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Sun Exposure Behaviors and Vitamin D Status in Healthy Adults

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ABSTRACT

Background: Vitamin D status is highly associated with behavioral factors such as sun exposure patterns. The present study aimed to determine sun exposure behaviors and vitamin D status among healthy adults in Shiraz, Iran.

Methods: In this cross-sectional study, 201 healthy individuals aged 20-40 years were randomly selected from different areas of Shiraz, Iran. Demographic characteristics, vitamin D intake through diet or supplements, and sun exposure habits were assessed and also serum 25-hydroxyvitamin D (25(OH)D) concentration was measured.

Results: The mean concentration of serum 25(OH)D was 21.43±9.2 ng/mL. There were no significant associations between 25(OH)D level and sun exposure habits except wearing long-sleeve shirts (p=0.010). However, in the participants who did not take vitamin D supplements, serum 25(OH)D level had a negative association with sunscreen use (p=0.045), frequent use of sunscreen (p=0.045), and wearing long-sleeve shirts (p=0.023), and positive correlation with duration (p=0.045) and time of sun exposure (p=0.026) and the percentage of body surface area exposed to the sun (r=0.245, p=0.010).

Conclusion: Vitamin D deficiency is a common problem among healthy young adults in Shiraz, Iran, and sun exposure habits can affect vitamin D status only among the participants who did not take vitamin D supplements.

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Introduction

Vitamin D is known as the sunshine vitamin (1). This vitamin is a steroid hormone that plays an important role in calcium and mineral homeostasis as well as in several tissues, such as pancreas, cardiovascular system, immune cells, and parathyroid. Vitamin D deficiency has been reported to be associated with skeletal diseases, such as osteopenia and osteoporosis, as well as non-skeletal diseases, such as cardiovascular diseases, autoimmune diseases, cancers and depression (2-5). About one billion people worldwide suffer from vitamin D deficiency or insufficiency (6). The prevalence of vitamin D deficiency has been reported to vary from 30% to 90% in developing countries. It is noteworthy that even in tropical areas, such as Iran and Saudi Arabia, the prevalence of vitamin D deficiency is high in apparently healthy

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adults (7). The results of the systematic review and meta-analysis performed by Tabrizi *et al.* indicated a high prevalence of vitamin D deficiency among Iranian males (45.64%) and females (61.90%) (8).

Generally, three sources of vitamin D include sunlight, foods containing vitamin D or fortified with vitamin D, and supplements. There are limited sources of vitamin D in food diets and such foods are not found in the Iranian food basket appropriately. In addition, in many developing countries including Iran, adding vitamin D to food is not a common strategy to prevent vitamin D deficiency. Therefore, in the absence of supplements, the most important source of vitamin D is sunlight exposure. Ultraviolet B radiation leads to vitamin D production in the skin, which is then converted to 25-hydroxyvitamin D (25(OH)D) in the liver (5, 7, 9, 10). Serum level of 25(OH)D reflects the total amount of skin synthesis and vitamin D intake from foods or supplements. The Endocrine Society has defined vitamin D deficiency as 25(OH)D <20 ng/mL, insufficiency as 25(OH)D <30 ng/mL, and sufficiency as 25(OH)D ≥30 ng/mL (6).

The serum 25(OH)D concentration depends on many factors, including environmental factors such as latitude, season, air pollution, and cloud coverage, behavioral factors such as duration and time of sun exposure, sunscreen use, clothing style, dietary vitamin D intake, and using vitamin D supplements, and genetic factors such as skin color, age and sex (5, 6, 9). Since the risk factors of vitamin D deficiency are different among populations, various strategies may be needed to prevent it. Therefore, the risk factors should be clearly identified in each population in order to provide appropriate recommendations to prevent or reduce vitamin D deficiency (11). Considering the importance of vitamin D in general health and the high prevalence of vitamin D deficiency in several cities of Iran, the present study aimed at determining sun exposure behaviors and vitamin D status among healthy adults in Shiraz, Iran.

