

Vitamin D status and healthy Egyptian adolescents

Where do we stand?

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Abstract

Vitamin D deficiency is a worldwide public health problem. Low vitamin D and its consequences among children and adolescents could be considered as one of the most important health-related problems. This study aimed to estimate the prevalence of vitamin D deficiency in healthy Egyptian adolescents and investigate factors associated with vitamin D status.

A cross-sectional study was conducted on 572 school children (270 males and 302 females) aged 14 to 18 years, who were randomly selected from high schools in one governorate in Egypt. Data were collected through a self-administered questionnaire. Vitamin D level, serum calcium, phosphorus, alkaline phosphates were measured.

Vitamin D deficiency was almost present in all the studied Egyptian healthy adolescents (99%), 94.8% had vitamin D deficiency and 4.2% had vitamin D insufficiency. Girls had a higher prevalence of vitamin D deficiency than boys. There was a significant association between lack of physical activity, sun exposure, and vitamin D deficiency.

Vitamin D deficiency and insufficiency are highly prevalent. In sunny countries, the special pattern of conservative clothing and the lack of outdoor physical activity might be the underlying factors for the high prevalence in females. Vitamin D supplementation seems to be mandatory to halt the problem.

Abbreviations: VD = vitamin D, VDD = vitamin D deficiency, VDI = vitamin D insufficient, VDS = vitamin D sufficient.

Keywords: Adolescents, Egyptian, healthy, vitamin D

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The study was approved by the research and ethical committee of the participating hospitals. All parents of enrolled children signed written informed consent for participation of their children in the current study.

All parents of enrolled children signed written informed consent for publication of the current study.

All data and materials related to the study are included in the current manuscript.

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1. Introduction

Vitamin D (VD) is an important hormone with autocrine, paracrine and endocrine effects. It is synthesized in the skin after exposure to ultraviolet rays and only 10% is derived from dietary sources.^[1,2] VD plays a key role in calcium and phosphorus homeostasis,^[3] bone health and various cellular and neuromuscular functions.^[4]

Vitamin D deficiency (VDD) is associated with skeletal deformity, increased fracture risk and growth retardation. In addition, VDD is associated with extra-skeletal health problems such as asthma and allergies, type 2 diabetes,^[5] depression, cancer^[6] and disorders of innate and adaptive immunity especially that regulating inflammatory response.^[7]

Over the last years, VDD has emerged as a worldwide health concern including all ages.^[8] Several authors reported that low VD levels in adolescents and children are sufficiently common to be considered a significant public health issue in many parts of the world.^[9] However, there is insufficient information concerning the magnitude of the problem in adolescents in sunny countries like Egypt. In this study, we aim to estimate the prevalence of vitamin D deficiency in healthy Egyptian adolescents and investigate factors associated with vitamin D status.

2. Methods

2.1. Study population

We carried a cross-sectional study on 572 high school students from Sharkia governorate, Egypt, aged 14 TO 18 years, during

the sunny period in Egypt; May to August; in two consecutive years, 2018 & 2019.

The sample size was calculated based on online calculator of sample size (Sample Size Calculator.^[10]) The previously reported vitamin D deficiency prevalence in Egypt; was between 21.3% and 60.9%.^[11,12] We chose VDD prevalence of 25%, that is, sample size proportion of 25%. At confidence level of 95% and margin of error of 5%, the estimated sample size was 286 or more participants. We chose a design effect of 2, that is, twice the sample size which is 572.

Parents/guardians of all participants provided written informed consent for enrollment in the current study and for publication. The study was approved by the Institutional Review Board of Zagazig University and the Ministry of Education in Sharkia governorate.

Inclusion Criteria:

- All healthy adolescents; 14 to 18 years; presenting during the study period were included in this study.

