ORIGINAL ARTICLE

Prevalence of Vitamin D Deficiency and Its Relationship with Metabolic Syndrome Markers and Lifestyle in the Adult Population in a Sunny Tropical Region

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Abstract

Background: Serum vitamin D (VIT D) concentration has been inversely associated with the prevalence of metabolic syndrome (MS), but the relationship has remained unclear.

We evaluated the prevalence of VIT D deficiency, and its association with MS, and its components in the adult population in a sunny tropical region (Lamerd: a city in the south of Iran)

Methods: Totally, 210 patients referring to different medical centers across the Lamerd city participated in this cross-sectional study through January and February of 2016. To select medical service center, we used a one-stage cluster sampling method. Anthropometric indices and dietary intake were measured using modified food frequency questionnaire (FFQ) and blood samples collected. Data were analyzed using SPPS version 16, Pearson's correlation was used to investigate the bivariate relationships between the variables, and unpaired t-test was used to determine the differences between genders for all variables. A P-value < 0.05 was considered statistically significant.

Results: Overall, 62 menand 144 womenwith a mean age of 35.84±10.84 years old completed this study; the prevalence of VIT D deficiency among the participants equaled 64.1% (women=66.7% and men=58.1%). A significant positive relationship between sun exposure time on the serum VIT (P≤0.0015), and a negative relationship between the serum VIT D on triglyceride (P=0.035), TC (P=0.025, age (P=0.001), and fasting blood sugar (P≤0.001) were found.

Conclusion: This study showed that lower VIT D concentrations were associated with increased MS risk factors.

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Keywords: Vitamin D, Metabolic syndrome, Life style, Iran

Introduction

Vitamin D (VIT D) deficiency is recognized as a global public health problem.[1, 2] It has been reported that 30-50% of both children and adults in the United States, Canada, Europe, and Asia are considered as VIT D deficient.[3, 4] Researchers have reported the associations between vitamin D and many serious diseases including cardiovascular diseases, diabetes, and cancer.[5, 6] VIT D deficiency is a risk factor for the metabolic syndrome (MS), a highly prevalent condition among Iranian population.[7] Vitamin D levels have been shown to be related to individual components of MS. It has been shown that VIT D is involved in the regulation of blood pressure in patients with elevated blood pressure.[1, 8, 9] Excess body weight and insulin resistance, as the major components of MS, are inversely associated with circulating concentrations of VIT D.[10] Evidence demonstrates that circulating concentrations of VIT D are inversely related to the concentration of glucose, insulin resistance, and the prevalence of diabetes.[11, 12]

Serum VIT D level is influenced by both sun exposure and dietary intake. While more than 90% of the VIT D requirement comes from sun exposure, a smaller part comes from food intake.[13, 14] Due to the limited source of vitamin D in foods, this vitamin is derived mainly from UV-B–induced synthesis in the skin, but many lifestyle and environmental factors often limit the sunlight exposure and thereby VIT D state, which results in a high prevalence of vitamin D deficiency.[15, 16] Recent studies have shown that the rate of vitamin D deficiency is also higher in the sunniest areas of the world. Studies performed in some Asian sunny countries such as Saudi Arabia revealed a high prevalence of VIT D deficiency in population due to cultural factors. Also, the results of numerous studies indicate a high prevalence of VIT D deficiency among Iranian population.[7, 11, 17]

Determination of vitamin D status has important implications for general health in a community. Few studies have examined this phenomenon in the Iranian population residing in sunny areas; thus, to promote the public health aspect, we designed the present study to assess the serum level of VIT D in adult population in a sunny tropical region (Lamerd City in the south of Iran), and its relationship with metabolic syndrome markers and lifestyle.

Materials and Methods

In this cross-sectional study, the participants were recruited from 12 selected medical service centers in urban areas from Lamerd city. Lamerd is the capital of Lamerd, Fars Province, Iran. The population consisted of 21,365 with 4,021 families according to the 2006 census. Lamerd city with 5683/4 square kilometers in a longitude of 54 52 and latitude of 28 27 is located in the southern Fars province, about 405 kilometers from Shiraz and 140 kilometers from Khonj; it comprises 4.6% of the total area of Fars province. With a height of 450 to 500 meters above the sea level, average annual rainfall of about 250 millimeters of torrential characteristics in a short period of years (three months), and 4000 mm annual evaporation, it is a hot and dry area, the maximum heat in summer is 50°C above zero and in the coldest time, it is zero degrees Celsius.

Three hundred and twenty adults (150 menand 170 women) aged 20 -70 years who were fully under medical services of a related insurance were eligible to be included in the study. To select medical service center, we used a one-stage cluster sampling method. Overall, 210 subjects (64men, 146female) participated in this study, and due to drop out only 206 completed all aspects of the study (Figure 1).

