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Prevalence of vitamin D deficiency in apparently healthy children in north India

Abstract

Background: The data on the prevalence of vitamin D deficiency (VDD) in apparently healthy children from India is limited.
Objective: To assess the prevalence of VDD in apparently healthy children.
Design: Prospective study.
Setting and subjects: Apparently healthy children from the age groups of 3 months–12 years, from the upper socioeconomical status (USES), attending the outpatient department (OPD) of a private pediatric hospital in Chandigarh, India, for minor ailments were enrolled over a period of 6 months (March–August 2013).
Methods: Plasma levels of 25-hydroxyvitamin D [25(OH)D] were measured by competitive electrochemiluminescence immunoassay.
Results: In total, 338 children (188 boys, 150 girls) with mean age of 3.31 years were enrolled. The percentages of children with deficient, insufficient, and sufficient levels of 25(OH)D were 40.24%, 25.44%, and 34.32%, respectively. Clinical signs of VDD were seen in only 8.53% of the children. The mean (±SD) levels of 25(OH)D were 27.48 (15.99) ng/mL. On univariate analysis, deficient levels of 25(OH)D were associated with relatively younger age group, female sex, failure to thrive, exclusive breastfeeding, inadequate sun exposure, and no vitamin D supplements.
Conclusion: A high prevalence of clinical and biochemical VDD was noted in apparently healthy children belonging to the USES.

Keywords: apparently healthy children; India; outpatient department; vitamin D deficiency.

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Introduction

Vitamin D is an important immuno-modulatory hormone derived predominantly from sunlight and diet (1). Vitamin D and vitamin D deficiency (VDD) play major roles in the modulation of the immune response, autoimmune and cardiovascular diseases, asthma, acute lower respiratory infections, sepsis, cancers, insulin production/diabetes mellitus, proper functioning of multiple organs, and regulation of cell proliferation and differentiation apart from their important role in calcium homeostasis, bone health, growth, and development (1–6).

There is an alarming rise in the prevalence of VDD throughout the world. Various studies from India and elsewhere estimated the prevalence of VDD in healthy children ranging from 10% to as high as 90% depending upon population and age group studied, the method used to estimate vitamin D levels, and the cut-off value of 25-hydroxyvitamin D [25(OH)D] used (7–13). This high prevalence of VDD is due to inadequate sunlight exposure, indoor lifestyle, wearing clothes, use of sun screens, high levels of skin pigmentation, inadequate dietary sources of vitamin D, and the lack of vitamin D supplementation (1). Overt cases of VDD represent only the tip of the iceberg of this important public health problem (1).

The data on the prevalence of VDD in apparently healthy children from India is limited to a few studies involving school children and urban slum children (10–12). The objectives of the present study were to assess the prevalence of clinical and biochemical VDD in apparently healthy children from the age groups of 3 months to 12 years belonging to the USES and to assess the factors influencing VDD.

Materials and methods

Subjects and protocols

The study involved 338 apparently healthy children (aged 3 months to 12 years) of both sexes attending the outpatient department (OPD) for

minor ailments in a private pediatric hospital in Chandigarh, India, that caters to children of upper socioeconomic status (USES) according to modified Kuppuswamy's socioeconomic scale (14, 15). All children enrolled were from Chandigarh and its surrounding areas located at 30.74°N and 76.79°E. These children were prospectively enrolled over a period of 6 months (March–August 2013). Informed written consent from the parents was obtained before recruitment into the study.

Demographic data, anthropometric measurements (weight and length/height), and detailed physical examination were recorded. Clinical signs suggestive of VDD (rachitic rosary, frontal bossing, Harrison's sulcus, wrist widening, wide anterior fontanelle, double malleolus, craniotabes, and bowing of legs), if present were recorded. Risk factors for VDD were also recorded. Parents and children were asked about sunlight exposure and a daily sunlight exposure of >30 min with the exposure of a minimum of 30% of the body surface area was labeled as adequate (10). Note was also made of the family size, birth order, exclusive breastfeeding in infants, dark skin complexion, and vitamin D supplementation. Blood samples for analyses of 25(OH)D were collected in heparinized amber colored glass vials to prevent photodegradation. Plasma was extracted after centrifugation and stored at –20°C until analyzed. The measurement of the total level of 25(OH)D in the plasma was done by competitive electrochemiluminescence immunoassay (ECLIA) (ADVIA Centaur Vitamin D assay, Rev. C, 2012–08, Siemens Healthcare Diagnostics Inc., New York, NY, USA) using kits, calibrators and controls from the same manufacturer. The assay limit of the method used is 4.2–150 ng/mL (10.5–375 nmol/L).