Exclusion Criteria:

- Age less than 14 years old.
- Patients with known metabolic bone disease
- Patients with chronic diseases known to be associated with bone abnormalities
- Patients with chronic renal and/or hepatic diseases
- Those currently on or with a history of medications interfering with vitamin D metabolism.

2.2. Data collection

Members completed detailed questionnaires including:

1. Demographic data: age, sex, residence,
2. Nutritional intake of dairy products and nutritional supplementation of VD,
3. Daily sunlight exposure time,
4. History of boney pain, fractures, deformities, etc,
5. Physical activity history during the previous year including time spent on team sports and other activities.

The activity was then computed in terms of total hours per week and time engaged in outdoor activities.

Anthropometric measurement was performed by a trained health care professional according to WHO training course on Child Growth Assessment.^[13] Weight was measured using the digital weight scale. Height was measured by a wall stadiometer.

2.3. Laboratory measurements

Five ml blood sample was collected from each participant for measurement of serum calcium, phosphorus, alkaline phosphatase by endpoint assay in a multichannel analyzer. Serum VD level was measured quantitatively by radioimmune assay (Roch Diagnostic Mannheim, Germany).

The students were classified according to VD levels into Vitamin D sufficient (VDS): >30ng/mL, vitamin D insufficient (VDI): 20-29.9ng/mL, and vitamin D deficiency: <20ng/mL.^[14]

2.4. Statistical analysis

The data were entered in SPSS (version 16, 2011; SPSS, Inc., Chicago, IL). Baseline variables were analyzed by descriptive

statistics. Comparison of proportions was performed with chi-square and Fisher's exact tests. Quantitative data were expressed as mean \pm standard deviation, median and range. Quantitative data were verified for normality using the Kolomogrov Smirnov test. Spearman's correlation coefficient (ρ) was used to calculate the correlation between nonparametric variables. Student "t" test was used to analyze normally distributed variables between 2 independent groups, or Man Whitney U test for nonparametric ones. The difference among 3 independent means was analyzed using ANOVA for parametric variables or Kruskal Wallis test for nonparametric ones.

Multivariate logistic regression analysis of risk factors for vitamin D deficiency was carried out.

3. Results

A total of 572 healthy adolescents were included in the study. Their age ranged from 14 to 18 years with a mean age of 17.63 years. Both genders were included in the study; 270 males and 302 females. The mean weight of the studied group was 55.7kg, the mean height was 163.2cm and the mean BMI was 23.12. The largest percentage of the studied adolescents consumed daily dairy products (64%), exposed to sunlight less than 1 hour daily (68.2%), had low physical activity per weak (92.3%), all females were wearing hijab dressing (52.8% of the whole cohort) and didn't receive VD supplementation (85.3%) (Table 1).

The mean serum VD was 11.4ng/ml, alkaline phosphate was 409.88U/L, serum calcium was 9.04mg/dl and serum phosphate was 3.99mg/dl (Table 2).

The prevalence of VDD was higher in girls than boys (100% VS 88%). VDD was more common in students who had higher BMI. The mean of BMI in VDD group was (27.7) and was (22.9) in VDS group. Most of the students had VDD exposed to sun less than 1hour daily. VDD was more in students who did exercise less than 6 hours per weak (Table 3).

High BMI has increased the risk of VDD by (0.9 times) and the female gender has increased risk by (4.284 times) while multivitamin usage has decreased the risk of VDD by 0.166 (Table 4).

The prevalence of VDD was 94.8%, VDI was (4.2%) while VDS was (1%) (Fig. 1).

4. Discussion

The frequency of vitamin D deficiency (VDD) in the Middle East and Africa, despite the abundant sunshine, is high especially in high-risk groups like adolescents and pregnant females.^[15]

Few data are available about the prevalence of this nutritional deficiency among healthy Egyptian adolescents.

