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RESEARCH ARTICLE

Prevalence and determinants of vitamin D deficiency in Iranian children and adolescents: the CASPIAN-V study

Hadith Rastad[1] · Armita Mahdavi Gorabi[2] · Mostafa Qorbani[3,4] · Ehsan Seif[5] · Hamid Asayesh[6] · Mohammad Esmaeil Motlagh[7] · Ramin Heshmat[4,8] · Roya Kelishadi[9]

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Abstract

Purpose To examine the prevalence and determinants of vitamin D deficiency in Iranian children and adolescents.

Methods We used data from a national school-based surveillance program conducted among 7-18-year-old children and adolescents living in rural and urban areas in 30 provinces of Iran. Data on student's lifestyle, health behaviors, and health status was obtained through a validated questionnaire. Serum 25-hydroxy vitamin D (25-OH-D) level was measured by chemiluminescent immunoassay. Vitamin D deficiency was defined as serum 25-OH-D concentrations < 30 ng/ml. Determinants of vitamin D deficiency were identified using logistic regression analysis.

Results Data of 2,596 participants were available for this study. Prevalence of vitamin D deficiency was 71.1 % (95 % Confidence interval (CI): 69.3–72.8 %), without significant difference between boys and girls (72.0 % vs. 70.1 %, respectively, p = 0.29). In the multivariate regression model, in both genders, those who reported having sun exposure for at least 30 min/day and those taking vitamin D supplementation had lower odds for vitamin D deficiency (all p values < 0.05). In boys, obesity increased the odds of vitamin D deficiency (adjusted OR, 95 % CI: 1.57, 1.08–2.27). The association of vitamin D deficiency with other demographic characteristics and food items was not statistically significant.

Conclusions This large population-based study revealed a high frequency of hypovitaminosis D in Iranian children and adolescents. Sun exposure for at least 30 min/day and taking vitamin D supplementation may reduce the risk of vitamin D deficiency.

Keywords Vitamin D · Obesity · Sunlight

Introduction

Vitamin D is a key hormone in regulating mineral ion metabolism [1] and an essential nutrient for bone health. Also, a growing number of evidence in recent years supports a role for vitamin D status as a potential player in several chronic and acute conditions [2].

✉ Mostafa Qorbani
mqorbani1379@yahoo.com

✉ Ramin Heshmat
Rheshmat@tums.ac.ir

1 Cardiovascular Research Center, Alborz University of Medical Sciences, Karaj, Iran

2 Social Determinants of Health Research Center, Alborz University of Medical Sciences, Karaj, Iran

3 Non-communicable Diseases Research Center, Alborz University of Medical Sciences, Karaj, Iran

4 Chronic Diseases Research Center, Endocrinology and Metabolism Population Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran

5 Student Research Committee, Alborz University of Medical Sciences, Karaj, Iran

6 Department of Medical Emergencies, Qom University of Medical Sciences, Qom, Iran

7 Department of Pediatrics, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran

8 Endocrinology and Metabolism Research Center, Endocrinology and Metabolism Clinical Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran

9 Department of Pediatrics, Child Growth and Development Research Center, Research Institute for Primordial Prevention of Non-communicable Disease, Isfahan University of Medical Sciences, Isfahan, Iran

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As rapid skeletal growth occurs during childhood and adolescence, adequate vitamin D concentrations are essential to ensure optimal peak bone mass development [3]. The bone mass in childhood is known to be a prognostic factor for the occurrence of osteoporosis in adulthood [4]. Moreover, during childhood, vitamin D deficiency can have serious long-term clinical consequences such as rickets, skeletal abnormalities, short stature, and delayed development [5].

Vitamin D deficiency and insufficiency is a silent health problem worldwide in all age groups and both sexes [6], particularly in Middle- Eastern countries [7]. Many countries still lack data, especially population-representative data, on the extent of deficiency in this nutrient; in most cases, there is only very limited information in some population subgroups such as infants, children, adolescents, and pregnant women [7].