Depending on the 25(OH)D level, children were classified into three categories (16, 17); vitamin D deficiency: 25(OH)D levels <20 ng/mL; vitamin D insufficiency: 25(OH)D levels 20–30 ng/mL; and vitamin D sufficiency: 25(OH)D levels >30 ng/mL.

Table 1 Clinico-demographic characteristics of children in the study group.

Characteristics	Total patients, n=338
Age (in years), mean (range, ±2SD)	3.31 (0.25–12, 3.16)
Sex	
Male, n (%)	188 (55.6)
Female, n (%)	150 (44.4)
Weight (in kgs), mean (range, ±2SD)	12.9 (3–48, 6.7)
Height (in cms), mean, (range, ±2SD)	94.24 (53–152, 28.62)
Failure to thrive, n (%)	25 (7.4)
Reasons for OPD visit	
Vaccination, n (%)	104 (30.78)
Upper respiratory tract infection, n (%)	96 (28.4)
Acute gastroenteritis, n (%)	62 (18.34)
Lower respiratory tract infection, n (%)	34 (10.06)
Asthma, n (%)	25 (7.39)
Other, n (%)	17 (5.03)
Signs of rickets	29 (8.58)
Rachitic rosary, n (%)	21 (6.21)
Frontal bossing, n (%)	19 (5.62)
Harrison's sulcus, n (%)	17 (5.03)
Wrist widening, n (%)	15 (4.44)
Wide anterior fontanelle, n (%)	14 (4.14)
Double malleolus, n (%)	12 (3.55)
Craniotabes, n (%)	10 (2.96)
Bowing of legs, n (%)	4 (1.18)
Risk factors for vitamin D deficiency	
Family size, mean (range, ±2SD)	3.9 (3–6, 1.5)
Birth order, mean (range, ±2SD)	1.91 (1–4, 1.1)
Infants with exclusive breastfeeding, n (%)[a]	32 (64)
Adequate sun exposure, n (%)	136 (40.24)
Dark skin color, n (%)	30 (8.87)
On vitamin D supplements, n (%)	51 (15.09)

[a]Total infants in study population were 50.

Outcomes

The primary outcome was the prevalence of clinical and biochemical VDD in apparently healthy children. The secondary outcomes were the relationships between VDD and factors like age, sex, anthropometric variables, and other risk factors for VDD. Children with VDD were supplemented with adequate doses of vitamin D and calcium.

Data analysis

The data entry and statistical analysis were performed using Microsoft Excel 2007 (Microsoft, Redmond, WA, USA) and SPSS software version 15 (SPSS, Inc, Chicago, IL, USA). Demographic variables were recorded as mean, standard deviation (SD), range, and percentages, as applicable. Dichotomous outcomes were compared by χ^2 test. Continuous variables were compared by Student's t-test. The association of VDD with various patient characteristics was measured by χ^2 test for categorical variables; and t-tests, Wilcoxon rank sum, Mann-Whitney, or Kruskal-Wallis tests for continuous variables, where appropriate. All tests were two-tailed and a p-value <0.05 was taken as significant.

Results

Clinical characteristics of the study population

Over the study period, 338 apparently healthy children, who attended the OPD with minor complaints, were enrolled. The clinico-demographic characteristics, reasons for OPD visits, clinical features of VDD, and risk factor for VDD are shown in Table 1. Out of 50 infants in the study, 64% (n=32) were exclusively breastfed. Adequate sun exposure was reported in 40.24% (136/338) of children. Only 15.08% (51/338) of them were on vitamin D supplements. One or other clinical signs of VDD were seen in 8.58% of children.

Prevalence of vitamin D deficiency and insufficiency

The percentage of children with deficient, insufficient, deficient plus insufficient, and sufficient levels of

Table 2 Distribution of children in four categories according to 25(OH)D levels.

25(OH)D levels (ng/mL)	Total patients (n=338)
<20 (Deficient), n (%)	136 (40.24)
20–30 (Insufficient), n (%)	86 (25.44)
<30 (Insufficient+deficient), n (%)	222 (65.68)
>30 (Sufficient), n (%)	116 (34.32)

25(OH)D were 40.24%, 25.44%, 65.68%, and 34.32%, respectively (Table 2). The percentage of children with VDD was highest in the age groups of 1–3 and 3–5 years (49.7% and 45.6%, respectively) (Table 3). Sixteen (4.73%) children had severe VDD (25(OH)D <10 ng/mL).

Distribution of serum 25(OH)D levels in the whole study population and among the different groups

The mean (±SD) levels of 25(OH)D were 27.48 (15.99) ng/mL. Mean 25(OH)D levels were lower in females than males (p=0.087), in the age group of 1–3 years (p=0.43), and in those who were not on vitamin D supplements (p=0.01) (Table 4).

