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Prevalence of Vitamin D Deficiency according to Climate Conditions among a Nationally Representative Sample of Iranian Adolescents: the CASPIAN-III Study

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Abstract

***Background*: **Sunlight is the main source of vitamin D; therefore, environmental factors might have an important role in the high prevalence of hypovitaminosis D in children. This study aimed to assess the vitamin D status according to the climate of the living area in a nationally representative sample of Iranian adolescents.

***Material and Methods*:** This nationwide cross-sectional survey was performed among a representative sample of 1,095adolescents aged 10-18 years, selected by multistage cluster sampling method from 27 provinces of Iran. Serum 25-hydroxyvitamin D [25(OH) D] concentrations was compared in inhabitants of humid-rainy, cold-mountainous, and sunny regions.

***Results*:** Vitamin D deficiency was documented in 40% of participants including 40.70% of boys and 39.30% of girls. We found significant difference in 25(OH) D concentrations among participants living in the three different climates of the living area (P<0.05). The median inter-quartile range (IQR) level for 25(OH)D was lower in humid-rainy climate: 11.40 (18.64). Hypovitaminosis D was more frequent in humid-rainy climate (42.30%), compared to other climates; this difference was more prominent in urban areas (P<0.05). Boys living in various climates had significantly different levels of 25(OH) D(P<0.05), however this figure was not significantly different for girls (P>0.05). The highest frequency of hypovitaminosis D (45.2%) was documented among boys living in humid-rainy regions.

Conclusion: The high prevalence of hypovitaminosis D, notably among inhabitants of humid-rainy region underscores the necessity of implementing national preventive strategies. This is of great importance especially in regions with lower exposure to sunlight.

***Key Words*:** Children and adolescents, Climate, Iran, Vitamin D deficiency.

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1- INTRODUCTION

Vitamin D is a fat-soluble vitamin that is produced in sun-exposed skin, and is obtained from dietary intake in lower amounts. Liver and kidneys are two important organs that activate vitamin D as 1,25-dihydroxy vitamin D3 (1). Vitamin D plays a key role in maintaining the mineral and skeletal homeostasis. Further associations of vitamin D status and risk of several chronic diseases as cardiovascular disease, multiple sclerosis, and inflammatory disorders are well documented (2-5).

Vitamin D deficiency (hypovitaminosis D) is a major public health challenges in both developed and developing countries (6-9). The consequences related to vitamin D deficiency include improper bone development and increased risk of some cancers, cardiovascular disease, type 1 diabetes and other autoimmune diseases (1, 10).

The prevalence of hypovitaminosis D varies significantly among different studies because of the diversity in populations studied and in the cut-offs used (11). It has been estimated that 30-50% of both children and adults living in the US, Canada, Australia, New Zealand, Europe and Asia are vitamin D deficient (11-16).

In spite of the important role of sunlight exposure in vitamin D synthesis, studies have indicated high prevalence of vitamin D deficiency in sunny areas located in the Middle-East countries such as Saudi Arabia, Qatar, United Arab Emirates, India, Turkey, and Iran (1, 11, 13, 14, 17). A remarkably high rate of vitamin D deficiency is reported among 79.6% of 20-69- year- old Iranian population (9) and 46.2% of 14-18-year-old adolescents (18). Various prevalence rates of vitamin D deficiency are reported among different age-groups of Iranian population, but all of them confirm high prevalence of hypovitaminosis D in different populations(8, 9, 18-20).

Understanding the vitamin D status of different age-groups in a country and in a wide range of climate conditions of a community is necessary for development of new and practical programs to improve general health. Therefore, the present study was performed to investigate the prevalence of vitamin D deficiency among a nationally representative sample of Iranian adolescents living in areas with different climate conditions in Iran.

2-2. Measuring tools

2-1. Study design and population

This nationwide cross-sectional study was conducted as a sub-study of the third phase of a national school-based surveillance program entitled Childhood Adolescence Surveillance and PreventIon of Adult Non-communicable disease (CASPIAN) study, in Iran. More details on the study are published elsewhere (21). Briefly, the CASPIAN-III survey was performed on a stratified multi-stage probability sample of 5,625 children and adolescents, aged 10-18 years, living in urban and rural areas of 27 provinces in Iran.

2-2. Measuring tools

Of 5,625 participants aged 10-18 years, who were selected by stratified multistage random sampling method from urban and rural areas of 27 provinces in Iran, 1,095 students were selected through systematic random method to measure their serum 25(OH)D concentration. After complete explanation of the study, written informed consent was obtained from parents and oral assent from students.

