Letter to the Editor

Analysis of Vitamin D Status in Men Highly Exposed to Sunlight[*]

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People living near the equator more easily obtain adequate 25-hydroxyvitamin D [25(OH)D]. However, studies indicated that vitamin D deficiency is common even in the sunniest areas. We mainly analyzed the vitamin D status and dietary patterns of men highly exposed to sunlight, and investigated the correlation of vitamin D status with dietary patterns and time for outdoor work or activities. The average vitamin D levels among men highly exposed to sunlight was sufficient, but parts of the population had vitamin D deficiency or insufficiency. Long-term vitamin D deficiency may correlate with obesity and hypertension. These results provide a scientific basis for future research.

Vitamin D is an essential liposoluble vitamin that is mainly synthesized in skin and stored in body fat. It can be provided by foods and supplements. Vitamin D plays an important role in maintaining skeletal health, and vitamin D deficiency can induce growth retardation and skeletal deformities in childhood, and osteoporosis, osteomalacia, and muscle weakness in adults[1]. People living near the equator more easily obtain adequate 25(OH)D because they are highly exposed to sunlight without use of sun-protective measures[2]. However, studies indicated that vitamin D deficiency is common even in the sunniest areas if most of the body skin is sheltered from sunlight[3]. The aim of our study was to analyze the vitamin D status and dietary patterns of men exposed to high sunlight in Zhejiang Province, and investigate the correlation of vitamin D status with dietary patterns, and time for outdoor work or activities.

The data used in this study were obtained from the 2012 Nutrition Study of Vitamin D among Residents in Different Latitude, and male subjects highly exposed to sunlight were chosen. All the subjects were living at around 27° 30′ north latitude and 120° 23′ east longitude. Fishermen, motorboat operators, sea lifeguards, and farmers who were exposed to sunlight more than 3 hours per day for at least 3 months consecutively were recruited in this survey. A questionnaire survey, physical examination, and food frequency questionnaire survey were conducted to obtain the basic information of the subjects. Vitamin D deficiency was defined as a serum 25(OH)D level of <20 ng/mL (50 nmol/L), and vitamin D insufficiency was defined as serum 25(OH)D levels ranging from 20 ng/mL (50 nmol/L) to 30 ng/mL (75 nmol/L). The serum 25(OH)D levels >30 ng/mL (75 nmol/L) are considered indicators of vitamin D sufficiency[3].

In this study, 335 men aged 18 to 70 years were included. Distributions of continuous variables were presented as mean±standard deviation values. *P* values were estimated by using the analysis of variance. The distributions of categorical variables were presented as frequencies, and *P* values were tested for Fisher's exact probability. The principal component factor analysis was used to obtain the dietary patterns. The Pearson correlation analysis was used to determine the correlation of vitamin D status with dietary patterns and outdoor work or activities. All statistical analyses were conducted by using the Statistical Package for the Social Sciences software version 17.0 (SPSS Inc. Chicago, Illinois, USA).

In our study, the average status of serum vitamin D level was 33.26 ng/mL in men highly exposed to sunlight in the Zhejiang province. When compared with the results from the tropics region, the result was close to the serum 25(OH)D level of

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men in Vietnam (tropics region, 36.8 ng/mL)[4].

Table 1 presents the average time for outdoor work, which was 7.62 months per year, 4.98 days per week, and 7.69 hours per day in our study. The average time for outdoor activities was more than 7 hours per day in each season. Although hours of sun exposure can be of some value in determining vitamin D status, the specific time (e.g., 1200 or 1300 hours) of exposure to sunlight plays an important role in determining vitamin D formation. However, the subjects in our research rarely used sun-protective items. The use rates of both sunglasses and umbrellas were <15%, even though the exposure rates of body skin (except the head) were relatively low, and the exposure rates of the skin of the foot, upper body, and lower body were <25%. According to our results, body skin exposure to solar radiation normally without deliberate use of sun-protective items is beneficial to the production of vitamin D.

