intake were the only foods significantly associated with vitamin D deficiency (Table 4).

The multivariate binary logistic analysis showed that milk intake, fish intake, and weekend sun exposure were significant risk factors of vitamin D deficiency (Table 4), while iPTH at the ≥ 6 pmol/L cutoff was found to be nonsignificant. The logistic model was considered a good fit and was able to explain 28% – 48% of the variation in vitamin D deficiency.

DISCUSSION

A total of 92.3% of apparently healthy premenopausal women had serum vitamin D levels < 50 nmol/L, and 84.6% had levels < 25 nmol/L. The high prevalence of vitamin D deficiency coincides with earlier reports from neighboring countries such as Saudi Arabia, Qatar, Bahrain, and the United Arab Emirates, as well as those from Kuwait.[3,7,13,16,22] It is assumed that the unique lifestyle of women in this region might be the cause. The hot weather, cultural dress, and perhaps common sun-related cosmetic beliefs are behind the limited sun exposure.

The results showed no impact of skin color, BMI, or WHR on 25OHD levels, contrary to their acknowledgement as common risk factors of vitamin D deficiency. Skin color and ethnicity have been reported previously as predictors of vitamin D deficiency,[1,2] and obesity, indicated by high BMI and WHR, has frequently been shown to correlate inversely with vitamin D levels.[4,23]

The significant impact of weekend sun exposure on vitamin D deficiency in this study reflects the need to encourage increased sun exposure among women. It might be speculated that veiled women may not be able to obtain sufficient direct sun exposure, but no differences were found in sun exposure across

differently covered women, meaning that less covered women did not report more direct sun exposure. Although veiling has been previously shown to be a risk factor of vitamin D deficiency in some studies,[5,6,24] others have not found a significant association.[25] The findings of this study show that covered women are able to achieve exposure to direct sun light.

Despite the lack of a significant correlation between 25OHD levels and physical activity in this study, a higher proportion of sedentary women were vitamin D deficient compared with moderately (1 – 3 days/week) and highly active (4 – 7 days/week) women. It is well known that physical activity exerts an impact on general health, including achieving and sustaining optimum levels of 25OHD.[6,26]

Earlier research showed that subcutaneous synthesis of vitamin D declines with age,[27] suggesting that the elderly are more susceptible to vitamin D deficiency. In this study, however, vitamin D deficiency occurred more frequently in younger women (not significant). This complies with a number of more recent studies showing that younger adults are more likely to be deficient in 25OHD levels than older adults.[3,12,16]

The level of education was not significantly associated with vitamin D deficiency, yet several reports have shown significant findings. A national study in the US found that having no college education was significantly associated with vitamin D deficiency in adults.[28] Maternal education specifically was found to be a significant risk factor in vitamin D deficiency in children in the UK[29] and Kuwait.[18] The influence of education on vitamin D levels could be due to the increased awareness on vitamin D-rich food and supplement intake and sun exposure among educated parents, which can subsequently raise vitamin D levels.[18]

Dairy is generally a popular food group in the human diet. It was found that milk and cheese were the most often consumed dairy foods, while gaimer (cream), lebna, and yogurt were less often consumed (Table 2). Daily milk consumption was found to lower the probability of vitamin D deficiency, and those who consumed milk daily were at least four times less likely to become vitamin D deficient. The impact of milk on vitamin D status can be attributed to milk fortification with vitamin D. In countries with a national vitamin D fortification policy for milk products, milk

consumption has been shown to contribute to vitamin D intake and 25OHD levels.[9] Vitamins A and D fortification in milk has been a standard practice in Kuwait for decades. Levels up to 200 IU/L are labeled on commercial milk products, among which some are imported from Saudi Arabia. A recent study showed that 85% of the milk products in the Saudi market matched their claim.[30]