In healthy Iranian children and adolescents, prevalence and determinants of vitamin D deficiency is not well-known yet; most of the available data come from subnational studies [8]. Therefore, this national survey examined the prevalence and determinant of vitamin D deficiency in Iranian children and adolescents to provide practical information for healthcare decision-makers.

Methods

We conducted this cross-sectional study using data from the fifth survey of Childhood and Adolescence Surveillance and Prevention of Adult Non-communicable disease (CASPIAN).

CASPIAN study consisted of national surveys on Iranian children and adolescents; started in 2003 and conducted every two or three years [9].

Details on methods and design of CASPIAN -V (2014–2015) are provided elsewhere [10]. In brief, a total of 14,400 schoolchildren aged 7 to18 years were recruited from urban and rural areas of 30 provinces of Iran using a multistage stratified cluster sampling approach. For this purpose, first, 48 clusters of schools in each province were randomly selected as the primary sampling unit. Ten students (and their parents) per cluster were selected randomly, resulting in 480 students from each province. Overall, among all selected students, 4,200 students were randomly selected for biochemical tests, from which 2594 samples have been assessed for vitamin D status.

Questionnaires and measurements

As point out above, details on all procedures, including the questionnaires that were utilized in CASPIAN-V, and also conditions under which the interviews were conducted, all are presented elsewhere [10]. A detailed protocol describing all data collection procedures, including questionnaire filling and physical examination, was developed and distributed among the team working with the project. The Data and Safety Monitoring Board of the project regularly monitored the data collection's quality control and quality assurance.

Demographic characteristics and lifestyle information were collected using survey questionnaires. The questionnaires were filled out anonymously, supervised by trained nurses. A trained team consisting of expert health care professionals performed physical examinations.

Anthropometric parameters including weight, height, and waist circumference (WC) were measured. Weight was measured by a digital scale with a minimum coverage without shoes with an accuracy of 100 g. Height were measured to the nearest 0.1 cm in a standing position.

Sun exposure was defined as spending ≥ 30 minutes outside in weekends and weekdays [11]. To assess students' physical activity (PA) status, data on past week frequency of leisure-time physical activity outside the school was collected using a validated questionnaire. Having enough physical activity was defined as at least 30 min duration of exercise per day that led to sweating and large increases in breathing or heart rate [12].

BMI was calculated as body weight in kilograms divided by square of height in meter. Participants fell into two groups based on their BMI: non-obese (age and sex specific BMI ≤ 95th) and obese (age and sex-specific BMI > 95th).

Socioeconomic status (SES) of students was detected using related questions including parental education, parents' job, possessing a private car, school type (public/private), and having a personal computer. these questions were combined using the principal component analysis (PCA) method as a single index, then categorized into three tertiles (low, intermediate and high SES) [13].

Intake of certain food including fish, beef liver, fresh fruit, vegetables, full-fat dairy products, fast food, cola, and juice were assessed using a single question, "how many times do you eat each of these food groups. Students reported the frequency of using these items defined as daily, weekly, seldom or never.

Serum 25-hydroxy vitamin D (25-OH-D) was measured using the direct competitive immunoassay chemiluminescent method applying LIASON®25 OH vitamin D assay TOTAL (DiaSorin, Inc.), with a coefficient of variation of 9.8 %. In this study, a vitamin D concentration level of less than 30 ng/ml was considered as vitamin D deficiency.

Consumption of different food items were recorded using a non-quantitative food frequency questionnaire (FFQ). In this questionnaire, the students reported each food item's frequency as daily, weekly, seldom or never. For statistical analysis, the frequency of food items consumption was considered daily, weekly, and seldom or never.

Research and Ethics Council of Isfahan University of Medical Sciences reviewed and approved the study protocol (Project Number: 194,049). Signed written informed consent was obtained from all parents/legal guardians and schoolchildren older 16 years, and verbal informed consent from schoolchildren less than 16 years.

