Vitamin D Deficiency in India: An Overview

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ABSTRACT: There is an increasing trend of vitamin D deficiency worldwide. In India, vitamin D deficiency is widespread and the frequency is found to be ranging from 34.5% to 99%. The present review aims to explore the various factors that affect vitamin D deficiency in the present scenario and provides an overview of the prevalence of vitamin D deficiency. This paper reveals several factors like dietary patterns, cultural and social lifestyles, cooking practices, poverty, and lack of awareness are contributing to low vitamin D status. Several health complications such as rickets, cardiovascular disorders, type 2 diabetes, various cancers, malabsorption, and autoimmune disorders have been associated with vitamin D deficiency. Therefore, it's high time for action to address the burden of vitamin D deficiency.

INTRODUCTION

The prevalence of vitamin D deficiency is reported globally, both in sunlight deficient and sunlight adequate countries. This is the most underdiagnosed as well as an undertreated nutritional deficiency (Bhardwaj and Singh, 2021; Natasja and Lips, 2011; Van der Meer *et al*., 2011; Mithal *et al*., 2009). As per the US Endocrine Society, serum 25-hydroxyvitamin D [25(OH) D] <20 ng/ml is classified as Vitamin D deficiency, and 25(OH) D levelsas 21-29 ng/ml is considered as Vitamin D insufficiency (Holick *et al*., 2011). Since the 2000s, attention to vitamin D has grown considerably among researchers leading to exponential rises in study outputs such as scientific testing of vitamin D status and accessibility of vitamin D supplements and fortified diets (Cashman *et al*., 2016). Despite these efforts, vitamin D deficiency remains a significant worldwide public health burden (Amrein *et al*., 2020; Palacios and Gonzalez, 2014). Tropical countries such as India, where the plentiful overhead sun is seen throughout the year, also reported a high frequency of vitamin D insufficiency (Sachan *et al*., 2005; Gupta, 2014). Many studies revealed a low level of Vitamin D in India regardless of their age, gender, culture, and geography (Bhardwaj and Singh, 2021).

Vitamin D is fat-soluble with an antirachitic activity (Sharman, 1975). Calciferols are a set of lipid-soluble compounds having a four-ring cholesterol backbone that denote both vitamin D3 (cholecalciferol) as well as vitamin D_2 (ergocalciferol) (Houghton and Vieth, 2006), which together known as vitamin D. Vitamin D can be produced endogenously. Due to sun exposure, around 90% of the necessary vitamin D is synthesized in the skin

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(Holick, 2003). It is required to upkeep usual blood levels, phosphate, and calcium, which are essential for general mineralization of bones, muscles contraction, nerve transmission, and common cell functions of the body. It is also vital for immunity, inflammation, cell propagation, and variation (Holick, 2003; Kumar *et al*., 2014). The active Vitamin D triggers the calcium absorption in the duodenum and raises calcium inflow in distal tubules of the kidney through nuclear Vitamin D receptor (VDR); later is precisely controlled by parathormone level (Holick, 2005).

The main source of Vitamin D is the endogenous synthesis in the skin on exposure to sunlight, known as ultraviolet B (UV-B) radiation of wavelength 290 to 320 nanometers. The major food sources are fish, fortified foodstuff, as well as supplements. Grains and vegetables are poor sources. Also, vitamin D production in the skin on exposure to UV-B rays is affected by latitude, solar zenith angle, pollution of the atmosphere, the ozone layer, as well as melanin pigments (Holick, 2007; Aparna *et al*., 2018).

PRESENT SCENARIO OF VITAMIN D DEFICIENCY

In India, the community-based researches on apparently healthy individuals described a considerably high frequency of vitamin D deficiency. Mostly, these studies explore both the genders and all age groups. Suryanarayan *et al*. (2018) studied 298 individuals of both sex and age above 59 years in urban areas of Hyderabad, revealed that the frequency of vitamin D deficit among females and males are 57.2% and 56.3%, respectively. Similarly, a study among 626 Children (6-18 years) from Shimla, Himachal Pradesh, illustrates that the prevalence of vitamin D deficit is as high as 93% (Kapil *et al*., 2017). In Cuttack district of Odisha, individuals (n=3056) of the age-group 30-65 years were studied and reported vitamin D deficiency of 84.9% (Rattan *et al*., 2016). In another study among 444 individuals of both sex and no specific age group in Ahmedabad, Gujurat, reported a high prevalence (93.3%) of vitamin D deficiency (Gunjaliya *et al*., 2015). Several studies have been stated from Delhi, which reported this prevalence ranges from 90.8% to 94% (Rao Vupputuri *et al*., 2006; Puri *et al*., 2008; Marwaha *et al*., 2011a).