Table 2 shows that we obtained three dietary patterns in our study, namely 'beverages and snacks,' 'thallophytes and vegetables,' and 'dairy products.' Serum vitamin D level was positively related with the 'dairy products' pattern. Dairy was a primary dietary source of vitamin D. Many studies proved that dairy products, including milk, yogurt, and cheese, were beneficial to calcium-phosphorus metabolism and bone health. The benefits were reported to be closely related to the calcium, protein, vitamin D, and phosphorus contents of dairy products[5]. In addition, vitamin D level was related with the duration of solar radiation. Serum vitamin D level was positively correlated with outdoor weekly working days in the general population. Moreover, vitamin D level was positively related to outdoor daily activity hours in winter. Further evidence is needed to support these findings.

Body mass index (BMI) is used to evaluate body fat. The results of the Pearson correlation analysis shown in Table 3 demonstrate that serum vitamin D level was negatively related to BMI (r=-0.116, P<0.05).

Table 1. General Distribution of Population with Different Level of Serum 25(OH)D

Variables	**Overall** *n* **(%)= 335 (100.00)**	**Deficiency** *n* **(%)= 39 (11.64)**	**Insufficiency** *n* **(%)= 108 (32.24)**	**Sufficiency** *n* **(%)= 188 (56.12)**	***P***
Age (year)	45.81±8.41	45.87±7.96	45.62±8.30	45.91±8.61	0.959
BMI (kg/m^2)	23.63±2.91	23.84±3.13	23.73±3.04	23.54±2.80	0.780
SBP (mmHg)	120.95±13.81	122.67±14.26	121.51±14.51	119.35±12.26	0.309
DBP (mmHg)	79.22±9.12	80.13±9.74	79.26±9.06	77.62±7.79	0.074
Outdoor work (month/year)	7.62±2.22	7.92±1.88	7.43±2.09	7.68±2.35	0.434
Outdoor work (day/week)	4.98±1.26	4.69±1.40	4.82±1.22	5.12±1.23	**0.046**
Outdoor work (hour/day)	7.69±2.12	7.69±2.71	7.65±2.29	7.72±1.88	0.964
Outdoor activity in winter (hour/day)	7.79±2.37	7.72±2.14	7.97±2.13	7.70±2.55	0.634
Outdoor activity in spring & autumn (hour/day)	7.36±1.97	7.60±2.00	7.55±1.85	7.20±2.02	0.240
Outdoor activity in summer (hour/day)	7.32±2.24	7.74±3.00	7.02±2.37	7.40±1.97	0.184
Diabetes history (%)	11 (3.28)	2 (5.13)	5 (4.63)	4 (2.13)	0.350
Hypertension history (%)	46 (13.73)	9 (23.08)	11 (10.19)	26 (13.83)	0.135
Dyslipidemia history (%)	14 (4.18)	2 (5.13)	4 (3.70)	8 (4.26)	0.855
No gloves (%)	162 (48.36)	23 (58.97)	49 (45.37)	90 (47.87)	0.335
No sunglasses (%)	312 (93.13)	36 (92.31)	101 (93.52)	175 (93.09)	0.906
No umbrella (%)	300 (89.55)	34 (87.18)	98 (90.74)	168 (89.36)	0.787
Head exposure (%)	278 (82.99)	34 (87.18)	93 (86.11)	151 (80.32)	0.380
Upper body exposure (%)	75 (22.39)	4 (10.26)	25 (23.15)	46 (24.47)	0.144
Lower body exposure (%)	17 (5.07)	1 (2.56)	7 (6.48)	8 (4.26)	0.652
Feet exposure (%)	53 (15.82)	2 (5.13)	20 (18.52)	30 (15.96)	0.119

Note. Data were from the 2012 Nutrition Study of Vitamin D among Residents in Different Latitude. Body mass index (BMI) was calculated by dividing weight by the square of the height; SBP, systolic pressure; DBP, diastolic pressure.

Table 2. Factor Loadings and Explained Variance for Main Factors of Dietary Nutrient Identified by Factor Analysis

Food Category	Pattern 1	Pattern 2	Pattern 3
Beverages	**0.828**	0.001	0.122
Snacks	**0.794**	0.270	-0.141
Fruits	**0.747**	-0.191	0.077
Legumes	**0.680**	**0.349**	-0.006
Meats	**0.619**	0.286	0.005
Aquatic products	**0.613**	0.239	0.248
Eggs	**0.580**	0.209	**0.304**
Staple foods	**0.425**	**0.404**	-0.331
Thallophytes	-0.070	**0.754**	**0.307**
Vegetables	0.291	**0.685**	-0.044
Dairy products	0.182	0.115	**0.870**
Proportion of explained variance (%)	33.93	14.80	10.52
Cumulative explained variance (%)	33.93	48.73	59.25

Note. Estimates from factor analysis were done on 11 food categories. Rotated factor loadings ≥0.300 were considered as the elements of the dietary pattern, and elements of loadings ≥0.300 are highlighted in boldface.