Measurements

On enrollment, after obtaining written consent form, anthropometric parameters, dietary intake, and metabolic parameters were obtained. All data were collected by trained researchers and all participants were provided with clear instructions. Data gathering forms collecting socio-demographic data (gender, age, education, tobacco usage, apartment residence, use of sun screeners.) were distributed among the individuals who agreed to participate in the study. These data were collected in October through December in 2015.

Height was measured to the nearest 0.5 cm, and weight to the nearest 0.1 kg, with participants wearing light clothes and no shoes. Then, the body mass index (BMI) was calculated by determining the ratio between the weight and height squared (kg/m2). Waist circumference was measured using a measuring tape with patients standing. The waist circumference was taken at the arrows point between the lower costal margin, and the superior iliac crest was measured at the horizontal level between the symphysis pubis and the greater gluteal protuberance that yielded the maximum measurement. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were

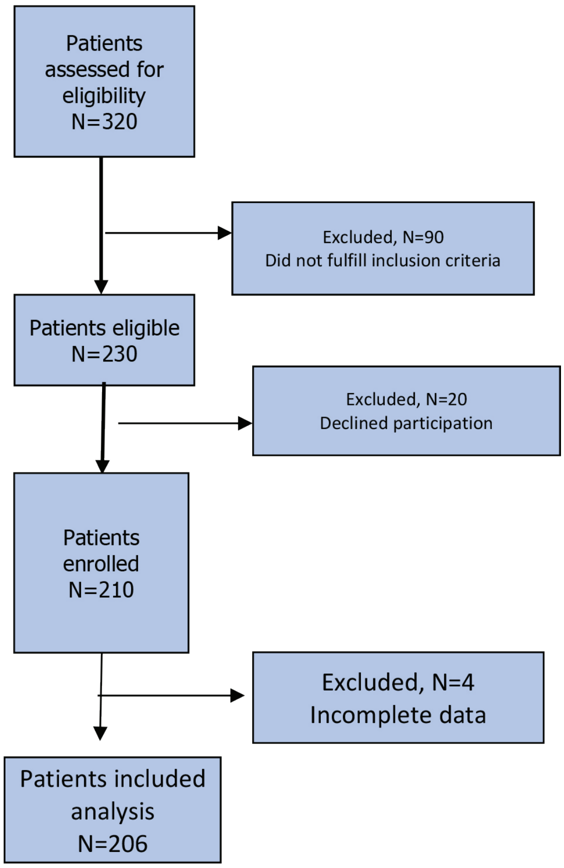

Figure 1: Shows the flow chart of the included and excluded patients

measured using a mercury HG monometer in a sitting position after the participants were in a relaxed state for at least 10 minutes.

Sun exposure time was derived by simple 1-week sun exposure recall questionnaire validated by Hanwell and others.[18] Physical activity information was collected from participants by Processing and Analysis of International Physical Activity Questionnaire.[19] Food intake was assessed by FFQ (using a validated semi-quantitative food frequency questionnaire with 168 food items[20] applied by a previously trained nutritionist. This included measurements were performed using available rich sources of VIT D, i.e. fish, egg, butter, and cream.

Five-cc venous blood samples were collected after fasting. The blood was then distributed in the tubes containing K2EDTA or heparin. Blood samples were centrifuged to separate the sera. Serum samples were stored at -70°C prior to biochemical measurements. The lipid profile, including total cholesterol (TC), low density lipoprotein (LDL), high-density lipoprotein (HDL), triglyceride (TG), and plasma fasting blood sugar (FBS), was also assayed using routine enzymatic methods. The plasma serum concentration of VIT D was quantitatively analyzed in vitro using standard ELISA method (IDS KIT). VIT D deficiency was defined as serum concentration of 25-OH-D <20 ng/ml.[21] All the laboratory processes were performed in the lab of Nutrition and Food Science School, Shiraz University of Medical Sciences, under the supervision of qualified experts and carried out in standard laboratory conditions. The baseline sociodemographic factors (including educational level, living conditions) were asked orally by the same researcher.

Those with at least three of the criteria mentioned below (on the basis of adjusted ATPIII criteria for Iranian population) were classified as people with metabolic syndrome (Table 1):[17]

Statistical Analysis

Data analyses were done using SPSS statistical software package, version 16·0 (SPSS Inc., Chicago, IL, USA). Pearson's correlation was used to investigate the bivariate relationships between the variables, and unpaired t-test was used to determine the differences between genders for all variables. Linear regression model was used to estimate the association between the vitamin D level and probability of having metabolic syndrome. A P-value<0.05 was considered statistically significant.