Hospital-based research reported a prevalence of vitamin D deficiency that varies from around 37% to 99%. Sofi *et al*. (2017) carried out a study on reproductive age, non-pregnant and non-lactating women (n=224) in Delhi and revealed that 88% of the samples were vitamin D deficient. A similar study on OPD (n=640) patients from Mahada, Maharastra, revealed that 65.4% of the patients were deficient in vitamin D (Bawaskar *et al*., 2017). Some recent studies were done in Delhi among Burka-clad pregnant women (n=200) of the age-group of 18-40 years, primigravida with single life pregnancy (n=418), adolescents (n=1829), pregnant women (n=521), lactating mothers (n=342) and extended breast feeding infants (n=342), and found the prevalence of 37.5% (Ajmani *et al*., 2016), 93.5% (Sharma *et al*., 2016), 96.9% (Garg *et al*.,2014), 96.3% (Marwaha *et al*.,2011b), 99.7% (Marwaha *et al*., 2011b) and 98.8% (Marwaha *et al*., 2011b) respectively. Pal *et al*. (2016) demonstrated a survey in Agra among 1132 patients attending orthopedics OPD and emergency department aged between 21-61 years and explored that 61.2% of the samples were of vitamin D deficiency (Pal *et al*., 2016). A recent study from Gurgaon among 26346 subjects found that 93% of them were vitamin D deficient (Shukla *et al*., 2016). A survey of Bengaluru mothers in labor (n=106) found vitamin D deficiency as 70.7% (Kumar *et al*., 2015). Basu *et al*. (2015), carried out research in Kolkata among 40 doctors and concluded that 92.5% of the subjects had vitamin D deficiency (Basu *et al*., 2015).

Significance of Vitamin D and Complications due to Vitamin D Deficiency

Nutrition and suitable physical activities are essential throughout childhood and adolescence for normal bone-tissue development to attain bone growth potential. Sufficient consumption of calcium and vitamin D benefit in maintaining bone mineral content at the time of rapid development period which elevates maximum bone mass that can prevent osteoporosis at a later age (Holick *et al*., 2011).

Also, vitamin D has been progressively accepted as vital for brain well-being, aside from its significance in endocrine as well as bone health. Vitamin D acts as an effective distinguishing element for brain cells by growing neuronal processes, controlling neurotrophic elements and responsive oxygen species, along with

down-regulating calcium channels. (Eyles *et al*., 2009). Various studies represent the relationship among vitamin D deficiency and mental health ailments among adults (McGrath, 1999). Some systematic reviews and meta-analysis studies on adults revealed that a lower status of vitamin D compared to controls was reported with anxiety (Anglin *et al*., 2013) and "schizophrenia" (Yüksel *et al*., 2014). According to a similar study, there found lowest levels of vitamin D among schizophrenia patients, and autism suggested that in the course of the growing period, low vitamin D affects mental disorders and affects the psychological well-being of adulthood (Humble *et al*., 2010).

As per the report of an Indian private pediatric hospital, among the healthy children of 3 months to12 years old, 40.2% and 25.44% of the subjects had vitamin D insufficiency and deficiency, respectively (Angurana *et al*., 2014). A study assessing vitamin D insufficiency in children having mental disorders found that 64% and 21% of the samples had insufficiency and deficiency, respectively (Zhang *et al*., 2012). A systematic review recommended that a lower level of vitamin D in children may be a hazard element for emerging "autistic spectrum disorder" (ASD) and "neurodevelopmental disorder" (Wang *et al*., 2016). Similar research revealed that almost 72% of the adolescent-onset psychological disorder had low vitamin D levels (mean vitamin D=20.4 ng/ml) (Gracious *et al*., 2012)

As per the report of the "International Osteoporosis Foundation," 91% of healthy school girls and 84% of pregnant women had hypo-vitamin D levels in northern parts of India. A study by Dasgupta (2012), among Assamese pregnant women during their first trimester found 42% cases of vitamin deficient and 14% cases of vitamin D insufficient. Nutrition and suitable physical activities are important during childhood and adolescence for normal bone development to attain bone growth potential. Also, recent data on adolescents suggest that a low level of vitamin D acts as a contributing cause for developing cardiovascular disease, hypertension, diabetes mellitus, certain cancer and autoimmune diseases, irregular menstrual cycles, and polycystic ovarian syndrome. This could be attributed to the style of clothing, duration of exposure to sunlight, skin type, pollution, increasing indoor lifestyle, and genetic mutations in vitamin D synthesis and absorption. Vitamin D is a fat-soluble vitamin formed endogenously in the skin from 7-dehydrocholesterol, which is present in the subcutaneous fat (Londhey, 2011). Vitamin D adequacy in adolescence helps to decrease the risk of osteoporosis in future life. Hence, screening of vitamin D is recommended among children and adolescence.