Materials and Methods

In this cross-sectional study, 201 healthy adults aged 20-40 years were selected from health centers in different areas of Shiraz (latitude: 29◦61′ N), Iran, using random cluster sampling method. The Sample size was estimated based on a study by Keykhaei *et al.* in Zahedan city (latitude: 29◦49′ N). Considering the mean serum level of 25(OH)D to be 13.75±11.79 ng/mL, α=5% and d=0.14SD, the sample size was calculated to be 196 (12). This study was part of a project that was previously published (13). The study was conducted between May and July 2018. Healthy adults within the age range of 20-40 years were included. The exclusion criteria were having a history of active cancer in the last five years, suffering from liver disease, renal diseases such as renal stone and chronic renal failure, digestive diseases such as celiac, chronic diarrhea, and inflammatory bowel disease, skin diseases, hypercalcemia, hyperthyroidism, hyperparathyroidism, and hormonal disorders, taking medications like oral corticosteroids, anticonvulsants, insulin, bisphosphonates, and hormonal medications that affect calcium or vitamin D metabolism, having any conditions affecting vitamin D synthesis or metabolism, and taking 50,000 IU vitamin D supplements on a weekly basis. It should be noted that written informed consent forms were obtained from all participants.

Information about the factors affecting serum 25(OH)D level was gathered through interviews. All questions were related to the participants' behaviors during the past 30 days. The gathered information was divided into the categories of (i) Demographic information (age, sex, marital status, education level, occupation, smoking). (ii) Information about sunlight exposure (duration and time, percentage of body surface area exposed to sunlight (%), outdoor physical activity, and protective behaviors such as use of sunscreen, hats and long-sleeve shirts). The participants' skin types were also determined using Fitzpatrick scale (14). Percent of body surface area exposed to sunlight (%) was also determined (15). Anthropometric information [height, weight, Body Mass Index (BMI), and waist circumference]. Weight was measured to the nearest 0.1 kg via the Seca 713 scale while the participants were minimally clothed. Additionally, height was measured by a non-stretchable tape meter, with the participants standing bare foot. Then, BMI was computed by dividing weight in kg by height in meters squared. Finally, waist circumference was determined by a non-stretchable flexible tape meter on a horizontal plane around the abdomen just above the iliac crest (16). It should be noted that the equipment was calibrated every morning.

(iii) Regarding information about dietary vitamin D intake, the frequency and amount of eating nine food items containing vitamin D, including Vitamin D containing fish, poultry, egg, yolk egg, milk, cream, canned tuna, butter, and margarine were asked. Food processor software Nutritionist-4, modified by incorporating the Iranian food table, was used to calculate vitamin D consumptions. (iv) In relation to information about the use of supplements containing vitamin D, the frequency and dose of vitamin D in supplements were requested.

In order to assess the serum levels of 25(OH) D, parathyroid hormone (PTH), calcium, and phosphorus, a five-milliliter blood sample was drawn from each participant. Blood samples were obtained at 8-9 A.M. after an overnight fasting. After centrifugation of the samples at 40 rpm for 10-30 minutes, the sera were immediately separated and stored at -80°C until analysis. All samples were analyzed in a valid private laboratory (Farzanegan laboratory). PTH was measured using the Immulite® 2000 device, and calcium and phosphorus levels were determined by colorimetry on a Mindray BS-380 autoanalyzer. Serum 25(OH)D concentration was determined by High-Performance Liquid Chromatography (HPLC), which has a lower limit of detection of 2 ng/mL and a between-run coefficient of variation of 2.6-4.9% for 25(OH)D. Vitamin D deficiency was defined as 25(OH)D <20 ng/mL, insufficiency as 25(OH)D <30 ng/mL, and sufficiency as 25(OH)D ≥30 ng/mL (6).

The normality of quantitative data was evaluated using Kolmogorov-Smirnov test. Non-normally distributed quantitative data were reported as the median. Other quantitative data were expressed as mean±SD and qualitative variables as frequency and percentage. Independent sample T-test and ANOVA were used for between group comparisons. Additionally, Pearson's correlation coefficient was used to assess the relationship between quantitative variables. All statistical analyses were performed using the SPSS statistical software (version 21, Chicago, IL, USA) and $p<0.05$ was considered to be statistically significant.