The result of the present work showed a very high prevalence of VDD (94.8%) and VDI (4.2%) while only (1%) of participants had VDS. Another small Egyptian-population-based study revealed a high prevalence of VDD 60.9% and VDI 17.7%^[11] while an earlier study in 2012 by Amr and his colleagues^[12] reported lower prevalence in Egyptian adolescent females where 54.7% were VDS, 24% were VDI and 21.3% were VDD. This incidence is lower than our incidence and Karim's study^[11] incidence which might be explained by significantly higher both sun exposure index and daily sun exposure time in their VDS females. About 68% of our students gave a history of sun exposure less than 1 hour per day.

Table 1
Demographic characteristics, dietary and social habits of the studied student.

Variable	Value
Age (years)	17.63 ± 0.65*
Gender	
Male	270 (47.2%)
Female	302 (52.8%)
Weight (kg)	55.7 ± 2.33*
Height (cm)	163.2 ± 4.97*
BMI	23.12 ± 3.58*
Dairy product consumption/d	
Daily	366 (64%)
Less	206 (34%)
Sun exposure (per d)	
Less than 1 h	390 (68.2%)
More than 1 h	182 (31.8%)
Physical activity (per wk)	
No	306 (53.5%)
<6 h	222 (38.8%)
>6 h	44 (7.7%)
Type of clothes	
Hijab dressing	302 (52%)
Vitamin D usage	
No	488 (85.3%)
Yes	84 (14.7%)

BMI = body mass index, d = day, wk = week, h = hour.
* Mean ± SD.

The high prevalence of VDD has been illustrated worldwide by many researchers from different countries. In middle East, one study from Kuwait detected VDD in 98.7% of the studied population^[16] while Al Shaikh et al., 2016^[17] reported a 45.5% prevalence of VDD and 49.9% in his cohort from Saudi Arabia.

Furthermore, studies released from Europe had demonstrated that. An Italian study detected 49.9% and 32.3% for VDD and VDI respectively.^[18] Öberg et al 2014^[19] and Eggemoen et al., 2013,^[20] reported VDD in 60.2% and 81% of their population

Table 2
Laboratory results of studied children.

Variables	Value Mean ± SD
Vitamin D (ng/ml)	11.14 ± 5.32
VDD	542 (94.8%)
VDI	24 (4.2%)
VDS	6 (1%)
Serum calcium (mg/dl)	9.04 ± 0.56
Serum phosphate (mg/dl)	3.99 ± 0.88
Alkaline phosphate (IU/L)	409.88 ± 33076

VDD = vitamin D deficiency, VDI = vitamin D insufficient, VDS = vitamin D sufficient.

from Norway. Radhakishun et al., 2014^[21] reported 57.6% VDD in their sample from Netherlands.

In contrary to these findings the prevalence of VDD was much lower in East Asia (24%) and in a group of Hispanic American adolescents (27.8%).^[22]

This difference in the prevalence of vitamin D between different countries may be partly explained by many factors including genetic factors, different styles of clothing, increased metabolic requirements, skin pigmentation and limited outdoor activity which led to decreased synthesis of vitamin D in the skin by ultraviolet radiation.^[23]

Our study detected a higher prevalence of VDD in girls as compared to boys, where all girls (100%) had VDD while 88% of boys had VDD, 8.8% had VDI and 2.2% had VDS. This agrees with Al Shaikh et al., 2016,^[17] who found that the prevalence of VDD combined with VDI was higher in females (97.8%) compared to males (92.8%). Atli et al 2005^[24] and Fuleihan et al 2001,^[25] have supported a high prevalence of VDD in girls than in boys. Another study of VD level in adolescent Turkish pregnant women^[26] detected a high incidence of VDD. On the contrary, Weng et al., 2007^[27] reported no gender difference.

The higher prevalence of VDD in females as compared to males might be explained by the more restricted outdoors activity in females, the conservative clothing they wear that prevent

Table 3
Relation between vitamin D level and demographic, dietary, and social characteristics.