Statistical analysis

Quantitative variables were presented as the mean (± standard deviation (SD)) and qualitative variables as frequency (percentage). Independent sample t-test was used to compare means and a Chi-square test was used to compare categorical outcomes. Vitamin D status was described as median and interquartile range (IQR). Univariate and multivariable logistic regression analysis was used to control for potential confounding factors. All independent variables with p-value < 0.2 in univariate logistic regression were included in multivariate logistic regression Statistical analysis performed using Stata package ver. 11.0 (Stata Statistical Software: Release 11. College Station, TX: Stata Corp LP. Package). All statistical measures were estimated using survey data analysis methods. $P < 0.05$ was considered statistically significant.

Results

A total of 2,596 children and adolescents aged 7–18 years participated in this study; the mean age (SD) was 12.2 (3.1), 44.9 % (n = 1,166) were girls, and 71.3 % (n = 1,850) were living in a urban area. The median (IQR) of vitamin D level was 26.49 [10]. The median (IQR) of vitamin D level in children with and without vitamin D deficiency was 24.9 (9.19) and 35 [6] respectively which was statistically significant (P < 0.001). Only 4.5 % of students (116) reported taking supplements containing vitamin D3 over the preceding 3 months. Median level of vitamin D in supplement users was significantly higher than non-users (28.71 versus 26.42).

Table 1 presents the prevalence of vitamin D deficiency in subgroups of study created by socio-demographic characteristics. Overall, deficiency in vitamin D was found in 71.1 % of students, without a significant difference between boys and girls (72.0 % vs. 70.1 %, p = 0.29). The prevalence of vitamin D deficiency was significantly lower in students who reported taking the vitamin D supplement compared with those who did not (51.7 % vs. 72.0 %, p < 0.001), and in students who had sun exposure ≥ 30 min/day compared to those with < 30 min sunlight (58.4 % vs. 83.3 %, p < 0.001); this difference was observed in both sexes. Obese students had a higher prevalence of vitamin D deficiency compared to non-obese students (77.4 % vs. 70.2 %, p = 0.008); however, in the subgroup of girls, this difference did not reach significance. Also, vitamin D deficiency was more prevalent in urban-living girls than in rural-living counterparts and the difference was marginally non-significant. (71.7 % vs. 66.0 %, P = 0.051).

In the subgroup analysis by intake of various foods, there were no significant differences among groups regarding the prevalence of vitamin D deficiency (Table 2).

Based on the results of multivariate regression analysis, in both sexes, students who exposed to sun for at least 30 min/day or taking vitamin D supplementation were less likely to have vitamin D deficiency (all p value < 0.05) (Tables 3 and 4).

In boys, obese students had a higher odds of vitamin D deficiency compared to non-obese students (adjusted OR, 95 % CI: 1.57, 1.08–2.27) (Table 3).

There was no significant association between vitamin D deficiency and other assessed factors.

Discussion

Our findings show that 71.1 % (69.3–72.8 %) of Iranian children and adolescents are hyopovitaminosis D. In both sexes, vitamin D deficiency was associated inversely with taking vitamin D supplement and being exposed to sun for at least 30 minutes per day, but directly with obesity. We did not find a significant association between deficiency in vitamin D and intake of certain foods including fish, liver, fresh fruit, vegetables, full-fat dairy products, fast food, cola, and juice.

In Iran, the prevalence of vitamin D deficiency seem to be very high among children and adolescents [8]. Based on our results, about 7 out of 10 Iranian children and adolescents suffering from vitamin D deficiency. Previous studies from different countries reported different prevalence of vitamin D deficiency ranged from approximately 6–98 % [14]; different characteristics of studied population (such as age groups, gender, and race/ethnicity), various cut points, and season of blood sampling all may justify the differences observed among their finding. However, since the early reports that showed Vitamin D deficiency/insufficiency is a serious health problem in childhood and/or adolescents, the condition remains epidemic according to recent reports, especially those from Asia [15].