Results

This study was conducted on 201 healthy subjects (126 females [62.7%) and 75 males (37.3%)] with the mean age of 31.92±5.09 years. Demographic and anthropometric characteristics of the participants were presented in Table 1. The mean serum levels

Table 1: The participants' demographic and anthropometric characteristics and their association with 25(OH)D level.

Variable	Total (n=201)	25(OH)D (Mean±SD)	*P* value
Age [years] (Mean±SD)	31.92±5.09		0.020[1]
Age group [n (%)]			0.082[2]
<30 years	67 (33.3)	19.8±9.2	
≥30 years	134 (66.7)	22.2±9.2	
Sex [n (%)]			0.066[2]
Female	126 (62.7)	20.5±9.8	
Male	75 (37.3)	22.9±7.9	
Marital status [n (%)]			0.141[2]
Single	41 (20.4)	19.5±10.2	
Married	160 (79.6)	21.9±8.9	
Occupation [n (%)]			0.164[3]
Homemaker	87 (43.3)	20.7±9.2	
Employee	53 (26.4)	22.5±9.3	
Student	7 (3.5)	15.0±7.6	
Self-employed	54 (26.4)	22.3±9.2	
Education level [n (%)]			0.518[3]
Under diploma	33 (16.4)	22.2±9.3	
Diploma	78 (38.8)	22.4±9.2	
Associate degree	19 (9.5)	20.6±9.4	
Bachelor's degree	63 (31.3)	20.4±8.9	
Master's degree	8 (4)	17.7±11.5	
BMI[4] [kg/m^2] (Mean±SD)	25.4±4.4		0.413[1]
BMI category [n (%)]			0.184[3]
<25	99 (49.3)	21.2±9.3	
25-29.9	73 (36.3)	21.6±9.3	
≥30	29 (14.4)	18.9±8.3	
Waist circumference [cm] (Mean±SD)	89.5±11.6		0.549[1]
Smoking [n (%)]			0.340[2]
Yes	28 (13.9)	22.9±8.9	
No	173 (86.1)	21.1±9.3	

[1]*P*-value of Pearson correlation test to measure the association between serum 25(OH)D level with age, BMI, and waist circumference variables. [2]*P*-value of independent t-test to compare serum level of 25(OH)D between subgroups of each variable. [3]*P*-value of ANOVA test to compare serum level of 25(OH)D between subgroups of each variable. [4]BMI, Body Mass Index.

of 25(OH)D and PTH were 21.43±9.2 ng/mL and 36.03±16.85 pg/mL, respectively. Additionally, the median (Inter Quartile Range) serum levels of calcium and phosphorus were 8.7 (8.3-9.2) mL/dL and 3.7 (3.3-4.1) mL/dL, respectively. Totally, 47.8% of the participants had vitamin D deficiency, 32.3% had vitamin D insufficiency, and 19.9% had optimal vitamin D status. A significant negative correlation was noticed between the serum 25(OH)D level and serum PTH level (r=-0.30, *p*<0.001). Serum phosphorus level also had a significant negative correlation with serum 25(OH)D level (r=-0.16, *p*=0.023). However, no significant correlations were observed between the serum 25(OH)D level and calcium levels.

Serum levels of 25(OH)D were 19.8±9.2 and 22.2±9.2 ng/mL in the subjects aged <30 and ≥30 years, respectively, but the difference was not statistically significant. There was a significant positive correlation between the serum levels of 25(OH)D and age (r=0.16, *p*=0.020). Although the serum levels of 25(OH)D was higher in males than in females, the difference was not statistically significant (22.9±7.9 and 20.5±9.8 ng/mL, respectively) (Table 1). Mean (median) dietary vitamin D intake was 65.25 (41.14) IU/day. No significant association was visible between serum 25(OH)D levels and dietary vitamin D intake (*p*=0.135, r=0.106).

In this study, 49.8% (n=100) of the subjects took vitamin D supplements. Besides, 92% of the supplement users (45.8% of the subjects in total) took 50,000 IU capsules monthly and 8% used vitamin D as part of calcium-D or multivitamin supplements. Serum levels of 25(OH)D was significantly higher among the supplement consumers (*p*<0.001) in comparison to those who did not take the supplements (26.11±8.2 and 16.78±7.7 ng/mL, respectively). Moreover, 56% of supplement consumers were above ≥30 years old, and 44% of them were under 30 years old. A significant positive association was noted between supplement use and age group (*p*=0.009).