	Deficiency N (%)	Insufficiency N (%)	Sufficiency N (%)	Test	P
Gender					
Male	240 (44.3)	24 (100)	6 (100)	17.706	<.001
Female	302 (55.7)	0 (0)	0 (0)		
Age (years)					
Mean ± SD	17.61 ± 0.66	18 ± 0	17.67 ± 0.58	2.057	.130
BMI					
Mean ± SD	27.74 ± 2.58	24.4 ± 4.72	22.98 ± 3.46	F (3.714)	.026
Range	25.44–30.53	17.97–29.82	15.78–41.25		
Dairy consumption/d					
Daily				2.713	.258
Less	348 (64.2)	12 (50)	6 (100)		
	194 (35.8)	12 (50)	0 (0)		
Physical activity/wk					
No	306 (56.5)	0 (0)	0 (0)	18.211	<.001
<6 h	194 (35.8)	24 (100)	4 (66.7)	20.938	<.001
>6 h	42 (7.7)	0 (0)	2 (33.3)	3.779	.151
Sun exposure/d					
Less than 1 h	374 (69)	12 (50)	4 (66.7)	1.916	.384
More than 1 h	168 (31)	12 (50)	2 (33.3)		

P value is considered significance if >.05. N = number, d = day, wk = week, h = hour.

Table 4
Multivariate analysis of risk factors for vitamin D deficiency.

	B	OR	CI	P
Female gender	1.456	4.287	(0.534–34.411)	.171
Multivitamin use (No)	−0.413	0.166	(0.136–3.225)	.609
Physical activity (yes)	−18.334	0.000	0.0	.995
BMI	−0.094	0.910	(0.822–1.007)	.069

β = beta value, BMI = body mass index, CI = confidence interval, OR = odd ratio.

exposure to ultraviolet radiation, using sun-screening agents to avoid darkening of their skin, lack of awareness of the importance of sun exposure for bone health. These factors lead to decrease in the synthesis of vitamin D in the skin by sunlight.^[28,29]

All female participants in our study were wearing hijab and conservative clothing covering nearly all their bodies apart from the face and hands, this might explain the high incidence of VDD as very little skin area is exposed to sunlight. This matches with another study from Jordan, which showed a strong relationship between clothing and VD level. Serum VD was highest in women wearing western clothing and levels decreased to be lowest in those wearing traditional clothing and hijab and completely veiled women wearing niqab.^[30] A similar finding was seen in Turkish women where western-dressed group women had VDS while women wearing a hijab with uncovered face and hands had VDI and the completed covered group had VDD.^[31] Another study was done in KSA detected VDD was more common in both women wearing Hijab and women wearing niqab and there was no significant difference in the serum levels of VD between both groups.^[32]

Due to the high prevalence of VDD in adolescent Turkish girls especially during pregnancy and its negative outcomes on fetus and labor, Öcal and colleagues suggested that effective

prophylaxis programs for VDD and/or fortification of foods with VD are essential to be implemented in all pregnant women especially during winter season.^[26]

Another predisposing factor that contributes to vitamin D deficiency is lack of physical activity. Our study showed that the largest percentage of the VDD group had nearly no physical activity which agreed with many other studies.^[33,34] This might be explained by the decreased exposure of skin to ultraviolet rays due to low outdoor physical activity and consequently decreased synthesis of VD.^[35] On the other hand, VDD may be the cause of low physical activity due to associated decline in neuromuscular function including muscular strength, walking speed, balance, jumping and sprinting performance, and aerobic capacity.^[36]

In contrary to this, Bezuglov et al, 2019^[37] reported that VDI and VDD are highly prevalent in adult soccer players and can exceed 80% even in regions with high insolation although their regular physical activity and suggested daily usage of cholecalciferol in a dose 5000 IU was an effective and well-tolerated treatment for VDI in them. An argument may be that the needs of VD in athletes are much higher than the general population and this could not be provided by the usual sun exposure even if the exposure time is adequate.

