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Review Article

Current status of Vitamin-D deficiency in India

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Abstract

Vitamin D Deficiency (VDD) is a major health problem in both the developed and developing countries across the globe. In India, despite of ample sunlight (required for the synthesis of vitamin D endogenously), VDD prevalence has been documented to be in range of 50-90% among all the age groups. Scientific evidence reveals that, in addition to skeletal disorders, Vitamin D is also associated with the risk of cardiovascular diseases, obesity, hypertension and diabetes mellitus etc. The factors responsible for VDD can be skin complexion, poor sunlight exposure, vegetarian food habits and lower intake of Vitamin D fortified foods. Adequate sunlight exposure and intake of foods rich in vitamin D along with fortification of foods with vitamin D can prove helpful to prevent VDD.

Keywords: Vitamin D, Obesity, Hypertension, Diabetes Mellitus, Fortification.

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1. Introduction

Vitamin D was classified as a vitamin in the early 20th century and in the second half of the 20th century as a prohormone ("conditional" vitamin) [1,2]. Vitamin D has been traditionally known as "anti-ricketic factor or sunshine vitamin". It is a unique nutrient because it can be synthesized endogenously (skin) and it functions as a hormone [3]. Vitamin D is a fat soluble vitamin and its synthesis in the body is dependent on multiple factors like latitude, atmospheric pollution, clothing, skin pigmentation and duration and time of exposure to sunlight. Vitamin D is required to maintain normal blood levels of calcium and phosphate, which in turn is needed for the normal mineralization of bone, muscle contraction, nerve conduction and general cellular function in all cells of the body. Assessment of vitamin D status of an individual is best reflected by measurement of circulating vitamin D metabolites. Only two metabolites, namely, 25-hydroxyvitamin D [25(OH) D] and 1,25-dihydroxyvitamin D [1,25(OH)2D], have received the greatest attention in biochemical estimation of

vitamin D. Of these, the need for measuring serum 1,25(OH)2D is limited. On the other hand, serum 25(OH)D provides the single best assessment of vitamin D status 25(OH)D as it has a half-life of about 3 weeks, making it the most suitable indicator of vitamin D status (4). Radioimmunoassay has been the most common method used for measuring 25(OH)D levels (5). Even though vitamin D deficiency is common worldwide, identifying a criterion for its definition remains unresolved (6). Exact cut–offs for "deficiency" and "insufficiency" remain controversial. A classification given by Lips to define vitamin D status is as follows: mild hypovitaminosis D: 10–20 ng/ml, moderate hypovitaminosis D: 5-10 ng/ml, and severe hypovitaminosis D: less than 5 ng/ml [7]. Growing body of evidence suggest that serum 25(OH)D cut-off <50 nmol/L or 20 ng/ml may be associated with greater risk of non skeletal chronic diseases (8,9).

The FAO/WHO expert Consultation [10] states that in most locations of the world between 42°N and 42°S latitude there is abundant sunshine. Exposure to sunlight is responsible for physiological production of Vitamin D endogenously in the skin from 7-dehydrocholesterol present in the subcutaneous fat. Thirty minutes of exposure of the skin over the arms and face to sunlight, without application of sunscreen, preferably between 10 am to 2 pm (as maximum ultraviolet B rays are transmitted during this time) daily is required for adequate synthesis of vitamin D. [11]. Although vitamin D has been traditionally considered important for skeletal health, recent studies have reported that vitamin D also has beneficial effects on extra skeletal tissues [1]. Several studies have suggested possible links between vitamin D and cardiovascular disease risk [12,13], diabetes [14,15], hypertension [16], and dyslipidemia [17,18]. Vitamin D Deficiency (VDD) is prevalent in India, a finding that is unexpected in a tropical country with abundant sunshine [19]. India is located between 8.4°N and 37.6°N latitude with the majority of its population living in regions experiencing optimum sunlight throughout the year. Despite its sunny environment, hypovitaminosis D is common in India. According to various studies published earlier there is widespread prevalence of varying degrees (50- 90%) of Vitamin D Deficiency with low dietary calcium intake in Indian population [20]. In the present article the status of VDD in Indian population in various age groups on the basis of the evidence available from the studies conducted earlier would be discussed.