Comparison of serum levels of 25(OH)D on the basis of demographic and anthropometric variables in the participants who did take vitamin D supplements

Table 2: Serum 25(OH)D based on demographic/anthropometric factors in the subjects who did take vitamin D supplements (n=100) and those who did not take vitamin D supplements (n=101).

Variable	Taking supplements (n=100)		Not taking supplements (n=101)	
	25(OH)D (Mean±SD)	*P* value[1]	25(OH)D (Mean±SD)	*P* value[1]
Age group[2]				
<30 years	26.6±7.7	0.681	15.7±7.4	0.251
≥30 years	25.9±8.4		17.5±7.9	
Sex[2]				
Female	25.2±8.2	0.044	13.4±7.7	<0.001
Male	28.9±7.6		20.0±6.3	
Marital status[2]				
Single	25.9±10.5	0.938	14.9±7.1	0.171
Married	26.1±7.7		17.3±7.9	
Occupation[3]				
Student	18.8±6.6	0.004	12.3±8.1	0.038
Homemaker	24.3±7.8		14.5±8.0	
Employee	27.7±8.1		16.2±6.4	
Self-employed	31.8±7.1		19.2±7.6	
Education level[3]				
Under diploma	26.0±7.5	0.966	16.4±9.0	0.060
Diploma	26.4±8.4		18.9±8.4	
Associate degree	25.2±10.5		15.5±4.6	
Bachelor's degree	26.4±7.6		15.3±6.5	
Master's degree	23.8±10.2		7.5±2.5	
BMI[4] category[3]				
<25	26.5±8.3	0.324	16.9±7.8	0.854
25-29.9	26.6±8.3		17±7.6	
≥30	22.9±7.4		15.7±7.9	
Smoking[2]				
Yes	29.0±7.2	0.230	20±8.3	0.063
No	25.8±8.3		16±7.4	

[1]*P*-value to compare serum level of 25(OH)D between subgroups of each variable. [2]The comparison was performed using independent t-test. [3]The comparison was performed using ANOVA. [4]BMI, Body Mass Index.

(n=100) and those who did not take vitamin D supplements (n=101) have been presented in Table 2. In both groups, the mean serum levels of 25(OH) D was significantly higher in males than in females (p=0.044, p<0.001 respectively). In addition, serum levels of 25(OH)D was significantly associated with occupational status (p=0.004, p=0.038 respectively) in both groups. The highest serum levels of 25(OH) D was detected in self-employed participants followed by employees, homemakers, and students, respectively. However, in both groups, there were no significant associations between serum 25(OH)D level and dietary vitamin D intake (r=0.135, p=0.180, r=0.035, p=0.729 respectively).

As shown in Table 3 and 4, among the participants and those who did take vitamin D supplements, there

Table 3: Serum 25(OH)D level based on sun exposure items.

Variable	Total (n=201)		
	N (%)	**25(OH)D (Mean±SD)**	***P* value[1]**
Use of sunscreen			
Never	88 (43.7%)	21.8±8.8	0.484
Sometimes	48 (23.8%)	20.0±9.7	
Always	65 (32.3%)	21.9±9.4	
Frequent use of sunscreen			
Never	88 (43.7%)	21.8±8.8	0.830
Once a day	86 (42.7%)	20.9±9.4	
Two or more times a day	27 (13.4%)	21.4±10.3	
Wearing long-sleeve shirts			
Never	19 (9.4%)	27.2±8.0	0.010[2]
Sometimes	87 (43.2%)	20.1±8.3	
Always	95 (47.2%)	21.4±9.8	
Wearing a hat			
Never	132 (65.6%)	21.9±8.9	0.181
Sometimes	52 (25.8%)	21.2±9.9	
Always	17 (8.4%)	17.5±8.7	
Duration of sun exposure			
<60 min	133 (66.1%)	20.6±9.4	0.084
>60 min	68 (33.8%)	22.9±8.8	
Time of sun exposure			
Before 11 A.M.			
Yes	125 (62.1%)	21.0±9.0	0.481
No	76 (37.8%)	22.0±9.6	
11 A.M.-4 P.M.			
Yes	118 (58.7%)	22.1±9.3	0.219
No	83 (41.2%)	20.4±9.1	
After 4 P.M.			
Yes	72 (35.8%)	22.2±8.8	0.350
No	129 (64.1%)	20.9±9.4	
Skin type			
Type 3	125 (62.1%)	20.8±8.7	0.257
Type 4	76 (37.8%)	22.4±10	
Month blood taken			
May	95 (47.3%)	21.3±9.6	0.237
June	60 (29.9%)	22.8±9.5	
July	46 (22.9%)	19.7±7.7	
Physical activity in the sun			
Zero	137 (68.1%)	21.5±9.1	0.882
<25%	25 (12.4%)	21.5±8.9	
25%-75%	32 (15.9%)	20.0±10.9	
>75%	7 (3.4)	22.8±9.7	