Table 3. Pearson Correlation between Serum Vitamin D and Variables Related with MetS

Variables	Overall		18-30 years		30-40 years		40-50 years		50-60 years		60-70 years	
	r	*P*	*r*	*P*	*r*	*P*	*r*	*P*	*r*	*P*	*r*	*P*
BMI	**-0.116**	**0.033**	0.574	0.106	-0.13	0.302	-0.114	0.168	-0.173	0.085	0.142	0.716
SBP	0.095	0.081	0.54	0.133	-0.1	0.413	**-0.204**	**0.013**	-0.004	0.972	-0.162	0.676
DBP	**-0.153**	**0.005**	0.427	0.252	0.074	0.546	**-0.163**	**0.048**	0.146	0.147	0.051	0.897
Outdoor work (Month/year)	0.093	0.091	0.591	0.094	0.098	0.421	0.044	0.594	0.041	0.687	0.565	0.113
Outdoor work (Day/week)	**0.168**	**0.002**	0.212	0.584	0.075	0.539	0.146	0.076	**0.217**	**0.003**	**0.841**	**0.005**
Outdoor work (hour/day)	0.006	0.919	-0.193	0.619	-0.04	0.758	-0.061	0.462	0.127	0.209	0.593	0.092
Outdoor activity in winter (hour/day)	-0.005	0.315	**0.672**	**0.047**	-0.04	0.766	-0.145	0.078	-0.004	0.967	0.157	0.687
Outdoor activity in spring & autumn (hour/day)	-0.087	0.114	-0.103	0.793	0.082	0.504	-0.143	0.084	-0.096	0.342	0.091	0.816
Outdoor activity in summer (hour/day)	0.022	0.696	0.036	0.926	-0.13	0.278	-0.026	0.759	0.133	0.19	0.439	0.238
Dietary Pattern 1	-0.069	0.209	0.126	0.746	0.068	0.585	-0.06	0.474	-0.197	0.053	0.414	0.268
Dietary Pattern 2	0.010	0.859	0.407	0.277	0.041	0.741	-0.002	0.983	-0.105	0.885	-0.204	0.599
Dietary Pattern 3	0.007	0.859	-0.524	0.147	**0.243**	**0.048**	-0.023	0.785	0.001	0.994	-0.024	0.951

Note. Pearson correlation was used to explore the correlation between vitamin D status and dietary patterns, outdoor work or activities.

This is in accordance with the cross-sectional study of Konradsen et al.[6]. The serum vitamin D levels in the population with overweight or obesity individuals were lower than those in a Chinese population with normal-weight individuals[7]. People with higher BMI seemed to choose long and large dresses or trousers to cover their skin, and disliked outdoor activities because of being overweight or obesity. Thus, their solar radiation exposure decreased relatively, causing a reduction in vitamin D synthesis. The lipid solubility of vitamin D is another cause of less vitamin D in overweight or obesity individuals . Excess fat could store more vitamin D, so the effective amount of serum vitamin D was decreased[8].

Serum vitamin D level was negatively related to SBP or DBP in our study. Song et al.[9] indicated that people in the group with the lowest vitamin D levels had an 81% increase (odds ratio, 1.81; 95% confidence interval, 1.15-2.85) in likelihood of having an elevated blood pressure. In the United States, the Third National Health and Nutrition Examination Survey showed that serum vitamin D level was inversely associated with blood pressure.

Above all, the average vitamin D status of men highly exposed to sunlight in the Zhejiang province was sufficient, but parts of the population had vitamin D deficiency or insufficiency. They could improve their vitamin D status by increasing their outdoor activities, minimizing the use of sun-protective items, increasing their intakes of foods rich in or fortified with vitamin D. Furthermore, long-term vitamin D deficiency may correlate with besity and hypertension.

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