Prevalence of Vitamin D Deficiency In India

Vitamin D Deficiency is on a rise as a major public health problem in India. Majority of the population in India resides in areas receiving ample sunlight throughout the year; still vitamin D deficiency is a problem of growing concern [21,22]. Skin complexion, poor sun exposure, vegetarian food habits and lower intake of vitamin D fortified foods could be attributed to the high prevalence of VDD in India [23]. However till the early 1990s, VDD was considered to be rare in India. Such belief was based on studies measuring serum calcium and alkaline phosphatase in Indian population [24]. Till the year 2000, there was no systematic study which directly assessed body vitamin D status of Asian Indians residing in India [23]. A study conducted amongst apparently healthy subjects to measure their serum 25(OH)D level using sensitive and specific assay documented that significant hypovitaminosis D was present in up to 90 per cent of the subjects [23]. Subsequently, studies conducted in different parts of the country have documented a widespread prevalence of VDD in all age groups including toddlers, school children, pregnant women and their neonates and adult

males and females residing in rural or urban areas [19, 25-28].

Vitamin D Deficiency amongst Newborns and Infants:

Vitamin D deficiency occurs in children when the mother is vitamin D deficient (29). A high prevalence of hypovitaminosis D (25(OH)D levels <10 ng/mL) was recordedamongst study infants with hypocalcemic seizures (90%), and control infants (41.7%) in a hospital based study. Mean serum 25(OH) D values of study infants (6.54 ± 5.32 ng/ml) were significantly lower than those of healthy breastfed infants (9.06 ± 4.78 ng/ml) . [30]. In a study conducted amongst infants , mean 25(OH) D levels were found to be 11.55 ± 7.17 ng⁄ml at 10 weeks and 16.96 ± 13.33 ng⁄ml at 6 months and by 6 months, 16.49% infants developed rickets [31]. A high prevalence of vitamin D deficiency (86%) in healthy term born infants at the age of 3 months was also documented. [32].

Vitamin D Deficiency amongst Children under 5 years of age:

VDD amongst young children can affect their skeletal growth and development. A community based study in three different regions of Delhi and NCR documented the prevalence of VDD (levels below 14ng/ml) amongst children as 82.9 % and 82% in two regions and 2% in third region. [33]. A study conducted amongst children aged 2-60 months reported the prevalence of VDD as 61.4% [34].

Vitamin D Deficiency amongst Children 6-18 years of age:

A study conducted amongst school girls, reported the prevalence of Vitamin D deficiency as 70% and mean serum 25(OH) D level as less than 12ng/ml [35]. A study conducted on school girls aged 6-18 years belonging to both lower and upper socio economic status, documented the prevalence of biochemical hypovitaminosis D (serum 25-hydroxyvitamin D,50 nmol/l) as 90·8% of the population; 89·6% LSES (5·2% severe, 25·4% moderate, 59% mild) and 91·9% USES (2·8% severe, 36·5% moderate, 52·6% mild) but the difference was non-significant. The definition of hypovitaminosis D in this study was based on two criteria: firstly, serum concentration of 25(OH)D below 20ng/ml and, secondly, as recommended by Lips [7], as mild :10–20 ng/ml, moderate: 5-10 ng/ml, and severe hypovitaminosis D :less than 5 ng/ml [36]. The prevalence of VDD amongst adolescent girls was found to be 88.6% in another study [37]. A study conducted on 6-17 years schoolgirls from both lower and upper socio economic status reported the prevalence of VDD as 93.7%. However, the prevalence of VDD in lower socioeconomic strata was higher (97.3%) as compared to upper socioeconomic strata (90.9%) [38]. A study conducted on obese Indian children and adolescents in the age group of 6–17 years concluded that all study subjects were vitamin D deficient (mean level 8.5 ± 4.2 ng/mL , median = 6.9 ng/mL). Severe vitamin D deficiency (<5 ng/mL) was seen in 17.7% while 49.3% subjects had serum 25(OH)D levels between 5–<10 ng/ml. Serum 25(OH)D equal to or more than 10 but less than 20 ng/ml was present in 33.8% of subjects. No significant difference was seen in serum 25(OH) D concentrations between boys and girls [39]. Another study conducted amongst adolescents reported the prevalence of VDD as 94.8% [40]. In a study conducted on school children 10-14 years of age, hypovitaminosis D was observed in 92.3 % subjects (using cut off value as serum 25(OH)D < 20 ng/ml) with mean serum 25(OH)D level of 11.69 ± 5.36 ng/ml [41].