[1]*P*-value to compare serum level of 25(OH)D between subgroups of each variable and the comparison was performed using independent t-test or ANOVA. [2]Significant differences between groups were investigated using Scheffe's test and was between never-sometimes (*P*-value=0.010) and never-always (*P*-value=0.042).

was no significant association between the serum level of 25(OH)D and sun exposure factors except wearing long-sleeve shirts (p=0.010, p=0.010 respectively). Also, no significant association was seen between percentage of body surface area exposed to the sun with serum 25(OH)D. After excluding the subjects who used vitamin D supplements, the use of sunscreen, frequent use of sunscreen throughout the day, wearing long-sleeve shirts when exposed to sunlight, duration of sun exposure, and exposure

Table 4: Serum 25(OH)D level based on sun exposure items in the subjects who did take vitamin D supplements (n=100) and those who did not take vitamin D supplements (n=101).

Variable	Taking supplements (n=100)		Not taking supplements (n=101)	
	25(OH)D (Mean±SD)	*P* value[1]	25(OH)D (Mean±SD)	*P* value[1]
Use of sunscreen				
Never	27.3±8.1	0.562	18.5±7.5	0.045[2]
Sometimes	25.8±8.4		14.7±7.7	
Always	25.3±8.3		14.6±7.5	
Frequent use of sunscreen				
Never	27.3±8.1	0.494	18.5±7.5	0.045[3]
Once a day	25.1±7.8		14.7±8.0	
Two or more times a day	26.4±9.8		14.5±6.1	
Wearing long-sleeve shirts				
Never	33.9±5.1	0.010[4]	22.3±5.8	0.023[5]
Sometimes	24.3±8.0		16.9±7.1	
Always	26.1±8.2		15.1±8.3	
Wearing a hat				
Never	26.2±8.4	0.834	17.8±7.4	0.135
Sometimes	26.2±8.0		14.9±8.5	
Always	24.1±7.2		14.0±7.5	
Duration of sun exposure				
<60 min	25.2±8.0	0.123	15.6±8.1	0.045
>60 min	28.0±8.4		18.7±6.7	
Time of sun exposure				
Before 11 A.M.				
Yes	25.4±8.3	0.326	16.5±7.4	0.719
No	27.1±8.1		17.1±8.3	
11 A.M.-4 P.M.				
Yes	26.8±8.1	0.333	18±8.3	0.026
No	25.2±8.3		14.5±6	
After 4 P.M.				
Yes	27.0±8.3	0.445	18.1±7.2	0.144
No	25.6±8.2		15.9±8	
Skin type				
Type 3	25.7±7.1	0.521	15.5±7.0	0.056
Type 4	26.8±10.0		18.6±8.4	
Month blood taken				
May	26.0±8.5	0.639	15.6±7.8	0.441
June	26.9±8.4		17.5±8.3	
July	24.4±6.8		17.7±7.2	
Physical activity in the sun				
Zero	25.9±8.1	0.987	17.3±7.9	0.647
<25%	26.6±7.6		16.1±6.7	
25%-75%	25.9±10.7		14.2±7.7	
>75%	26.8±7.2		17.5±11.6	

[1]P-value to compare serum level of 25(OH)D between subgroups of each variable and the comparison was performed using independent t-test or ANOVA. [2]Significant differences between groups were investigated using LSD test and was between never-sometimes (*P*-value=0.039). [3]Significant differences between groups were investigated using LSD test and was between never-once a day (*P*-value=0.023). [4]Significant differences between groups were investigated using Scheffe's test and was between never-sometimes (*P*-value=0.010) and never-always (*P*-value=0.042). [5]Significant differences between groups were investigated using Scheffe's test and was between never-always (*P*-value=0.023).