Based on our findings, being exposed to the sun for at least 30 min/day reduce odds of deficiency in vitamin D up to 72 % in both sexes. Other reaserchers also reported that sun exposure time were good predictors of 25(OH)D values [16, 17]. Exposure to ultraviolet B sunlight has been identified as a main source of vitamin D for children and adults [2] Though, sun-induced cutaneous synthesis of vitamin D3 is affected to a large extent by factors such as time of day, season, latitude, skin pigmentation, sunscreen use, aging, altitude, and glass [14].

In our study, taking supplementation was another significant determinant of vitamin D status which is supported by available evidence [14, 18, 19]. Vitamin D supplementation is recommended to start from the first days of life and continue until the age of 2 years, and in older children, it should be tailored to sun exposure and risk factors for vitamin D deficiency [14]. However, less than 5 % of our samples reported taking vitamin D3 supplement. Although it is not clear yet if genetic and environmental factors can affect the response to vitamin D supplementation, but results from a meta-analysis

Table 1 Prevalence of vitamin D deficiency (vitamin D < 30ng/ml)

Variables		Boys N=1,430	Girls N=1,166	Total N=2,596
Region	urban	737(72.1 %)	594(71.7 %)	1331(71.9 %)
	rural	292(71.6 %)	223(66.0 %)	515(69.0 %)
p-value		0.836	**0.051**	0.139
Age group	7-10y	329(72.6 %)	294(70.5 %)	623(71.6 %)
	11-14y	422(70.6 %)	345(70.3 %)	767(70.4 %)
	15-18y	278(73.4 %)	178(69.0 %)	456(71.6 %)
p-value		0.595	0.910	0.811
Father occupation	No paid	93(69.9 %)	64(68.1 %)	157(69.2 %)
	paid job	931(72.1 %)	746(70.3 %)	1677(71.3 %)
p-value		0.593	0.651	0.497
Mother occupation	No paid	902(72.5 %)	697(69.4 %)	1599(71.1 %)
	paid job	126(68.5 %)	118(75.2 %)	244(71.6 %)
p-value		0.166	0.911	0.862
Father education	illiterate	116(74.4 %)	112(65.9 %)	228(69.9 %)
	≤ diploma	737(72.8 %)	572(69.8 %)	1309(71.5 %)
	academic	144(67.9 %)	110(75.3 %)	254(70.9 %)
p-value		0.288	0.186	0.844
Mother education	illiterate	170(74.9 %)	152(68.5 %)	322(71.7 %)
	≤ diploma	733(71.8 %)	566(69.4 %)	1299(70.8 %)
	academic	120(68.6 %)	97(77.6 %)	217(72.3 %)
p-value		0.374	0.149	0.813
Physical activity*	high	472(73.0 %)	326(70.7 %)	798(72.0 %)
	low	552(71.0 %)	486(69.5 %)	1038(70.3 %)
p-value		0.425	0.666	0.347
Socioeconomic state	low	300(74.1 %)	276(68.5 %)	576(71.3 %)
	moderate	355(71.6 %)	227(68.6 %)	582(70.4 %)
	high	338(70.9 %)	270(73.8 %)	608(72.1 %)
p-value		0.544	0.201	0.732
Vitamin D suppl.	no	998(72.8 %)	788(71.0 %)	1786(72.0 %)
	yes	31(51.7 %)	29(51.8 %)	60(51.7 %)
p-value		**0.000**	**0.002**	**0.000**
Sunscreen use	no	182(29.8 %)	139(29.1 %)	767(70.5 %)
	occasionally/frequently	219(26.8 %)	210(30.5 %)	1078(71.5 %)
p-value		0.210	0.624	0.565
Sun exposure time	Low (<30 min/day)	588(84.2 %)	503(82.2 %)	1091(83.3 %)
	High (≥30 min/day)	437(60.1 %)	307(56.1 %)	744(58.4 %)
p-value		**<0.001**	**<0.001**	**<0.001**
Obesity	no	869(70.9 %)	728(69.3 %)	1597(70.2 %)
	yes	158(77.8 %)	89(76.7 %)	247(77.4 %)
p-value		**0.043**	0.099	**0.008**
N: number				

showed that required vitamin D supplementation doses to reach desirable levels in the MENA region, is higher than the doses recommended by the NAM (IOM) for Northern America and Canada [20]; however, this meta-analysis was conducted on only four RCTs and none of them was from Iran.

