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Original Article

Dairy products consumption and serum 25-hydroxyvitamin D level in Saudi children and adults

Nasser M Al-Daghri[1,2], Naji Aljohani[1,3], Omar S Al-Attas[1,2], Soundararajan Krishnaswamy[2], Hanan Alfawaz[4], Abdulrahman Al-Ajlan[5], Majed S Alokail[1,2]

[1]Department of Biochemistry, Prince Mutaib Chair for Biomarkers of Osteoporosis, College of Science, King Saud University, Riyadh 11451, Saudi Arabia; [2]Department of Biochemistry, Biomarkers Research Program, College of Science, King Saud University, Riyadh 11451, Saudi Arabia; [3]Specialized Diabetes and Endocrine Center, King Fahad Medical City, King Saud Bin Abdulaziz University for Health Sciences, Riyadh 11525, Saudi Arabia; [4]Department of Food Science & Nutrition, College of Food Science & Agriculture, King Saud University, Riyadh 11451, Saudi Arabia; [5]Department of Clinical Lab Sciences, College of Applied Medical Sciences, King Saud University, Riyadh 11451, Kingdom of Saudi Arabia

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Abstract: Vitamin D deficiency is implicated in several calcium deficiency-related disease conditions. We aimed to investigate vitamin D status and its association with consumption frequencies of various dairy products in Saudi population. Subjects consisted of 820 children (327 boys; mean age 14.9 yrs and 493 girls; 14.8 yrs) and 565 adults (249 men, 27.9 yrs and 316 women 32.2 yrs). We estimated the consumption frequencies of various dairy food products (fresh milk, powdered milk, laban, yoghurt and cheese) using a qualitative food frequency questionnaire and serum level of 25-hydroxyvitamin D (25 (OH) D). Associations between variables of interest were assessed by Pearson correlation analysis. Among the study subjects, 80% boys, 90% girls, 64% men and 50% women had deficient/insufficient levels of vitamin D. Modest associations were found between mean serum 25 (OH) D concentration and fresh milk consumption in children (r=0.11) (especially in girls (r=0.12)), and overall dairy products consumption in women (r=0.12). Conclusion: Results indicated widespread vitamin D deficiency in Saudi Arabian children and adults. High level of vitamin D deficiency and a lack of strong correlation between dairy product consumption and serum level of vitamin D imply a need for adequate fortification of milk and other dairy products with vitamin D.

Keywords: Dairy products, vitamin D deficiency, vitamin D fortification, children, saudi

Introduction

It is well known that vitamin D aids bone growth by increasing calcium absorption [1] and its deficiency is associated with numerous calcium deficiency-related conditions such as rickets, osteomalacia, secondary hyperparathyroidism and fracture risk [2, 3]. Furthermore, vitamin D is a regulator of several physiological functions as observed from the expression of its receptor, VDR, in several human tissues [4, 5], and vitamin D insufficiency has also been implicated as a risk factor for type 1 diabetes mellitus, multiple sclerosis, autoimmune conditions, CVD and cancer [6, 7].

Sunlight is an indispensable source of endogenous vitamin D. However, inadequate exposure to sunlight or dark skin color can significantly affect the synthesis and necessitate additional dietary sources or supplements of vitamin D [8]. Various factors such as ethnicity, geographical location, cultural practices and food habits can influence vitamin D levels necessitating population specific approach to dietary requirements and related studies.

High levels of vitamin D deficiency have been reported from many parts of the world [9, 10]. Even though Saudi Arabia gets ample, year-round sunlight, high prevalence of vitamin D insufficiency has been reported in the population, mainly attributed to reduced outdoor activity and lack of vitamin D-fortification of common foods [11-13].