Table 5: Sun exposure behaviors in female and male participants (n=201)

Variable	n (%)	Sex		*P* value[1]
		Female	Male	
Use of sunscreen[2]				
Never	88 (43.7%)	28 (22.2%)	60 (80%)	<0.001
Sometimes	48 (23.9%)	36 (28.6%)	12 (16%)	
Always	65 (32.3%)	62 (49.2%)	3 (4%)	
Frequent use of sunscreen[2]				
Never	88 (43.7%)	28 (22.2%)	60 (80%)	<0.001
Once a day	86 (42.8%)	71 (56.3%)	15 (20%)	
Two or more times a day	27 (13.4%)	27 (21.4%)	0 (0%)	
Wearing long-sleeve shirts[2]				
Never	19 (9.5%)	2 (1.6%)	17 (22.7%)	<0.001
Sometimes	87 (43.3%)	47 (37.3%)	40 (53.3%)	
Always	95 (47.3%)	77 (61.1%)	18 (24%)	
Wearing a hat[2]				
Never	132 (65.7%)	76 (60.3%)	56 (74.7%)	0.073
Sometimes	52 (25.9%)	36 (28.6%)	16 (21.3%)	
Always	17 (8.5%)	14 (11.1%)	3 (4%)	
Duration of sun exposure[2]				
<60 min	133 (66.2%)	102 (81%)	31 (41.3%)	<0.001
>60 min	68 (33.8%)	24 (19%)	44 (58.7%)	
Time of sun exposure				
Before 11 A.M.[2]				
Yes	125 (62.2%)	76 (60.3%)	49 (65.3%)	0.478
No	76 (37.8%)	50 (39.7%)	26 (34.7%)	
11 A.M.-4 P.M.[2]				
Yes	118 (58.7%)	67 (53.2%)	51 (68%)	0.039
No	83 (41.3%)	59 (46.8%)	24 (32%)	
After 4 P.M.[2]				
Yes	72 (35.8%)	39 (31%)	33 (44%)	0.062
No	129 (64.2%)	87 (69%)	42 (56%)	
Skin type[2]				
Type 3	125 (62.2%)	63 (73.8%)	32 (42.7%)	<0.001
Type 4	76 (37.8%)	33 (26.2%)	43 (57.3%)	
Physical activity in the sun[2]				
Zero	137 (68.2%)	90 (71.4%)	47 (62.7%)	0.036
<25%	25 (17.4%)	19 (15.1%)	16 (21.3%)	
25%-75%	32 (10.9%)	10 (7.9%)	12 (16%)	
>75%	7 (3.5)	7 (5.6%)	0 (0%)	

[1]*P*-value to compare subgroups of each variable between females and males. [2]The comparison was performed using chi-square test.

between 11 A.M. and 4 P.M. (peak hours of solar radiation) significantly affected vitamin D status (Table 4). Also, serum level of 25(OH)D showed a significant positive correlation with the percentage of body surface area exposed to the sun (r=0.254, p=0.010). Gender differences were observed in sun exposure factors, as well. Accordingly, almost all factors of sun exposure were significantly higher in males compared to females (p<0.05) (Table 5). Mean (median) percentage of body surface area exposed to the sun was also significantly higher in males 15.67 (15.50) than in females 11.18 (8.50) (p<0.001).