Results

A total of 206 participants (mean±SD age: 35.8±10.8 years) were included in this cross-sectional study. Table 2 presents basic characteristics of the participants. Based on two-sided t-test, comparison between men and women showed a significant difference in variables such as height, weight, waist circumference, physical activity score, TG, HDL, serum VIT D in favor of greater amounts in men than women in this study. There were no significant differences regarding BMI, age, FBS, sun exposure time, TC, LDL, SBP, DBP between men and women. Further analysis revealed that VIT D deficiency prevalence among the participants equaled 64.1% (women=66.7% and men=58.1%)

The analysis of the correlation between the plasma level of VIT D and various factors among the participants is shown in Table 3. Serum VIT D had no significant relationship with sex, height, weight, BMI, waist circumference, physical activity score, FBS, HDL, DBP, tobacco usage, education level, place of residence, sun blocker usage, fish, butter, egg, and cream consumption. In contrast to this finding, a significant positive relationship was found between the sun exposure time on the serum VIT (P≤0.0015), and also a negative relationship between the serum VIT D on triglyceride (TG) (P=0.035), TC (P=0.025, age (P=0.001), and fasting blood sugar (FBS) (P≤0.001).

Regression analysis revealed that the sun exposure time (β=0.241, P<0.001), age (β=0.193, P=0.005), WC (β=-0.153, P=0.025), and place of residence (β=0.136, P=0.042) were the predictors of VIT D status.

Discussion

Adequate VIT D status is important for optimal

etabolic syndrome on the basis of adjusted ATPIII criteria for Iranian population

Measure	Categorical cut-off points
Elevated waist circumference)	95 cm (men and women)
Elevated triglycerides or drug treatment for elevated triglycerides	150 mg/dL (1.7 mmol/L)
Reduced HDL-C or drug treatment for reduced HDL-C	40 mg/dL (1.0 mmol/L) in males; 50 mg/dL (1.3 mmol/L) in females
Elevated blood pressure or antihypertensive drug treatment in a patient with a history of hypertension	Systolic 130 and/or Diastolic85 mm Hg
Elevated fasting glucose or drug treatment of elevated glucose	100 mg/dL

Spell out HDL-C here

Table 2: Characteristics of the participants

	Female	Male	P value
Age (year)	35.52±11.46	36.59±9.29	0.19*
Height (cm)	160.67±5.95	172.80±6.78	<0.001
Weight (kg)	70.94±14.51	83±16.79	<0.001
BMI (kg/m^2)	27.15±5.33	27.29±4.96	0.86
Waist circumference (cm)	91.56±13.27	97.58±13.39	0.003
Sun exposure time (hour/week)	2.93±4.61	4.04±4.79	0.11
Physical activity score	523.12±481.77	681.58±548.56	0.03
FBS (mg/dl)	90.56±20.91	86.48±20.66	0.19
TG (mg/dl)	129.03±62.51	198.69±102.61	<0.001*
TC (mg/dl)	179.41±41.55	184.66±40.66	0.40
LDL (mg/dl)	108.35±32.69	110.69±27.33	0.62
HDL (mg/dl)	46.80±10.17	38.72± 6.74	<0.001*
SBP (mm Hg)	113.31±17.11	113.90±17.64	0.82
DBP (mm Hg)	75.86±9.01	77.46±9.88	0.25
Serum VIT D (ng/ml)	21.17±20.05	26.33±20.67	0.09

Data are expressed as Mean±SD. *Non-parametric test: Man-whitney

Table 3: Correlation analysis between the plasma level of VIT D and various factors among the participants

Dependent variable	Total	
	r	P value
Age (year)	0.27	<0.001
Height (cm)	0.00۱	0.98
Weight (kg)	0.005	0.94
BMI (kg/m^2)	0.007	0.92
Waist circumference (cm)	-0.028	0.686
Sun exposure time (hour)	0.89	<0.001
Physical activity score	0.69	<0.001
FBS (mg/dl)	-0.29	<0.001
TG (mg/dl)	-0.150	0.03
TC (mg/dl)	-0.156	0.025
LDL (mg/dl)	-0.038	0.58
HDL (mg/dl)	-0.042	0.54
SBP (mm Hg)	-0.58	0.40
DBP (mm Hg)	0.057	0.40
Fish consumption (serving/week)	0.71	0.30
Butter consumption (serving/day)	0.10	0.90
Egg consumption (serving/day)	0.81	0.66
Cream consumption (serving/day)	0.41	0.38