In support of our findings, a meta-analysis on eight studies revealed that obese children and adolescents had a 35 % greater prevalence of vitamin D deficiency compared to their non-

Table 2 Prevalence of vitamin D deficiency (vitamin D < 30 ng/ml) according to intake of food items

Food items		Boys N=1,430	Girls N=1,166	Total N=2,596
Fat dairy products	daily	256(71.1%)	213(68.5%)	469(69.9%)
	weekly	349(71.5%)	269(68.8%)	618(70.3%)
	rarely	375(72.4%)	292(74.3%)	667(73.2%)
p-value		0.909	0.144	0.259
Fish	daily	451(73.7%)	322(69.8%)	773(72.0%)
	weekly	475(70.3%)	390(71.4%)	865(70.8%)
	rarely	97(75.8%)	94(66.2%)	191(70.7%)
p-value		0.252	0.471	0.784
Beef Liver	daily	43(75.4%)	34(60.7%)	77(68.1%)
	weekly	149(75.6%)	120(66.3%)	269(71.2%)
	rarely	837(71.2%)	662(71.4%)	1499(71.3%)
p-value		0.374	0.113	0.769
Fast food	daily	25(89.3%)	21(61.8%)	46(74.2%)
	weekly	152(69.1%)	140(71.1%)	292(70.0%)
	rarely	849(72.1%)	651(70.2%)	1500(71.3%)
p-value		0.079	0.543	0.760
Cola	daily	31(63.3%)	27(69.2%)	58(65.9%)
	weekly	226(70.0%)	167(69.0%)	393(69.6%)
	rarely	767(73.0%)	620(70.5%)	1387(71.9%)
p-value		0.234	0.892	0.308
Fresh fruit	daily	500(72.8%)	383(71.5%)	883(72.2%)
	weekly	284(70.6%)	224(68.3%)	508(69.6%)
	rarely	244(71.8%)	209(69.7%)	453(70.8%)
p-value		0.749	0.604	0.458
Juice	daily	54(68.4%)	62(73.8%)	116(71.2%)
	weekly	216(67.9%)	171(67.6%)	387(67.8%)
	rarely	755(73.4%)	583(70.5%)	1338(72.1%)
p-value		0.123	0.503	0.133
Vegetable	daily	361(71.2%)	484(73.4%)	845(72.5%)
	weekly	306(70.8%)	370(69.3%)	676(70.0%)
	rarely	148(66.1%)	172(74.5%)	320(70.3%)
p-value		0.190	0.343	0.410

N: number

Table 3 Factors associated with vitamin D deficiency /deficiency in boys in multivariate logistic regression

Variables	Adjusted odds ratio	95% CI	P-value
Mother occupation (paid/unpaid)	0.83	0.58–1.18	0.300
Sun exposure time (high/low)	0.28	0.21–0.36	**<0.001**
Vitamin D supplementation (yes/no)	0.35	0.20–0.61	**<0.001**
Obesity (yes/no)	1.57	1.08–2.27	**0.018**
Fast food consumption (yes/no)	0.86	0.64_1.16	0.323
Vegetable consumption (yes/no)	0.98	0.82_1.16	0.776
Juice consumption (yes/no)	1.20	0.97–1.48	0.093

CI: Confidence intervals

Table 4 Factors associated with vitamin D deficiency /deficiency in girls in multivariate logistic regression