Table 1. General characteristics of children

Parameter	Boys	Girls	*P*-Value
N	327	493	
Age (years)	14.9±1.6	14.8±1.6	NS
BMI (kg/m^2)	23.1±0.4	22.9±0.2	NS
25-OH Vitamin D (nmol/l)	37.3±0.9	28.5±0.7	<0.001
Vitamin D Status			
Deficient (%)	22.0	49.5	
Insufficient (%)	59.6	45.6	<0.001
Sufficient (%)	16.2	2.2	
Desirable (%)	2.1	2.6	
How many times do you consume fresh milk (≈ 240 ml)?			
One to three times per day	38.7	35.4	<0.001
One to two times per week	19.3	23.9	
Three to five times per week	20.3	12.5	
Three to five times per month	12.8	9.8	
Chose not to answer	8.9	18.4	
How many times do you consume powdered milk (≈ 240 ml)?			
One to three times per day	26.1	18.6	0.02
One to two times per week	18.5	16.9	
Three to five times per week	15.5	13.4	
Three to five times per month	14.9	16.1	
Chose not to answer	25.1	34.9	
How many times do you consume laban (≈ 240 ml)?			
One to three times per day	23.9	24.5	0.02
One to two times per week	34.7	26.2	
Three to five times per week	16.7	15.1	
Three to five times per month	14.4	13.6	
Chose not to answer	10.4	20.6	
How many times do you consume yoghurt (≈ 170 ml)?			
One to three times per day	22.4	21.4	0.04
One to two times per week	25.6	32.7	
Three to five times per week	21.4	13.9	
Three to five times per month	14.4	15.3	
Chose not to answer	16.3	16.7	
How many times do you consume cheese?			
One to three times per day	40.2	44.1	NS
One to two times per week	24.4	24.6	
Three to five times per week	17.4	15.8	
Three to five times per month	9.6	6.8	
Chose not to answer	8.4	8.8	

Note: Data presented as percentage (%) for frequencies; mean ± standard deviation for continuous variables. *P*-value significant at <0.05.

Very few of the common food items contain vitamin D. Some fish (such as salmon, tuna, and mackerel) and fish liver oils are among the best sources, while small amounts of vitamin D are found in beef liver and egg yolks [14, 15]. Some mushrooms contain vitamin D2 in variable amounts [16]. The common dietary food sources of vitamin D are fortified milk and dairy products [14, 15].

Complete data on the dietary intake and its serum status are needed to device future dietary fortification plans to overcome vitamin D deficiency situation. Therefore, the aim of the present study was to assess the vitamin D status and to further define the association between frequency of different dairy products consumption and vitamin D status in young and adult populations of Saudi Arabia.

Table 2. General characteristics of adults

Parameter	Men	Women	*P*-Value
N	249	316	
Age (years)	27.9±0.8	32.2±0.6	<0.001
BMI (kg/m^2)	25.6±0.40	28.6±0.4	<0.001
25-OH Vitamin D (nmol/l)	38.4±1.1	34.4±1.2	0.017
Vitamin D Status			
Deficient (%)	37.7	25.9	0.004
Insufficient (%)	26.4	23.6	
Sufficient (%)	14.7	15.7	
Desirable (%)	9.5	14.1	
Chose not to answer	11.7	20.8	
How many times do you consume fresh milk (≈ 240 ml)?			
One to three times per day	18.8	13.6	
One to two times per week	18.8	19.8	NS
Three to five times per week	16.6	15.6	
Three to five times per month	14.0	16.9	
Chose not to answer	31.9	34.1	
How many times do you consume powdered milk (≈ 240 ml)?			
One to three times per day	23.9	15.8	0.01
One to two times per week	34.7	30.6	
Three to five times per week	16.7	18.4	
Three to five times per month	14.4	14.8	
Chose not to answer	10.4	20.3	
How many times do you consume laban (≈ 240 ml)?			
One to three times per day	18.0	18.5	NS
One to two times per week	30.7	30.7	
Three to five times per week	21.5	19.5	
Three to five times per month	20.2	16.9	
Chose not to answer	9.6	14.4	
How many times do you consume yoghurt (≈ 170 ml)?			
One to three times per day	36.0	45.4	NS
One to two times per week	33.8	28.4	
Three to five times per week	14.9	13.7	
Three to five times per month	10.5	7.7	
Chose not to answer	4.8	4.8	
How many times do you consume cheese?			
One to three times per day	36.8	21.4	0.001
One to two times per week	19.1	21.1	
Three to five times per week	11.8	10.2	
Three to five times per month	11.3	16.8	
Chose not to answer	21.1	30.6	

Note: Data presented as percentage (%) for frequencies; mean ± standard deviation for continuous variables. *P*-value significant at <0.05.