2-3. Methods

Vitamin D levels were measured using blood samples collected after a 12-hour overnight fasting. Serum concentration of 25(OH)D was analyzed quantitatively using direct competitive immunoassay chemiluminescene method and LIASON® 25 OH vitamin D assay TOTAL (DiaSorin, Inc.), with a coefficient of variation (CV) of 9.8%. Serum 25(OH)D concentration of less than 30ng/mL was considered as vitamin D deficiency, and vitamin D insufficiency was defined as a 25(OH)D concentration of 20 to 30 ng/ml (22). Country classification into sub-national regions was according to a previous study. In which, the sub-national areas were defined based on the combination of different factors including their geographical situation (23). The regions were categorized as humid-rainy climate (North-Northeast), cold-mountainous (West), and sunny climate (Central) parts.

2-4. Data analyses

Normal distribution of serum 25(OH)D concentration was assessed using Kolmogrov- smirnov test and because of the lack of normality, the concentrations are presented as median and inter-quartile range (IQR), and were compared across regions by using Kruskal-Wallis test. Prevalence of vitamin D deficiency and insufficiency across regions was assessed using Pearson Chi-square test. Data were analyzed using survey data method in the Statacrop, 2011 (Stata Statistical Software: Release 12. College Station, TX: Stata Crop LP.Package). P<0.05 was considered as statistically significant.

2-5. Ethical considerations

The ethical committees of Tehran and Isfahan University of Medical Sciences approved the main study, and the current sub-study was approved by the research and ethics committee of Isfahan University of Medical Sciences (ID Number: 190149).

3- RESULTS

This cross-sectional nationwide survey was conducted among 1,095 Iranian school students (48.1% girls, 67.0% urban), with mean $\pm$ standard deviation (SD) age of 14.74 $\pm$ 2.60 years. More than 90% of the study participants were from public schools.

Table.1 demonstrates the median and IQR of vitamin D at national and regional levels according to gender and the living area. The median (IQR) for vitamin D concentration was 13.00 (20.56) ng/ml at national level. The median (IQR) of vitamin D concentration was 13.15 (17.41) for urban and 12.45 (20.99) for rural inhabitants. Although the humid-rainy climate (North, North-eastern regions) showed lower levels of 25(OH) D than cold-mountainous (West) and sunny (Central) climates, it was not statistically significant (P =0.54).

Table.2 shows the prevalence of vitamin D insufficiency and deficiency at national and regional levels. In total, the prevalence of vitamin D deficiency was 40%, including 40.70% of boys and 39.30% of girls. Among urban students, 42.50% were vitamin D deficient, this figure was 40% for students living in rural areas. We found significant difference in 25(OH) D levels between three different climates (P=0.003). The highest prevalence of vitamin D deficiency was observed in humid-rainy climate (42.30%) followed by cold-mountainous (42.19%) and sunny (35.31%) climate, which was statistically significant (P= 0.003). The prevalence of vitamin D deficiency in urban inhabitants of sunny climate (Central) was significantly lower than urban inhabitants of other regions (P=0.001). Moreover, the prevalence of vitamin D deficiency in boys living in sunny climate (Central) was significantly lower than boys in other regions (P=0.04). The lowest and highest frequency of vitamin D deficiency was documented among boys living in sunny (35.32%) and humid-rainy regions (45.26%), respectively.

Table 1: Median (IQR) of 25(OH)D concentration of Iranian adolescents at national and regional levels by gender and living region: the CASPIAN-III study

Vitamin D concentration					
Regions	North-Northeast (Humid-rainy)	West (Mountainous)	Central (Sunny)	National	P-value
Variables	Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)	
Boys	10.85 (18.77)	15.70 (25.54)	13.20 (17.18)	12.70 (21.80)	0.27
Girls	13.60 (18.32)	11.90 (20.93)	13.80 (17.97)	13.20 (19.33)	0.53
Urban	11.40 (16.52)	15.70 (25.41)	14.10 (16.82)	13.15 (17.41)	0.11
Rural	13.90 (23.58)	12.30 (19.96)	12.50 (19.03)	12.45 (20.99)	0.46
Total	11.40 (18.64)	13.55 (23.74)	13.50 (17.40)	13.00 (20.56)	0.54

IQR: Inter quartile range, 25^{th} -75^{th}

Table 2. Vitamin D status of adolescents at national and regional level by gender and living area: the CASPIAN-III study