Among animal proteins, chicken was the most consumed, while fish was the least consumed despite the availability of local and affordable varieties of fish in the market. Fish, and especially oily fish, is one of the few natural and rich food sources of cholecalciferol, the animal form of vitamin D.[31] However, many seem to avoid eating fish either due to certain beliefs regarding its contamination or due to disliking its smell. Fish consumption was shown to significantly decrease the likelihood of having vitamin D deficiency in this study; similar results were found in Norway and Japan.[32,33]

Nonstarchy vegetables were not commonly consumed, yet leafy vegetables including lettuce, parsley and arugula were frequently consumed as a side dish with meals. It was also found that legumes, nuts, and seeds were not consumed as frequently as expected. Studies have shown that plant-based proteins are associated with better health.[34] Plant-based foods are generally rich in antioxidants, fiber, vitamins, and minerals. Thus, it is important to encourage the consumption of more plant-based foods as a means to lower the risk of morbidity.

The odds of having vitamin D deficiency were five times higher in those with PTH levels ≥ 6 pmol/L ($p = 0.052$). It is with no doubt that vitamin D and PTH are closely and tightly controlled.[35] PTH plays an important role in the activation of 25-hydroxy vitamin D to 1,25-dihydroxy vitamin D in the kidneys, which stimulates both calcium and phosphorus absorption from the intestines. As calcium levels increase in the blood, PTH decreases. The accepted normal range of PTH is $1 - 6.89$ pmol/L.[36] Serum levels above 6.9 pmol/L are diagnosed as hyperparathyroidism, which is commonly associated with vitamin D deficiency.[37]

Although all of those with hyperparathyroidism were vitamin D deficient, not all vitamin D deficient women had hyperparathyroidism. Hyperparathyroidism accounted for 30% of the vitamin D deficient group and 25% among the total sample. It is suggested that the response in PTH levels may take longer to be detected on a blood test as a result of a decrease in 25OHD levels.[38] The 25OHD threshold at which PTH levels begin to rise has been shown to differ between ethnic groups. An earlier study by Aloia et al.[39] found that PTH starts to rise when 25OHD decreases to 32 nmol/L in black women, versus 56 nmol/L in white women. In Saudi females living in Riyadh, the threshold was found to be 24 nmol/L, much lower than in their Western counterparts.[40] This suggests that ethnicity plays a significant role in defining the normal range of 25OHD levels based on its threshold for PTH secretion and should be considered when setting the normal range of serum vitamin D in the Middle East. Indeed, there have been attempts to identify common genetic variants that affect vitamin D levels in ethnic Arab individuals, among which the GC gene plays a significant role.[41]

Numerous studies show that low 25OHD levels are linked to an array of ailments including osteoporosis, cardiovascular disease, diabetes, obesity, cancer, and autoimmune disorders.[42] But the combined effect of both low vitamin D levels and hyperparathyroidism has been shown to exert a larger effect on the cardiovascular system,[8] glycemic dysregulation,[43] and mortality.[44] Therefore, these metabolites are suggested to be important health markers and an indication of an increased risk for morbidity. It is thus urgent to encourage citizens to increase their vitamin D levels through diet modification and sun exposure to avoid such risks in women of this region.

CONCLUSIONS

Vitamin D deficiency is common in apparently healthy, disease-free premenopausal Kuwaiti women. The impact of lifestyle, especially poor dietary consumption and a lack of sun exposure may explain the high prevalence of vitamin D deficiency. Promoting a healthier diet that includes vitamin D sources and more sun exposure is highly recommended.

Limitations

It is acknowledged that the sample size was limited, which was likely to limit the number of factors associated with vitamin D deficiency. Detailed questionnaires were not used due to the large amount of data in different areas and the limited duration of the interview.

ABBREVIATIONS

25-hydroxyvitamin D

iPTH: Intact Parathyroid hormone

IQR: interquartile range

BMI: Body mass index

WHR: Waist hip ratio

SPSS: Statistical Package for the Social Sciences

Competing interests

I declare no competing interests.

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