In univariate analysis, VDD was significantly associated with relatively younger age group (p=0.01), female sex (p=0.003), failure to thrive (p=0.0007), exclusive breastfeeding (p=0.000), inadequate sun exposure (p=0.008), and no vitamin D supplements (p=0.000) (Table 5).

Discussion

We observed that the prevalence of clinical and biochemical evidence of VDD in apparently healthy children was 8.58% and 40.24%, respectively. Only a third of them had sufficient 25(OH)D levels and the rests had either deficient or insufficient levels.

Table 3 Children deficient in vitamin D in the various age groups.

Age groups distribution	Total patients, n	Deficient, n (%)	p-Value
<1 year	50	15 (30)	0.004
1–3 years	148	72 (49.7)	
3–5 year	57	26 (45.6)	
5–8 year	42	13 (31)	
8–12 year	44	10 (22.7)	

Currently, the whole world is facing an unrecognized and untreated pandemic of VDD even in countries with abundant sunshine (1, 18, 19). Various studies from developed countries estimated that the prevalence of VDD in healthy children ranged from 9% to 24% (20–23). Similarly, few recent studies also reported the prevalence of VDD in range of 21%–29% in healthy children (24–26).

Limited studies from India demonstrated high prevalence of VDD (36%–90%) in the healthy pediatric population (10–12). Marwaha et al. (10) assessed the vitamin D and the bone mineral density status of 5137 healthy school children aged 10–18 years in northern India. Clinical evidence of VDD was noted in 10.8% of these children. The mean serum concentration of 25(OH)D was 11.8±7.2 ng/mL and 35.7% children had levels of 25(OH)D <9 ng/mL. Tiwari and Puliyel (11) estimated the 25(OH)D levels in slum children from three areas in Delhi and found that the prevalence of 25(OH)D levels <35 nmol/L (<14 ng/mL) was as high as 84%. Puri et al. (12) studied clinical and laboratory evidence of VDD in 3127 apparently healthy Delhi schoolgirls in the age group of 6–18 years and found that 11.5% of girls had clinical evidence of VDD and 90.8% of them had biochemical VDD. The mean concentration of 25(OH)D was 31·87 nmol/L (12.75 ng/mL). In contrast to these studies, we found that the mean 25(OH)D level in our study population was 27.48±15.99 ng/mL and only 4.73% of our children had 25(OH)D levels <10 ng/mL, which can be explained by the USES and the better nutrition profile of our study population. Also, we observed that the clinical signs of VDD were seen in a lower number of children (8.58%) than biochemical VDD, similar to the results of the above studies. This is because the clinical signs develop only when there is extreme VDD for a longer duration (27). So, relying only on clinical signs will lead to missing a significant number of children with VDD, which would otherwise be identified by measuring 25(OH)D levels.

The differences observed in the prevalence of VDD in the different studies are due to differences in studied populations, sunlight exposure, latitude of residence, skin color, sunscreen use, environmental pollution, weather, dietary intake, vitamin D supplementation, genotype variation in proteins involved in the vitamin D transportation, functioning, and metabolism; and different methods used to measure 25(OH)D level, and different cut-off values used (4, 26, 28). The possible determinants of low vitamin D status in our children could be due to the lack of vitamin D supplementation, inadequate sun exposure, less time spent on outdoor physical activity and greater indulgence in indoor activities like watching television, computer gaming, and other recreational activities among USES children.

Table 4 Mean levels of 25(OH)D in the different groups.

Groups	25(OH)D levels (ng/mL)	p-Value
25(OH)D level in all enrolled children (n=338), mean (range, ±2SD)	27.48 (5.8–123, 15.99)	
Males, mean (±2SD)	28.82 (15.81)	0.087
Females, mean (±2SD)	25.81 (16.12)	
<1 year, mean (±2SD)	28.82 (11.54)	0.43
1–3 years, mean (±2SD)	24.22 (12.18)	
3–5 year, mean (±2SD)	27.41 (20.11)	
5–8 year, mean (±2SD)	27.87 (11.63)	
8–12 year, mean (±2SD)	29.99 (15.98)	
On vitamin D supplements, mean (±2SD)	31.56 (16.42)	0.01
Not on vitamin D supplements, mean (±2SD)	23.98 (12.14)	

We observed that children in the age groups of 1–3 years and 3–5 years had a high prevalence of VDD and the lowest 25(OH)D levels (Tables 3 and 4). Similar to our findings, Flores et al. (23) in a study involving Mexican children in the age group of 2–12 years found that the mean concentration of 25(OH)D was lower in preschool children (2–5 years) than in school-aged children (6–12 years) (78.3 nmol/L vs. 105.8 nmol/L) and 24% of preschool children had VDD compared with 10% of school-aged children.

