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Original Article

Dietary products consumption in relation to serum 25-hydroxyvitamin D and selenium level in Saudi children and adults

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Abstract: Vitamin D deficiency is a global health threat that has been associated with several chronic diseases. Selenium is an essential trace element because of role in major metabolic processes, immune function, thyroid hormone metabolism, male infertility, neoplasms and cardiovascular disease. We aimed to investigate for the first time in the Saudi population the association between vitamin D and selenium status with various dietary products consumption. A total of 259 children and 95 adults were included in this cross-sectional study. We estimated the consumption frequencies of various dietary food products using a qualitative food frequency questionnaire (FFQ) and also measured serum levels of 25-hydroxyvitamin D and selenium. Associations between variables of interest were assessed. Vitamin D deficiency and insufficiency were observed in 80% of the boys, 90% of the girls, 64% of men and 50% of women. Modest associations were found between mean serum 25 (OH) D concentration and consumption frequencies of fresh milk in children ($r=0.11$; $P<0.05$), more specifically in girls ($r=0.12$; $P<0.05$), and to the overall consumption of dairy products in women ($r=0.12$; $P<0.05$). Vitamin D status was also inversely associated with selenium in adults ($r=-0.43$; $P<0.05$). There was a significant correlation between delta changes of serum selenium, triglycerides and HDL levels (*P*-values <0.05). Vitamin D and selenium levels are modestly associated with dietary products consumption. Changes in selenium levels were associated with increased serum triglyceride levels, indicating a potential biomarker for cardiovascular risk and dyslipidemia. The widespread vitamin D deficiency observed in the present study highlight the need for adequate fortification of dairy products.

Keywords: Vitamin D, selenium, dietary products

Introduction

Both vitamin D and selenium are essential micro-nutrients for the human body. Their deficiencies are significantly linked to skeletal and immune system disorders. 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]. Vitamin D has recently been found to functions beyond bone formation. Vitamin D plays an important role in the immune system's battle against infection and control of inflammation. Receptors for active Vitamin D 1, 25 $(OH)_2$ D_3 (VDRs) are found in almost all immune cells. In umbilical cord blood samples, low levels of 25 OHD have been associated with low levels of the anti-inflammatory cytokine, Interleukin-10. Both the innate and adaptive arms of immunity are affected by Vitamin D. In adaptive immunity, 1, 25 $(OH)_2$ D_3 both enhances the release of IL-10 and inhibits the expression of inflammatory cytokines in monocytes, including IL-1, IL-6, TNF alpha, IL-8, and IL-12. Furthermore, vitamin D is

Table 1. General characteristic of subjects

Parameters	Adults			Children		
	Males	Females	*P*-Value	Boys	Girls	*P*-Value
N	24	71		113	146	
Age (years)	28.33 ± 12.91	33.08 ± 10.79	0.08	14.39 ± 1.54	14.43 ± 1.57	0.20
BMI (kg/m^2)	30.66 ± 6.04	29.75 ± 7.35	0.59	23.38 ± 6.23	22.95 ± 4.97	0.56
Systolic Blood Pressure (mmHg)	114.61 ± 56.3	125.52 ± 19.85	0.16	119.8 ± 26.0	116.8 ± 14.4	0.25
Diastolic Blood Pressure (mmHg)	62.87 ± 31.56	77.17 ± 13.50	0.04	69.65 ± 18.23	73.14 ± 12.33	0.07
Glucose (mmol/l)	5.57 ± 1.07	5.87 ± 2.57	0.58	5.34 ± 0.95	5.16 ± 0.99	0.13
Triglycerides (mmol/l)#	1.3 ± 0.48	1.46 ± 0.83	0.97	1.19 ± 0.59	1.21 ± 0.59	0.81
Total Cholesterol (mmol/l)	3.85 ± 1.05	4.45 ± 1.21	0.03	3.66 ± 0.84	3.56 ± 1.19	0.45
HDL-Cholesterol (mmol/l)	0.86 ± 0.18	1.0 ± 0.21	0.007	0.93 ± 0.24	0.97 ± 0.23	0.15
Vitamin D (nmol/l)#	33.25 ± 16.36	32.99 ± 20.37	0.46	34.54 ± 13.57	27.58 ± 15.75	< 0.001
Selenium (µg/L)#	128.69 ± 33.23	91.63 ± 54.38	< 0.001	114.93 ± 61.04	101.09 ± 54.73	0.013

Note: Data presented as mean ± standard deviation; #Denotes non-Gaussian distribution; *p*-value significant at P<0.05.