In the current study, 84.5% and 100% of those who were VDD and VDI respectively, had a lack of VD supplementation. This agreed with other studies^[38,39] which found that the children and adolescents who were not receiving VD supplementation had a higher prevalence of VDD. Vidailhet and Mallet, 2013^[40] suggested that using VD supplements should be focused on high-risk groups such as low socioeconomic groups, overweight or obese people, and children/ adolescents.

The association between obesity and overweight and VDD has been reported by many researchers.^[41–46] Most VDD participants in the current study had a high BMI with significantly higher BMI in the VDD group as compared to the VDI one ($P < .02$). This agrees with Shady et al, 2015^[41] who found that

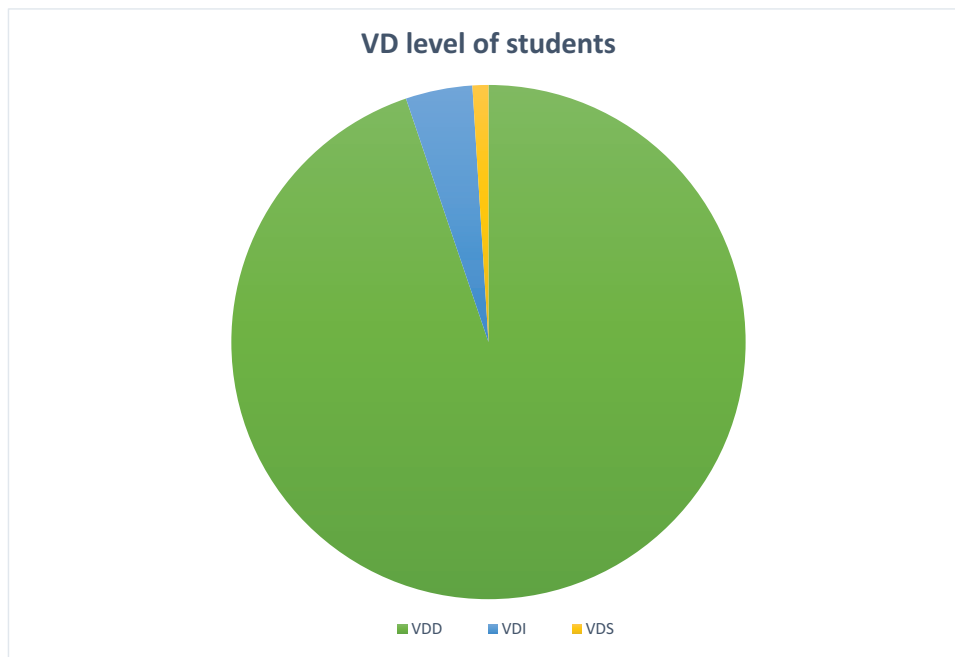


Figure 1. Distribution of studied children according to vitamin D status.

serum VD was significantly correlated with BMI. Makariou and colleagues^[42] found that adolescents with obesity had lower VD. Plesner JL et al, 2018^[43] reported that VDD was common among Danish children and adolescents with obesity and Au et al, 2013^[44] reported that about 75% of overweight/ obese children were at risk of VDD.

These findings may be explained by the sequestration of the fat-soluble vitamin D within adipose tissues. Moreover, adiponectin has been recently identified as a key plasma protein that links vitamin D deficiency to pediatric obesity.^[47]

5. Limitations of the study

An important limitation of the current study is that it was carried in only one Egyptian governate. Hence a multicenter Egyptian national study is needed to validate our results.

6. Conclusions

Vitamin D deficiency and insufficiency are highly prevalent even in sunny countries like Egypt, especially in females. The special pattern of clothing and the lack of outdoor physical activity in female adolescents are the most contributing factors. Vitamin D supplementation appears to be an important factor to decrease the magnitude of the problem. A Multicenter national study is warranted to generalize these conclusions.

Author contributions

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