We found that the mean levels of 25(OH)D were less in females than in males, similar to that documented by Marwaha et al. (10). This observation may be due to discrimination against the females or male preference for intra-familial distribution of food, which are well-documented facts in India (12). But, these facts may be less pronounced in children belonging to USES.

Children on vitamin D supplements had significantly higher 25(OH)D levels and a smaller number of them had VDD than those who were not on supplements. The American Academy of Pediatrics recommendations call for a daily intake of 400 IU/day of vitamin D for all infants, children, and adolescents beginning in the first few days of life (27). In India, there are no such governmental regulations mandating fortification of food products or routine supplementation with vitamin D. Therefore, the main source of vitamin D is through cutaneous synthesis in response to sun exposure (12). This finding highlights the fact that vitamin D supplementation or fortification of foods with vitamin D remains the only alternative if cutaneous synthesis is inadequate. The majority (85%) of our children were not on vitamin D supplements, similar to the findings reported by Ward et al. (29) from Canada.

Table 5 Comparison of the various variables between vitamin D deficient and non-deficient children.

Characteristics	Deficient, n=136	Non-deficient, n=202	p-Value
Age (in years), mean (±2SD)	2.77 (2.61)	3.67 (3.45)	0.01
Sex			0.003
Males, n (%)	63 (46.31)	125 (61.9)	
Female, (%)	73 (53.7)	77 (38.1)	
Weight (in kg), mean (±2SD)	12.4 (6.1)	13.39 (5.9)	0.12
Height (in cm), mean (±2SD)	91.43 (24.55)	96.8 (29.35)	0.51
Failure to thrive, n (%)	18 (13.24)	7 (3.46)	0.0007
Risk factors for vitamin D deficiency			
Family size, mean (range, ±2SD)	4.2 (3–6, 1.13)	3.6 (3–5, 1.215)	0.92
Birth order, mean (range, ±2SD)	2.07 (1–4, 0.96)	1.81 (1–3, 1.02)	0.41
Infants with exclusive breastfeeding, n (%)[a]	26 (19.12)	6 (2.97)	0.000
Adequate sun exposure, n (%)	40 (29.4)	96 (47.52)	0.008
Dark skin color, n (%)	17 (12.5)	13 (6.43)	0.54
On vitamin D supplements, n (%)	6 (4.41)	45 (22.28)	0.000
Biochemical parameters			
25(OH)D level (ng/mL), mean (±2SD)	16.7 (8.16)	37.8 (15.33)	0.000

[a]Total infants in study population were 50. Out of them, only 32 were exclusively breastfed.

In addition, VDD was associated with relatively younger age group, female sex, failure to thrive, exclusively breastfed infants, inadequate sun exposure, and children without vitamin D supplements (Table 5). These findings were similar to the observations in other studies (10, 12, 30). Although breast milk is the ideal food for infants, it typically contains about ≤25 IU/L of vitamin D (31) which is insufficient for the prevention of VDD. This fact explains our observation that the majority of our breastfed infants (26/32) had VDD.

The strengths of our study include the sample size which was large enough to assess the status of VDD in apparently healthy children attending OPD. To our knowledge, this is the first study that assessed 25(OH)D levels and the prevalence of VDD in apparently healthy children belonging to USES attending OPD for minor ailments from India. The drawbacks of this study include the study period (March–August) which only spanned the summer season, VDD being season dependent with lower 25(OH)D levels in winters (32, 33). The current study might not be representative of the vitamin D status throughout the entire year and the data may have underestimated the actual prevalence of VDD in the population. Also, we did not included serum calcium, phosphorus, alkaline phosphatase, parathyroid hormone and 1,25(OH)D levels, and radiographs for evidence of VDD, which could give more insight into VDD. The children with VDD were not followed up with either biochemical or radiological tests though they were given adequate doses of vitamin D and calcium.

Evidence from our study suggests that all children should be given vitamin D supplements even in countries where sunshine is adequate, including India. It is important for public health sector and private sector to implement actions like vitamin D supplementation or fortification of food with vitamin D to face the problem of VDD in Indian children even in those belonging to USES. Further, we must remember that sun exposure is the main natural source of vitamin D and interventions in this regard need to be encouraged.

Conclusion

The high prevalence of clinical and biochemical VDD was noted in apparently healthy children belonging to USES in north India. We suggest that vitamin D supplementation should be considered throughout the childhood.

Conflict of interest statement

Authors' conflict of interest disclosure: none.
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