Methods

Subjects and data collection

The study subjects were randomly selected from different primary health care centers within Riyadh, Saudi Arabia, and consisted of 327 boys (mean age, 14.9±1.6 years), 493 girls (14.8±1.6), 249 men (27.9±0.8), and 316 women (32.2±0.6), who were apparently healthy. Written informed consents from adults as well as from parents of children and adolescents were obtained prior to inclusion. Subjects with chronic conditions such as asthma, type 1 diabetes mellitus, hypertension, history of cardiac, kidney or liver disease, use medications known to affect body weight (such as steroids), afflicted by psychiatric conditions, and those taking calcium, vitamin D, or multivitamin sup-

Table 3. Bivariate associations between vitamin D status and dairy product consumption

	Over-All	Children	Adults	Boys	Girls	Men	Women
N	1385	820	565	327	493	249	316
Dairy product consumption	0.02	0.09	0.03	0.03	0.08	0.01	0.12*
Intake of fresh milk (240 ml)	0.09**	0.11**	0.07	0.06	0.12**	0.06	0.03
Intake of powdered milk (240 ml)	0.02	0.04	0.01	0.08	0.04	0.01	0.01
Intake of laban (240 ml)	0.03	0.07	0.01	0.07	-0.03	0.01	0.05
Intake of yoghurt	0.02	0.02	0.06	0.09	0.03	0.03	0.10*
Intake of cheese	0.04	0.05	0.01	0.06	-0.07	0.03	0.06

Note: Data presented as coefficient (r); *denotes *p*-value significant at p<0.05; **denotes *p*-value at <0.01.

plements were excluded from the study. Ethical approval was obtained from the Ethics Committee of the College of Science Research Center, King Saud University, Riyadh, Saudi Arabia. A pre-designed and approved questionnaire, which included questions on socio-demographic data, medical history, and food frequency, was administered to all participants. Physical examination was carried out by the attending physician to determine whether the participants met the inclusion criteria. Weight and height were recorded to the nearest 0.2 kg and 0.5 cm, respectively, using an appropriate international standard scale (Digital Pearson Scale, ADAM Equipment Inc., USA). Waist circumferences were measured using non-stretchable tape. Definition of BMI was based on the cutoffs proposed by Cole and colleagues [17].

Vitamin D measurement

25 (OH) D was measured using COBAS e-411 automated analyzer (Roche Diagnostics, Indianapolis, IN, USA). The various states of vitamin D status were defined as following: deficient (<25 nmol/L); insufficient (25-50 nmol/L); sufficient (50-75 nmol/L) and desirable (>75 nmol/L).

Statistical analysis

Data was analyzed using the Statistical Package for the Social Sciences (SPSS version 16.0). Frequencies were presented as percentages (%) and continuous variables were presented as mean ± standard deviation. Chi-Square test was done to compare frequencies and independent T-test for normally distributed continuous variables. Pearson correlation was done to assess associations between variables of interest and linear regression analysis was carried out to adjust the elicited associations for age and BMI. Significance was set at *p*-value <0.05.

Results

General characteristics of children

General characteristics of participating children are presented in **Table 1**. Overall, boys had a significantly higher level of mean vitamin D than girls (P<0.05), the subjects of the two groups being similar in mean age and BMI. This positive bias towards boys was also reflected in higher (49.5) percentage of girls having vitamin D deficiency. Approximately 80% of the boys and 90% of the girls of our study population had deficient/insufficient levels of vitamin D. Significant differences between boys and girls were also observed with regard to the consumption frequencies specific products, such as fresh milk, powdered milk, laban (butter milk) and yoghurt, but not cheese.

General characteristics of adults

Results of general characteristics of participating adults are presented in **Table 2**. Approximately 64% of men and 50% of women participants of our study had deficient/insufficient levels of vitamin D. The vitamin D status of men and women were different with men having slightly higher vitamin D levels than women. However, due to differences in mean age and BMI of men and women a direct comparison between the genders was not possible. Overall, men had a higher percentage of individuals with deficient and insufficient vitamin D levels than women, and women had higher percentage of individuals with sufficient and desirable levels of vitamin D. Significant differences

between men and women were observed only with regard to the consumption frequencies of powdered milk and cheese.

Association between type and frequency of consumption dairy products and vitamin D status

Results of bivariate analysis of association between vitamin D status and frequency and type of dairy product consumption are shown in **Table 3**. Frequency of overall dairy product consumption was significant only in women ($r=0.12$, $P<0.05$) and this association was lost after adjusting for age and BMI. Frequency of fresh milk consumption affected vitamin D levels in the overall population and more specifically in children and female gender.