Discussion

The present study aimed at evaluating vitamin D status and its related factors in healthy adults. The mean serum levels of 25(OH)D in the study population indicated inadequacy of vitamin D in the community, which had a significant positive correlation with supplements use and age, and a significant negative correlation with PTH and calcium serum levels. Although no significant association was observed between serum 25(OH) D levels and dietary vitamin D intake. In the subgroup of participants who did not take vitamin

D supplements, serum 25(OH)D level was significantly correlated to sex, occupation status, use of sunscreen, frequent use of sunscreen, use of long-sleeve shirts when exposed to sunlight, duration of sun exposure, exposure to the sun at peak hours (11 A.M. to 4 P.M.), and percentage of body surface area exposed to sunlight.

In this study, 47.8% of the participants had vitamin D deficiency and the mean 25(OH)D serum level was within the range of insufficiency. Studies conducted in other cities of Iran have also revealed the high prevalence of vitamin D deficiency; 68% in Mashhad (17), 85.2% in Zahedan (12) and 50.8% in Isfahan (18). A high prevalence of vitamin D deficiency was also reported in other Middle Eastern countries, such as Turkey (55%) and Jordan (48%), which are almost similar to Iran in terms of latitude and culture (19, 20). However, the prevalence of vitamin D deficiency was much lower in countries located at high latitudes, such as Canada (54-74 °N), and Sweden (63 °N) [3% (21), and 0.7% (22), respectively]. Shiraz (29◦61′ N) is located at a latitude under 32°N and vitamin D skin synthesis is possible throughout the year (23). Therefore, vitamin D status was expected to be more desirable in Shiraz compared to the countries or cities located at higher latitudes. However, the country's culture and covering style prevent direct exposure to the sun, especially in women. Moreover, fortification programs in countries located at higher latitudes as well as their race have led to a lower prevalence of vitamin D deficiency in those countries.

The results of the present study showed a positive association between 25(OH)D serum level and age. Other studies have confirmed this finding in adult populations (7, 20, 21). However, several studies have shown an inverse association between 25(OH) D serum level and age (6, 24, 25), which might be due to reduction of skin capacity in vitamin D production with aging (26). In the present study, supplement use was seen more in the individuals aged above 30 years compared to those below 30 years of age. Therefore, the positive association between the serum level of 25(OH)D and age could be attributed to taking vitamin D supplements. Findings of the current study indicated a significant inverse correlation between serum level of 25(OH)D and PTH serum levels, which has been confirmed in many studies (27, 28). Vitamin D deficiency stimulates the secretion of PTH and leads to secondary hyperparathyroidism (28).

The study results also revealed a significant positive correlation between the serum level of 25(OH)D and taking vitamin D supplements, which has been approved in numerous studies conducted on the issue (5, 21, 29). Due to the implementation of vitamin D supplementation program by family physicians in Shiraz (most people are covered by the family physician program), almost half of the population (45.8%) benefited from a monthly 50,000 IU vitamin D supplementation. Hence, the results showed the association between serum 25(OH)D level and taking supplements.

Results of the present study illustrated no significant correlation between serum 25(OH)D levels and dietary intake of vitamin D. Also, in a study on 1102 children in Great Britain, Absuod *et al.* found that dietary vitamin D intake had no effect on vitamin D status (30). There are limited number of foods that naturally contain significant amounts of vitamin D, and fortification of foods with vitamin D is not a common strategy in Iran, so, dietary vitamin D does not make a major contribution to meet the body requirements of vitamin D. Vitamin D required by the body is mainly synthesized through exposure to ultraviolet radiation (UVR) and only about 10% of it is supplied from food sources (7, 31). Therefore, achieving such a result is not unexpected in countries where foods are not fortified with vitamin D.

After excluding the participants using vitamin D supplements in the present study, serum 25(OH) D levels were significantly higher in males than in females, which is in accordance with the results of other studies (6, 24, 25, 32). The gender difference in 25(OH)D status was attributed to different lifestyle factors in men and women. As indicated in the results section, the factors that reduce the serum 25(OH)D level such as using sunscreen, frequent use of sunscreen, lower exposure time to the sun, less exposure to the sun at peak hours, increased coverage, and lower body surface area exposed to the sun were seen more among women probably because they tend to have fair skins and try to reduce their sun exposure through protective strategies (32). However, such difference was not detected in the studies performed in Sweden (22) and Denmark (33). The reason for this inconsistency can be the existence of different cultural norms, such as the style of coverage, in different parts of the world. It should be noted that the present study was conducted among a Muslim population where women present in the community with hijab coverings, which would reduce their exposure to the sun.