functioning of many organs.[22] Due to lack of scientific evidence on the role of vitamin D in the manifestation of many non-communicable diseases, it becomes necessary to carry out further research and establish the association of vitamin D with socioeconomic, behavioral factors; physical activity; and sun exposure time.[23, 24] Some studies have shown an inverse relationship in both genders of serum 25(OH) D levels with MS, diabetes and insulin resistance. In spite of evidence on the association of serum VIT D levels with MS in different areas, data for southern region of Iran is lacking. MS is a combination of characteristics including high waist circumference, blood pressure, and concentrations of triglycerides and fasting glucose, and low circulating levels of HDL.[22, 25, 26] The presence of MS is associated with multiple adverse health outcomes, including diabetes, cardiovascular disease, and cancer; thus, identification of the risk factors of this syndrome and its components remains critical. Insufficient VIT D status has been proposed to be a potential contributor to MS.[27, 28]

In our study, higher concentrations of serum VIT D was associated with lower concentrations of TG. The precise mechanism by which vitamin D may affect the TG levels is not clear yet, but activity may be mediated via calcium-mediated fecal fat excretion.[22, 24, 29] As VIT D is a necessary mediator for optimum calcium metabolism, sufficient serum level of VIT D promotes better calcium absorption. In turn, the increase in fecal fat loss has been suggested to be caused by formation of insoluble conjugates between calcium-phosphate complexes and bile acids.[30]

Also, independent of calcium, a significant positive correlation between serum VIT D and apolipoprotein A-I levels is reported in some studies.[31, 32] In this regard, VIT D can influence the formation of HDL particles. Collectively, it seems that VIT D affects the TG level via more than a single mechanism.

Another potential mechanism of action for VIT D on this parameter is suggested by the activity of 1,25(OH)$_2$D binding to the VIT D receptor.[3, 33] It has largely been demonstrated in various experimental models that circulating concentrations of VIT D may also affect the availability of this potent hormone to target tissues; thus, an increase in the serum level of VIT D may result in better VIT D and intracellular receptor coupling. It has been suggested from animal studies that VIT D might be directly involved in the adipogensis process. VIT D is sequestered in the adipose tissue and it has been hypothesized that obesity, by increasing the volume of adiposity, will result in lower serum VIT D levels due to more VIT D retention in itself.[27, 34-36] To date, a statistically significant association has been reported between the measured concentrations of 25(OH)D and MS in several studies;[5, 37, 38] *in our study, higher concentration of serum VIT D was associated with lower concentrations of TG.*

In the present study, higher concentrations of serum VIT D was positively associated with sun exposure time; previous studies have demonstrated that reduced sun exposure in relation to lower outdoor physical activity levels is strongly associated with lower levels of serum VIT D. Of note, place and time of day and season are important.[39-41] In many eastern countries, exposure to the sun is limited by clothing, and work time being spent indoors. However, given the well-recognized seasonal variation in vitamin synthesis, particularly in northern latitudes, more consideration related to season is important, but the present study was conducted in a tropical region, and it would be better to consider clothing rather than seasonal variations. Consistent with the results of the present study, numerous previous published studies demonstrated that VIT D deficiency was common among women. In previous studies, the reason is suggested to be strict dressing habits based on Islamic beliefs, which is in the same line with the situation of the present study.[36, 42, 43] The authors concluded that women with full cover of dressing are susceptible to low serum VIT D levels and are at increased risk of MS.

Usually, food sources of VIT D are limited and a large part of individual needs arise from sun exposure, so any relationship between VIT D and intake of food sources is not sizeable. Nutritional intake of VIT D food sources did not correlate with VIT D status in the present study, which is not consistent with previous studies.[44, 45] It can be explained by the limited number of the sample size in the present study because most of other inconsistent results are shown in the studies with larger sample size; larger sample size enables previous studies to detect such small correlations.

The result of the present study is in agreement with the majority of previously published studies. Parker et al.[11] reported a significant association between higher levels of 25(OH)D and reduced MS prevalence (OR=0.49, 95%CI: 0.38-0.64). Ju et al.[29] reported that the pooled OR for the metabolic syndrome per 10 ng/mL increment in a concentration of 25(OH)D was 0.87 (95%CI: 0.83-0.92).

Seasonal variations might have affected the VIT D measurement of the present study, and inability to distribute the sample measurement in an equal manner across the seasons can be mentioned as a limitation of this study. Furthermore, due to the sample size, it was not possible to categorize the subjects into subgroups according to the severity of vitamin D deficiency.

Conclusion

The findings of the current study demonstrate a negative association between vitamin D and some associated risk factors with MS. The result of the present study confirms the findings of several previous studies in which serum VIT D was negatively associated with blood lipid level, an important component of MS. Regarding considerable confusion about the association between vitamin D and the MS, the result of the present study indicates that more research in this area is warranted.

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Conflict of Interest: None declared.

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