Vitamin D Deficiency amongst Pregnant Mothers and Lactating Mothers:

Studies on pregnant mothers from southern and northern states of India have reported high vitamin D deficiency levels with values ranging from 67% to 96% [1,42-45]. A study conducted amongst pregnant mothers in India, reported that 74% of the mothers had vitamin D deficiency (25OHD < 30ng/ml) [37]. Vitamin D status of pregnant mothers aged 20-40 years was assessed and it was found that 20% of

the mothers had vitamin D deficiency and 24% had vitamin D insufficiency [46]. A study was conducted to determine the vitamin D status of lactating mothers and it was documented that the mean serum 25(OH) D values in lactating mothers was 27.2 ± 14.6 nmol/1 (10.9 ± 5.8 ng/ml), and serum 25(OH) D levels <25 nmol/1 (10 ng/ml) were found in 47.8% of the mothers [47].

Vitamin D Deficiency amongst Adults aged 18-50 years:

Various studies have revealed that a large proportion of adults are suffering with low serum Vitamin D level. In a study conducted amongst adult male and females residing in both rural and urban areas, the prevalence of VDD estimated in urban population was 62% in male subjects and 75% in female subjects, while the prevalence of Vitamin D deficiency was slightly lower in rural area as 44% in males and 70% in females. This indicates that the prevalence of VDD was more in females as compared to male subjects in both rural and urban areas [28]. A study conducted amongst adults aged 18-40 years of age, documented that 83% of the subjects studied had vitamin D deficiency—25%, 33%, and 25% had mild, moderate, and severe deficiency, respectively [48]. Another study carried out on school and college students aged 16-60 year demonstrated that the mean serum 25(OH)D value of study subjects was 17·5 nmol/l; 87% (95% CI 84·5, 89·6) of the subjects had 25(OH)D ≤ 25 nmol/l confirming the earlier reports of wide prevalence of hypovitaminosis D in apparently healthy Asian Indians [49]. In a study, a high prevalence of VDD as 70% (male 64%, females 76%) was found amongst the subjects in the age group of 25-35 years. The cut off used to define VDD was taken 25 (OH) D levels as 20ng/ml [50]. A study conducted amongst female subjects of nursing college and other postgraduate courses with the mean age 21.7 ± 4.4 years revealed that the mean serum 25-hydroxy- vitamin D (25(OH)D) of the subjects was 9.3 ± 3.37 ng/ml at baseline, and none of them had sufficient vitamin D levels (≥32ng/ml). Only 19.6% participants had serum 25(OH) D values of 12 ng/ml or higher, and 39.9% had serum 25(OH)D values of 10 ng/ml or higher [51]. In a study conducted amongst adults , the biochemical analysis revealed that 83.7% subjects had vitamin D deficiency (25(OH)D <20 ng/ml), 8.7% subjects had vitamin D insufficiency (25(OH)D 20-30 ng/ml) and 7.6% subjects had normal vitamin D status defined as 25(OH)D >30 ng/ml [52].

Table: Prevalence of Vitamin D Deficiency in India

Vitamin D Deficiency amongst Elderly people aged 50 years and above:

Vitamin D deficiency is associated with muscle weakness (53) and is common in elderly people (54). Older people are prone to develop VDD because of various risk factors like decreased dietary intake, diminished sunlight exposure, reduced skin thickness, impaired intestinal absorption and impaired hydroxylation in liver and kidneys (55-57). A study carried out amongst elderly with the mean age of 58.0 ± 9.5 years showed a high prevalence of VDD amongst them. It was also reported that vitamin D deficiency [VDD, serum 25(OH) D levels < 20 ng/ml) was present in 91.2% and Vitamin D insufficiency [VDI, serum 25(OH)D levels 20-<30 ng/ml] in 6.8% subjects [58]. A study conducted amongst postmenopausal women to evaluate their dietary calcium and vitamin D status documented that, 18% subjects had normal 25(OH)D levels (> 20 ng/ml), 52% subjects had 25(OH)D insufficiency (10-20 ng/ml), and 30% subjects had 25(OH)D deficiency (< 10 ng/ml) [26].