Table 2. Bivariate associations between serum selenium, dietary intake of selenium-rich foods, and measured variables

	All Subjects	All Adults	Males	Females	All Children	Boys	Girls
Intake of Sardines	0.04	0.07	0.01	0.02	0.05	0.13	0.006
Intake of Salmon	0.08	-0.02	0.05	-0.10	0.12*	0.14	0.14
Intake of Tuna	0.03	0.007	-0.14	0.01	0.03	0.14	-0.02
Intake of Egg	-0.04	-0.02	0.34	-0.03	-0.04	0.12	-0.11
Intake of Yoghurt	0.08	0.10	-0.34	0.14	0.09	0.11	0.06
Intake of Cheese	-0.10	-0.16	0.009	-0.16	-0.08	-0.08	-0.08
Age (years)	0.04	-0.16	0.11	-0.09	0.13*	0.19*	0.12
BMI (kg/m^2)	-0.02	-0.02	0.21	-0.08	-0.002	0.04	-0.06
Systolic Blood Pressure (mmHg)	0.05	0.01	0.05	-0.08	0.09	-0.13	0.20*
Diastolic Blood Pressure (mmHg)	-0.02	-0.10	0.03	-0.03	0.03	-0.11	0.14
Glucose (mmol/l)	0.02	0.02	0.002	0.02	-0.001	-0.08	0.02
Triglycerides (mmol/l)#	-0.10*	-0.12	-0.08	-0.15	-0.10	-0.02	-0.16*
Total Cholesterol (mmol/l)	-0.08	-0.29**	-0.41*	-0.21	0.009	-0.10	0.06
HDL-Cholesterol (mmol/l)	-0.13*	-0.32**	-0.25	-0.24*	-0.07	-0.11	0.04
Vitamin D (nmol/l)#	0.09	0.05	-0.43*	0.02	0.12*	0.07	0.10

Note: Data presented as coefficient (R); *Denotes significance at 0.05 level; **Denotes nificance at 0.01 level.

a regulator of several physiological functions as observed from the expression of 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 in many parts of the world [9, 10]. Even though Saudi Arabia gets ample sunlight throughout the year, high prevelance of vitamin D insufficiency has been recorded in the population, which has been mainly attributed to reduced outdoor activity and lack of vitamin D-fortification of common foods [11-13].

Selenium is a trace element considered essential because of its participation in major metabolic functions, immune system, thyroid hormone metabolism [14, 15], male infertility, neoplasms and cardiovascular disease [15]. It also has antioxidant properties [14]. Selenium is an active-site component of glutathione peroxidase (GPx) [16]. This enzyme contains four

Table 3. Bivariate associations between serum vitamin D, dietary intake of vitamin D-rich foods, and measured variables

	All Subjects	All Adults	Males	Females	All Children	Boys	Girls
Intake of Fresh Milk	-0.17**	-0.10	-0.02	-0.14	-0.18**	-0.05	-0.24**
Intake of Powdered Milk	-0.05	0.04	0.26	-0.02	-0.06	-0.07	-0.003
Intake of Laban	-0.08	-0.08	0.20	-0.18	-0.07	-0.03	-0.06
Intake of Yoghurt	-0.045	-0.05	0.41	-0.20	-0.03	-0.03	-0.09
Intake of Cheese	-0.11*	-0.14	-0.17	-0.15	-0.09	-0.06	-0.14
Age (years)	0.002	0.22*	0.39	0.16	-0.05	-0.20*	0.06
BMI (kg/m^2)	-0.07	-0.008	0.11	-0.06	-0.11	-0.16	-0.09
Systolic Blood Pressure (mmHg)	0.004	0.06	-0.21	0.15	-0.03	-0.28**	0.02
Diastolic Blood Pressure (mmHg)	-0.08	-0.03	-0.26	0.07	-0.14*	-0.16	-0.09
Glucose (mmol/l)	0.02	0.14	0.13	0.16	-0.012	-0.10	-0.01
Triglycerides (mmol/l)#	0.03	0.18	0.14	0.20	-0.04	-0.19	0.05
Total Cholesterol (mmol/l)	-0.05	-0.007	0.34	-0.06	-0.09	-0.11	-0.08
HDL-Cholesterol (mmol/l)	0.01	-0.01	0.25	-0.04	0.01	0.10	0.05
Selenium (μg/L)#	0.09	0.05	-0.43*	0.02	0.12*	0.07	0.10