Regions						
Varibles		North-Northeast (humid-rainy)	West (mountainous)	Central (sunny)	National	P-value
		N (%)	N (%)	N (%)	N (%)	
Boys	Deficient	86 (45.26)	80 (41.03)	65 (35.52)	231 (40.70)	0.04
	Insufficient	66 (34.74)	61 (31.28)	81 (44.26)	208 (36.60)	
	Sufficient	38 (20.00)	54 (27.96)	37 (20.22)	129 (22.70)	
Girls	Deficient	65 (38.92)	82 (43.39)	60 (35.09)	207 (39.30)	0.10
	Insufficient	68 (40.72)	66 (34.92)	84 (49.12)	218 (41.40)	
	Sufficient	34 (20.36)	41 (21.69)	27 (15.79)	102 (19.40)	
Urban	Deficient	109 (42.58)	111 (41.11)	64 (30.77)	284 (38.70)	0.001
	Insufficient	101 (39.45)	88 (32.59)	106 (50.96)	295 (40.20)	
	Sufficient	46 (17.97)	71 (26.30)	38 (18.27)	155 (21.10)	
Rural	Deficient	42 (41.58)	51 (44.74)	60 (41.38)	153 (42.50)	0.52
	Insufficient	33 (32.67)	39 (34.21)	59 (40.69)	131 (36.40)	
	Sufficient	26 (25.74)	24 (21.05)	26 (17.93)	76 (21.10)	
Total	Deficient	151 (42.30)	162 (42.19)	125 (35.31)	438 (40.00)	0.003
	Insufficient	134 (37.54)	127 (33.07)	165 (46.61)	426 (38.90)	
	Sufficient	72 (20.17)	95 (24.74)	64 (18.08)	231 (21.10)	

Data are presented as number (%)

4- DISCUSSION

This study revealed significant difference in 25(OH)D levels between three diverse climates, with the highest frequency of hypovitaminosis D observed among boys living in humid-rainy climate, in Iran.

Results of previous studies in Iran reported relatively high prevalence of vitamin D deficiency among different age groups (8, 17-19). In these studies, high-school students, pregnant women, and newborns were the most vulnerable groups for hypovitaminosis D (8, 19, 20).

Vitamin D deficiency is recognized as a widespread disorder among different populations because of the lack of sufficient sunlight exposure and/or insufficient dietary intakes (24-26). In addition to the large number of vitamin D functions, there are several non-skeletal roles of vitamin D including modulation of immune system (27), increasing insulin production, increment of myocardial contractility and inhibition of rennin system (1, 28). Thus, vitamin D deficiency might lead to increase the risk of immune and non-immune disorders such as type-1 diabetes, rheumatoid arthritis and congestive heart failure (1).

Determinants of vitamin D levels among different age groups in a country and in diverse climates seem necessary and might have useful implications in practice for general health. In our study, similar patterns of vitamin D deficiency were documented among boys and girls. It might represent the other causes leading to vitamin D deficiency rather than gender differences such as clothing style and exposure to sunlight. Our findings are consistent with another study that found a high prevalence of vitamin D deficiency among Iranian adults (17).

In the present study, we found the highest frequency of vitamin D deficiency among inhabitants of humid-rainy climate. This region is almost all days rainy, therefore limited exposure to sunlight might explain this higher frequency compared to other climates. As the dietary habits in different parts of the country have the same pattern, the current finding underscores the role of environmental factors in the high prevalence of hypovitaminosis D in Iran.

A growing body of evidence exists on the high prevalence of vitamin D deficiency at global level (29-31). Despite different causes of vitamin D deficiency, diverse methods and measurements of serum vitamin D levels, air pollution might be considered as a possible leading cause of vitamin D insufficiency and/or deficiency.

Previous studies have demonstrated the effect of atmospheric pollution on vitamin D concentration (32, 33). Evidence suggests that increased air pollution as a result of industrialization and urbanization might absorb the solar ultraviolet B (UVB) photons, thus leading to reduced synthesis of cutaneous vitamin D (33-35). During sunlight exposure, the UVB photons (290-315 nm) go through the skin, where they cause the photolysis of 7-dehydrocholesterol to cholecalciferol. Latitude, seasonal changes, and time of day as well as atmospheric ozone pollution affect the number of UVB photons that reach the earth's surface, and thus, alter the cutaneousproduction of cholecalciferol (33, 34). Air pollution has been a serious environmental problem, and known as a global health threat in developedcountries (36, 37), and also, developing countries such as Iran (38, 39). Thus, as documented in some previous studies it seems that a relatively high prevalence of vitamin D deficiency in central parts of our country, i.e. sunny climate, is due to the atmospheric air pollution. Some previous studies in Iran documented higher prevalence of hypovitaminosis D in children and cord blood of pregnant women living in sunny but air-polluted regions (40). This is in line with findings of studies in sunny countries located in Africa and the Middle East (7). Several features of the current study make its results valuable and practical. The data were obtained from a large nationally representative sample of Iranian school-aged children, both genders and inhabitants of different climates. However, due to its cross-sectional nature, causality could not be inferred. Another possible limitation is that a single serum 25 (OH)D concentration might not accurately reflect vitamin D status for the whole year, however in all regions, blood samples were obtained at the same time, and the findings are compared in regions with different climates.

5- CONCLUSION

The prevalence of hypovitaminosis D is considerably high in Iranian adolescents, notably in inhabitants of humid-rainy climate region. Although the prevalence of vitamin D deficiency was similar in urban and rural areas, the importance of environmental factors should be highlighted in this regard, and implementing preventive strategies are recommended at national level by focusing on vulnerable groups.

6- CONFLICT OF INTEREST: None.

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