Discussion

This study aimed to explore the association between the type and frequency of dairy products consumption on vitamin D status in children and adult populations of Saudi Arabia. We found that fresh milk consumption frequency was significantly associated with vitamin D status in the overall population and this association was more pronounced in children, specifically among girls; in addition, overall dairy products consumption was associated with vitamin D status in women.

Approximately 80% of the boys and 90% of the girls of our study population had deficient/insufficient levels of vitamin D suggesting an overwhelming prevalence of vitamin D deficiency in Riyadh, Saudi Arabia. In our previous study in 2010, performed on a Saudi population consisting of boys and girls (n=300) of similar ages and from the same region of Riyadh, approximately 10% had severe 25-hydroxyvitamin D deficiency (<12.5 nmol/L), while 50% of the boys and 40% of the girls had mild vitamin D deficiency (12.5-24.9 nmol/L) [18]. In another study involving 331 Saudi boys and girls, aged 6-17 years, we showed that almost all the subjects had mild, moderate or severe vitamin D deficiencies [11]. High prevalence of vitamin D deficiency in Saudi Arabia was also reported by Al-Elq in a study involving 198 subjects (mean age of 19.4 yrs) in which he showed low vitamin D levels in 100% of the students [19].

Approximately 64% of men and 50% of women participants of our study had deficient/insufficient levels of vitamin D, which suggests an improvement in vitamin D status with age. In this respect, it is relevant to note that in a previous study age was identified as an independent predictor of vitamin D status among Saudi adults [20]. Our results are similar to that of Elsammak et al., who reported a high prevalence of vitamin D deficiency in a population living in the Eastern region of Saudi Arabia, despite >65% of the participants having adequate exposure to sunlight and >90% reporting adequate intake of dairy products [21].

Natural milk and various dairy products contain only negligible amounts of vitamin D and hence are fortified voluntarily by manufacturers in Western countries, following FAO guidelines [22]. However, completely absent or deficient vitamin D fortification of dairy and other products in Saudi Arabia, as reported by Sadat-Ali et al., [23], may be one of the major reasons for widespread deficient levels of vitamin D as compared to that in US and other Western countries. Inadequate fortification has been identified as the reason behind low vitamin D status even in developed nations, while the determination of appropriate level of vitamin D required for healthy living and hence the required level of fortification are still under active research [22].

The authors acknowledge certain limitations of this study. Sadat-Ali et al., in a recent study [23], analyzed various dairy products from the major manufacturers and found wide variations in their vitamin D content; these were: fresh milk (from 5 different manufacturers)-0 to 400 IU/L; powdered milk (from 4 manufacturers)-65 to 350 IU/100 gm; cheese (5 manufacturers)-0 to 350 IU/100 gm and yoghurt (6 manufacturers) 0 to 400 IU/L. Sadat Ali et al., also compared these levels with those of corresponding items in US and confirmed completely absent or highly inadequate fortification Saudi Arabia. The implication of this large variation in the vitamin D content of various dairy products from various manufacturers was not taken into account in our study. Besides, this study doesn't take into account the different dietary habits of the participants, which may have influenced the vitamin D intake, and other variables like skin color and sun exposure, which are also known to affect vitamin D levels.

In summary, vitamin D deficiency/insufficiency was highly prevalent in both young adult popu-

lations of Saudi Arabia, and had not improved much from our previous estimates of 2010 and 2012. Vitamin D levels correlated only modestly to consumption of overall dairy products in women and to fresh milk in girls. The absence or only modest correlations found between dairy products consumption and vitamin D levels in the Saudi population may be due to their low vitamin D content. Adequate vitamin D fortification of dairy products may improve the vitamin D levels in the Saudi population.

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Disclosure of conflict of interest

None.

Abbreviations

25 (OH) D-25-hydroxyvitamin D; BMI-Body Mass Index; CVD-Cardiovascular disease; SPSS-Statistical Package for the Social Sciences; USDA-U.S. Department of Agriculture; VDR-Vitamin D receptor.

Address correspondence to: Dr. Nasser M Al-Daghri, Biomarkers Research Program, Biochemistry Department, College of Science, King Saud University, PO Box, 2455, Riyadh 11451, Kingdom of Saudi Arabia. Tel: 0096614675939; Fax: 00966146-75931; E-mail: aldaghri2011@gmail.com

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