Note: Data presented as coefficient (R); *Denotes significance at 0.05 level; **Denotes significance at 0.01 level.

atoms of selenium and is responsible for nearly 30% of plasma selenium levels [14]. GPx has antioxidant function, thereby protecting body cells from oxidation and reducing toxic substances caused by oxidative stress. Furthermore, selenium has known roles in thyroid and immune function [17], while its serum level has been associated with cardiovascular risk [18] and hypertension [19]. Mykkanen and colleagues have demonstrated an increase in selenite (inorganic form of selenium) uptake by cholicalciferol treatment [20].

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, 21]. Some mushrooms contain vitamin D2 in variable amounts [22]. The common dietary food sources of vitamin D are fortified milk and dairy products [14, 21]. Likewise variety food contain selenium, like nuts (0.53 mg/kg), offal (0.44 mg/kg), fish (0.3 mg/kg) eggs (0.19 mg/kg) and poultry (0.14 mg/kg) [23].

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

Materials and methods

Study population

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 a medications known to affect body weight (such as steroids), afflicted by psychiatric conditions, and those taking calcium, vitamin D, or multivitamin supplements 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.

Table 4. Intake of selenium-rich food comparison between adults and children

Parameter	Adults	Children	*P*-Value
N	95	259	
How many times do you eat Sardines?			NS
One to three times per day	1.1	1.2	
One to two times per week	10.9	7.2	
Three to five times per week	2.2	4.4	
Three to five times per month	21.7	18.5	
Chose not to answer	62.1	68.7	
How many times do you eat Salmon?			NS
One to three times per day	2.2	1.2	
One to two times per week	3.3	4.5	
Three to five times per week	3.3	5.8	
Three to five times per month	23.1	20.6	
Chose not to answer	68.1	67.9	
How many times do you eat Tuna?			NS
One to three times per day	7.8	8.0	
One to two times per week	24.4	28.0	
Three to five times per week	20.0	21.6	
Three to five times per month	28.9	24.8	
Chose not to answer	18.9	17.6	
How many times do you eat Egg?			0.004
One to three times per day	16.7	29.0	
One to two times per week	32.2	32.1	
Three to five times per week	30.0	19.0	
Three to five times per month	16.7	9.5	
Chose not to answer	4.4	9.9	
How many times do you consume yoghurt (≈ 170ml)?			0.051
One to three times per day	20.7	20.8	
One to two times per week	23.9	30.8	
Three to five times per week	18.5	17.6	
Three to five times per month	29.3	15.6	
Chose not to answer	7.6	15.2	
How many times do you consume cheese?			NS
One to three times per day	40.2	42.9	
One to two times per week	30.4	28.2	
Three to five times per week	15.2	16.3	
Three to five times per month	9.8	6.3	
Chose not to answer	4.3	6.3	

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

Anthropometry

All anthropometric parameters were obtained while the subject was standing erect and barefoot. Anthropometrics included height (rounded off to the nearest 0.5 cm); weight (rounded off to the nearest 0.1 kg) using an appropriate international standard scale (Digital Pearson Scale, ADAM Equipment Inc., USA). Waist circumferences were measured using non-stretchable tape. Body mass index (BMI) was calculated using the formula: weight in kilograms (kg) divided by height in squared meters (m^2). Definition of BMI was based on the cutoffs