In the current research, the use of sunscreen and frequent use of sunscreen were associated with a decrease in serum levels of 25(OH)D among the participants who did not take supplements, which is in agreement with the findings of the study by Golan-cohen *et al.* (24). Another investigation also indicated that the individuals who always used sunscreen were at a greater risk for vitamin D deficiency; because sunscreen could reduce the vitamin D synthesis by

95% (2). However, Vandevijvera *et al.* (29) reported that the women who used sunscreen were at a lower risk for severe vitamin D deficiency; because they were more exposed to the sun.

The current study, findings revealed that in the participants who did not take vitamin D supplements, the serum level of 25(OH)D was positively associated with the duration of sun exposure (more than one hour per day) and time of sun exposure (exposure at peak hours of radiation). Similar findings were achieved in other studies (24, 34, 35). Sunlight is the main source of vitamin D synthesis in the human body. However, Al-daghri *et al.* (36) reported no significant correlations between serum levels of 25(OH)D and duration of sun exposure. This finding was attributed to dark-skinned people who were exposed to the sun for less than 20 minutes a day. Overall, it was claimed that the association between sun exposure and serum 25(OH)D level could be affected by skin type.

The amount of skin pigmentation also affects vitamin D synthesis in the skin and is consequently associated with the serum level of 25(OH)D (35). Individuals with fair skins can obtain the maximum amount of vitamin D needed in exposures shorter than half an hour, while those with darker skins require 10-50 times as much time to get the same amount of vitamin D (34). Although many studies have revealed a significant positive association between the serum level of 25(OH)D and skin type (5, 24, 36), this result was not confirmed in the present study. Our findings were supported by those obtained by Wuertz *et al.* (28). On the other hand, the findings of the research by Sahota *et al.* (34) suggested that dark-skinned people had a higher serum level of 25(OH)D compared to those with fair skins, because individuals with fair skins tend to protect more against sun exposure compared to those with darker skins.

Another factor that affects the skin synthesis of vitamin D is the percent of body surface area exposed to the sun. In accordance with the study conducted by Sahota *et al.* (34), the present study demonstrated a significant positive correlation between serum 25(OH)D level and the percentage of body surface area exposed to the sun among the participants who did not take vitamin D supplements. However, this association was not significant in the study performed by Hanwell *et al.* (35). It was argued that individuals with a higher percentage of their body surface areas exposed to the sun did not spend much time in the sun or used protective methods, such as sunscreen.

There were some limitations in our study. Since the information was obtained through retrospective questions, recall bias might have occurred. Yet, this limitation was compensated by the large sample size of the research. The study had some strengths too. The study sample was selected randomly and encompassed almost all the population of Shiraz with different economic, social, and cultural statuses. In this study, almost all factors affecting serum 25(OH)D level were taken into consideration. The study questionnaire was completed through interviews, which reduced the probability of missing data to a great extent. Serum level of 25(OH)D was measured using HPLC, which is the gold standard for measurement of vitamin D status.

Conclusion

The study results revealed that the prevalence of vitamin D deficiency and inadequacy was high among adults in Shiraz, Iran; despite the presence of sunny weather throughout the year. Mean serum level of 25(OH)D had a significant positive correlation with supplements use and age. In the subgroup of participants who did not take vitamin D supplements, serum 25(OH)D level was significantly higher in males than in females and it was correlated with occupation status, use of sunscreen, frequent use of sunscreen, use of long-sleeve shirts when exposed to sunlight, duration of sun exposure, exposure to the sun at peak hours, and percentage of body surface area exposed to sunlight. Overall, food-based strategies, such as fortification of foods with vitamin D, may help controlling vitamin D deficiency in the entire community.

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Authors' Contribution

MK designed the study, and significantly contributed to data gathering, data analysis and preparing the manuscript. MZ had role in study design and data analysis and preparing the manuscript. ZS participated in study design and data analysis. MA designed the study, supervised data gathering, data analysis and preparing the manuscript. All of the authors have read and approved the final version of this manuscript.

Conflict of Interest

None declared.

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