	Adjusted odds ratio	95% CI	P-value
Father education (≤diploma /illiterate)	1.39	0.88–2.20	0.163
Father education (academic/illiterate)	1.46	0.77–2.78	0.248
Sun exposure time (high/low)	0.28	0.21–0.37	**<0.001**
Mother education (≤diploma /illiterate)	0.82	0.54–1.24	0.339
Mother education (academic/illiterate)	1.09	0.56–2.13	0.802
Vitamin D supplementation (yes/no)	0.48	0.27–0.87	**0.016**
Obesity (yes/no)	1.49	0.91–2.46	0.112
Region (urban/rural)	0.84	0.62–1.14	0.252
Liver consumption(yes/no)	1.04	0.78–1.39	0.809
Fat dairy products consumption (yes/no)	1.10	0.92–1.31	0.290

CI: Confidence intervals

obese counterparts (PR: 1.37; 95 % CI: 1.20–1.56) [21]. Sequestration of vitamin D in adipose tissue [22], altered vitamin D metabolism, reduced intestinal absorption, along with reduced cutaneous synthesis of the vitamin D (through reduced sun exposure), and lower dietary intake [23] all are proposed as underlying mechanisms for lower 25(OH)D concentrations in obese individuals.

In the current study, there was not a significant association between deficiency in vitamin D and intake of certain foods such as fish, liver, fresh fruit, and vegetables. Small proportion of our samples consumed beef liver. This could justify why we did not find an association between beef liver consumption and vitamin deficiency in children and adolescents. Fish intake was not associated with 25(OH)D deficiency in our study. Kumar et al. also reported that low fish intake was not associated with 25(OH)D deficiency among participants aged 1 to 21 years [24]. Although fish is known to be a natural source of vitamin D, but the type of the fish (oily or non-oily) also seem to play a key role; oily fish was associated with a larger increase in 25(OH)D concentrations [25].

As dietary sources of vitamin D are limited (oily fish, egg yolk, nuts, cheese, and certain mushrooms),[26] in some countries, certain food products are fortified with this nutrient like some dairy products, orange juice, soy milk, and cereals; although this strategy does not always lead to the sufficient levels of vitamin D [14, 27].

Limitations and strengths

Our study suffered from some limitations, such as interpretation of the findings is restricted by the cross-sectional nature of the CASPIAN V survey. Our finding is also limited by the lack of data on the pubertal status of participants, which may influence vitamin D level. Still, students may not remember certain details, such as the frequency of consuming a variety of certain food in the 6 months before the survey.

However, our study is one of the limited studies in Iranian studies that use a nationally representative large sample of children and adolescents across urban and rural areas to examine the prevalence and determinant of vitamin D deficiency in school children.

Conclusions

This study showed that vitamin D deficiency is a prevalent condition among schoolchildren in Iran, especially among obese students. Based on our findings, taking vitamin D supplement and being exposed to the sun for at least 30 minutes per day both can reduce the odds of vitamin D deficiency.

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Author contributions Design: Mostafa Qorbani, Ramin Heshmat, Roya Kelishadi, Mohammad Esmaeil Motlagh.

Study conduct: Mostafa Qorbani, Ramin Heshmat, Roya Kelishadi, Mohammad Esmaeil Motlagh.

Statistical analysis: Mostafa Qorbani, Hadith Rastad.

Paper drafting: Mostafa Qorbani, Hadith Rastad, Hamid Asayesh, Ehsan Seif.

All authors have contributed to revising the manuscript, confirmed the final draft for submission, and accepted the manuscript content's responsibility.

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Data Availability All the data supporting the findings is contained within the manuscript.

Declarations

Ethics approval and consent to participate The study was conducted according to the Declaration of Helsinki (Seoul, 2008). Ethical approval was given by the Isfahan University of Medical Sciences ethics committee and other relevant national and provincial regulatory organizations. After a complete explanation of the objectives and protocols, each participant was assured that his/her responses would remain anonymous and confidential. Participation was voluntary, and all potential participants had the right to withdraw from the study at any time. Written informed consent and oral assent were obtained from the parents and students, respectively.

Consent for publication Not applicable.

Conflict of interest The authors declare that they have no competing interests.

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