Table 5. Intake of vitamin D-rich food comparison between adults and children

Parameter	Adults	Children	*P*-Value
N	95	259	
How many times do you consume fresh milk (≈ 240 ml)?			0.047
One to three times per day	25.0	38.7	
One to two times per week	27.4	20.6	
Three to five times per week	12.6	14.5	
Three to five times per month	11.6	12.5	
Chose not to answer	21.1	13.7	
How many times do you consume powdered milk (≈ 240 ml)?			0.161
One to three times per day	8.9	22.3	
One to two times per week	18.9	12.1	
Three to five times per week	16.7	16.6	
Three to five times per month	22.2	15.0	
Chose not to answer	33.3	34.0	
How many times do you consume laban (≈ 240 ml)?			0.033
One to three times per day	20.0	30.3	
One to two times per week	24.2	26.5	
Three to five times per week	11.6	16.3	
Three to five times per month	17.9	11.8	
Chose not to answer	21.1	15.5	
How many times do you consume yoghurt (≈ 170 ml)?			0.707
One to three times per day	20.7	20.8	
One to two times per week	23.9	30.8	
Three to five times per week	18.5	17.6	
Three to five times per month	29.3	15.6	
Chose not to answer	7.6	15.2	
How many times do you consume cheese?			0.96
One to three times per day	40.2	42.9	
One to two times per week	30.4	28.2	
Three to five times per week	15.2	16.3	
Three to five times per month	9.8	6.3	
Chose not to answer	4.3	6.3	

proposed by Cole and colleagues [17]. Standardized mercury sphygmomanometer was used to take the blood pressure of each participant 30 min after complete rest.

Lipid profile measurement in serum samples

Fasting blood glucose, lipid profile, concentrations were measured routinely using a chemical analyzer (Konelab, Espoo, Finland).

Vitamin D measurement in serum samples

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).

Selenium measurement in serum samples

Serum Se level was determined by Shimadzu graphite furnace atomic absorption spectrometry, Shimadzu, Model: AA- 7000 Series equipped with auto sampler. Pyrolytically coated tubes were used as atomizers. The conditions for selenium were: A Shimadzu selenium hollow cathode lamp with wavelength of 196.0 nm, lamp current: 290 mA, slit width: 2.0 nm, matrix modifier was Paladium modificator. The detection limit of the method was less than 5 ug/L, precision (<11%) and inaccuracy (<1%). Samples were diluted in proportion 1:10 with a special reducing reagent containing Ascorbic acid, Triton X-100 and Antifoam B Emulsion in deionized water to improve the sample viscosity and reproducibility of the results. Stock standard solutions for selenium were prepared from the commercial Se standard (1000 mg/L) Solution Acros Organics (USA). The working standard solutions were prepared weekly by appropriate dilution and kept refrigerated at 4 oC. Argon was applied as protective gas and 10 µL samples were injected into the graphite furnace (GF). All samples were analyzed in duplicate. Human reference serum (Seronorm™ Trace Elements in Serum) from Sero AS (Billingstad, Norway) was used to check the entire proposed analytical method reliability. This reference material was supplied in lyophilized form and reconstituted by dissolving the vial total content using high purity de-ionized water. The results for the reference sample agreed with the certified acceptable range of selenium concentration.

Statistical analysis

The Statistical Package for the Social Sciences (SSPS) for Windows version 16.0 (Chicago, Illinois) was used for statistical evaluation of the data. 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. 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 and selenium than girls (P<0.05), the subjects of the two groups being similar in mean age and BMI. This 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. consumption frequencies of specific products, such as fresh milk, powdered milk, laban (butter milk) and yoghurt but not cheese (**Table 2**), gave significant boys and girls. There are significant differences in the salmon intake by children and their selenium level (**Table 3**).

General characteristics of adults

Results of general characteristics of participating adults are presented in **Table 1**. Approximately 64% of men and 50% of women participants of our study had deficient/insufficient levels of vitamin D. The vitamin D statuses of men and women were different with men having slightly higher vitamin D levels than women. However, men and women differed in their respective mean ages and BMI and hence, do not allow a direct comparison between the genders. Overall, men had higher percentage of individuals with deficient and insufficient vitamin D levels than women, and women had higher percentage of women 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. Significant differences between males and females were also observed with regard of selenium level. Girls and females always have lower selenium than boys and males, respectively. In males there was a significant correlation between delta changes of serum selenium and triglyceride and HDL levels (r=0.32, P=0.04) (**Table 3**). Moreover, a significant correlation between delta changes of vitamin D and PTH (r=-0.28, P=0.03 and r=-0.26, P=0.03) were observed both in males and females, respectively.