Conclusion

Vitamin D is synthesized endogenously in the presence of sunlight. India is a country with abundant sunshine but still a high prevalence of VDD has been documented amongst all the age groups in the range of 50-90%.

Sr. No.	Author	Year	Sample	Age	CB/ HB	Prevalence (%) of VDD (Serum 25 (OH)D<20ng/ml)	Cut off levels considered to Define VDD	Ref
1.	Sachan et al.	2005	Pregnant Women	ING	CB	84	ING	19
2.	Harinarayan et al.	2005	Postmenopausal women	ING	CB	30	<10ng/mL	26
3.	Harinarayan et al.	2007	Adults: Urban Rural	ING	CB	(U) Males: 62 (U) Females: 75 (R) Males: 44 (R) Females: 70	ING	28
4.	Mehrotra et al.	2010	Infants	ING	HB	90	<10 ng/mL	30
5.	Agarwal et al.	2010	Infants	10 weeks-6 months	HB	16.4	ING	31
6.	Jain et al.	2011	Infants	3 months	CB	86	ING	32
7.	Tiwari and Puliyel	2004	Children	ING	CB	82	<14ng/mL	33
8.	Wayse et al.	2004	Children	2-60 months	HB	61.4	ING	34
9.	Khadilkar et al.	2007	School Girls	ING	CB	70	<12ng/mL	35
10.	Puri et al.	2008	School Girls	6-18 years	CB	90.8	<20ng/mL	36
11.	Sahu et al.	2009	Pregnant Women	ING	CB	74	<20ng/mL	37
12.	Marwaha et al.	2010	School Girls	6-17 years	CB	93.7	ING	38
13.	Khadgawat et al.	2012	Children and adolescents	6-17 years	CB	48.3 33.8	5–<10 ng/mL >10 to <20 ng/mL	39
14.	Garg et al.	2013	Adolescents	ING	CB	94.8	<30ng/mL	40
15.	Khadgawat et al.	2013	School Children	10-14 years	CB	92.3	<20ng/mL	41
16.	Dasgupta et al.	2012	Pregnant Women	20-40 years	HB	42	<20ng/mL	46
17.	Seth et al.	2009	Lactating Mothers	ING	CB	47.8	<10ng/mL	47
18.	Zargar et al.	2007	Adults	18-40 years	CB	83	<50nmol/L	48
19.	Goswami et al.	2009	College students	16-60 years	CB	87	≤25nmol/L	49
20.	Shivane et al.	2011	Adults	25-35 years	CB	70	<20ng/mL	50
21.	Goswami et al.	2012	Females	21.7±4.4 years	CB	80.4	<12ng/mL	51
22.	Agarwal et al.	2013	Adults	ING	CB	83.7	<20ng/mL	52
23.	Marwaha et al.	2011	Elderly	58.0±9.5 years	CB	91.2	<20ng/mL	58

ING: Information Not Given; HB: Hospital Based; CB: Community Based; U: Urban; R: Rural

VDD is responsible for skeletal disorders but recent evidence suggests that VDD can also lead to other health issues like cardiovascular diseases, Diabetes Mellitus, Obesity, Hypertension etc. The prevalence of VDD was found to be higher amongst females than in males. The factors responsible for VDD could be skin complexion, inadequate exposure to sunlight and vegetarian

food habits. However, looking at the spectrum and high prevalence of VDD in India, there is a need for further research to identify the major factors responsible for VDD, despite of abundant sunshine available in the country. As VDD affects all age groups, therefore, strategies such as increasing awareness among masses about adequate exposure to sunlight, rich dietary sources of vitamin D and fortification of foods with Vitamin D which are consumed by majority of Indian population irrespective of the socio-economic status can be adopted and implemented for prevention and control of VDD throughout the nation.

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