Association between type and frequency of consumption dietary products and vitamin D and selenium status

Results of bivariate analysis of association between selenium status and frequency and type of selenium-rich Food are shown in **Table 4**. Frequency of overall egg and Yoghurt consumption was significantly in children (P<0.05). Also, frequency of overall vitamin D dairy product consumption was significant in women (r=0.12, P<0.05). Frequency of fresh milk consumption affected the vitamin D levels in the overall population and more specifically in children including girls (Table 5).

Discussion

This study aimed to explore the association between the type and frequency of dietary products consumption on the vitamin D and selenium status in children and adults of Saudi Arabia. We found that frequency of intake of fresh milk was significantly associated with vitamin D status in the overall population and this was more pronounced in children especially 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, overwhelming prevalence of vitamin D deficiencies in Riyadh, Saudi Arabia. In our previous study in 2010, 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) [24]. 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]. A 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 [25]. 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 in Saudi adults [26]. Our results are similar to those of Elsammak et al., who reported high prevalence of vitamin D deficiency in a population living in the Eastern region of Saudi Arabia despite >65% of participants having adequate exposure to sunlight and >90% reporting adequate intake of dairy products [27]. 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 [28]. However, completely absent or deficient vitamin D fortification of dairy and other products in Saudi Arabia, as reported by Sadat-Ali et al., [29] 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 [28].

In males, a significant increase in the serum selenium level was observed and there is significant relation between vitamin D and selenium level. This relation has not been well studied, but low selenium intake has been associated with an increased risk for bone diseases [30]. Moreover, it has been shown that a single intravenous doses of 100 IU cholecalciferol, 100 IU ergocalciferoi, or 0.1 μg 1,25 dihydroxycholecalciferol could increase selenite uptake, exhibiting an important association with different vitamin D compounds [31]. Recently this issue was solved by new science of epigenetics, which studies the relationship between lifestyle choices and genetic expression. New research in human volunteers has shown that certain molecular changes to our genes-referred to as epigenetic marks-can be affected by nutrition. For the study, researchers examined DNA methylation in volunteers free from any intestinal disorders or disease and consumed their usual diet without any supplements. Results indicated that volunteers with higher vitamin D levels tended to show lower levels of methylation, and a similar observation was made in relation to selenium. The results of this study support the hypothesis that the epigenetic status of some genes can be effectively modulated by dietary factors.

There are contradictory results regarding serum selenium levels in males and females. Several studies shows that the serum selenium levels do not differ in T2DM patients based on sex differences [32]. Study performed by Lee et al. demonstrated a decreasing tendency of selenium levels with age (>40 y) and concluded that the association of selenium status with blood lipid levels are applicable only in young-adult females [33]. On the other hand, the analysis of males and females in NHANES III studies exhibited significantly higher mean serum selenium concentration in males with age (31-50 y 124 μg/L) than in the same age group of females. (122 μg/L) [34]. Apart from gender differences, the level of selenium intake is also influenced by several confounding factors like health-related behaviors and dietary intake of other nutrients. For instance, alcohol consumption was in direct association with serum selenium in women, but not in the men of NHANES III [34], while, an inverse relation was demonstrated between toenail selenium concentration and smoking which was stronger in men than in women [35]. The present study supports the NHANES III results showing significant increase in serum selenium concentration in males, but the gender difference regarding selenium increase after vitamin D supplementation is still not clear and needs to be studied further. Observational studies show positive association of serum selenium level with triglycerides concentration in different populations [36]. Yang and colleagues [37] showed a significant increase in the levels of triglycerides with increased serum selenium concentrations in Taiwanese elderly. Gender-specific analysis of the same study demonstrated that triglycerides increased significantly across the highest selenium quartiles in men, while total HDL- and LDL-cholesterol concentrations increased significantly across the highest selenium quartiles in women [37]. Our results support the study performed by Yang et al. showing a positive correlation of triglycerides with the level of serum selenium in males.

Conclusion

In summary, vitamin D deficiency/insufficiency was highly prevalent in both young adult populations of Saudi Arabia, and had not improved much from previous estimates of 2010 and 2012. Vitamin D and selenium levels correlated only modestly to consumption frequency of overall dietary products. Vitamin D the serum level positively correlate with selenium in a gender-dimorphic manner. Change of selenium levels were associated with increased triglyceride levels. 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, in future, could improve the vitamin D levels in the Saudi population.

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Disclosure of conflict of interest

None.

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