FACTORS AFFECTING VITAMIN D DEFICIENCY

Dietary Pattern

Dietary sources have a light vitamin D content (Nimri, 2018). The foodstuffs which are rich in vitamin D are mostly from animal sources. The populations of India are mostly vegetarians. Hence, milk is their primary dietary source for vitamin D. Vitamin D is fortified with provided milk, and the unfortified milk has very low vitamin D content (2 IU/100 mL). In India, the widespread dilution, as well as adulteration of milk and milk products, are another matter of concern. Various studies described insufficient and abundant calcium intake that leads to vitamin D problems (Goswami *et al*., 2000; Tandon *et al*., 2003). Also, ICMR reported that calcium consumption in India is lesser than that of western countries.

Poverty and Lack of Awareness

India constitutes a huge percentage of people having poor socioeconomic conditions. The poor and marginalized groups predominantly suffer from overall poor nutrition. Most of the individuals in India could not afford Vitamin D-rich foodstuffs. On the other hand, most individuals are also not taking vitamin D supplements because of unawareness. Moreover, the price of these vitamin D supplements is basically unaffordable to most people. Fortification of vitamin D in primary diets may help to eradicate vitamin D deficiency in India (Gupta, 2014).

Cultural and Social Life

Socio-cultural practice often commands lifestyle patterns like clothing that might minimize sun exposure and vegetarianism, which restricts vitamin-D content foods. A result of which this creates vitamin D insufficiency. Maximum clothing absorbs UV-B radiation from the sun (Matsuoka *et al*., 1992). Clothes

materials made up of black or white cotton, polyester, or wool prevent elevating in flowing concentrations of vitamin D (Matsuoka *et al.*, 1992). Some communities in which clothes are worn over maximum sun-exposed areas have a higher threat of vitamin D insufficiency (rickets) among children, as well as "osteomalacia" and "osteoporosis" among adults (Sedrani *et al*., 1990).Nowadays, there is great concern about the usage of topical sunscreen creams having a sun protection factor (SPF) of 15 before going outdoor (Holick, 1995). To avoid mild sunburns, people generally apply sunscreen having an SPF of 8, which causes vitamin D deficiency (Matsuoka *et al*., 1987). Also, chronic sunscreen that aged individuals use can reason for vitamin D deficiency (Matsuoka *et al*., 1988).

Indoor Design

Most of the glass, as well as plastics, absorb solar UV-B photons. This results, the sunlight is passing through these glasses or plastics that cannot produce vitamin D in the skin. So, a substitute should be considered during indoor designing to deliver a few UV-B rays (Holick, 1995).

Traditional Cooking Practices

Indians commonly follow the traditional cooking practices, nevertheless of their settlement to anywhere in the world. In a tropical environment, unpreserved foodstuffs spoil rapidly. Remarkably, in India, there is no noticeable governmental guideline on cleanliness as well as a microbial quality check of fresh foodstuffs, which distributes from the producer to the end consumer. The intake of raw foods like vegetables, milk, etc., is usually measured as unwise. As stated earlier, degradation of vitamin D occurs at a temperature beyond 200°C. Cooking gas flame extents above 1900°C and coal stove heat ranges from 300°C to 700°C. However, water boils at a temperature of 100°C. Baking is also generally done at a temperature above 175 °C; therefore, the temperature could not reach that point to spoil the stability of vitamin D (Natri *et al*., 2006).

Sports Culture Lacking

Sports culture in India is declining, resulting in children and adults being less exposed to sunlight. This causes vitamin D deficiency. Hence the government of India has taken the initiative at the school level. Sufficient sun exposure during the school period is a worthy and practically practicable step to introduce a good habit in children and ensure bodily vitamin D making in a secure and low-priced approach. "*Project Dhoop*," an inventiveness reinforced by "The Food Safety and Standard Authority of India," is a welcome step in this dimension (Dharmshaktu, 2018). The organization started the program currently in link with the Central Board of School Education in March 2018 and advised all schools to support the program actively. Boosting schools to alter morning assemblies to midday between 11 am to 1 pm to get the optimum advantage of exposure to sun and maximum vitamin D production (Moan *et al*., 2014). However, this practice does not seem to be observed in most schools (Bindhani, 2021).

Advent of Technology

Technologies also play a vital role in making children and adults busy with more indoor games. Nowadays, irrespective of age and gender, they are busy with their cell phones or computers rather than go for an outside walk during their free time. That is directly linked to less exposure to sunlight and leads to vitamin D deficiency.

Genetic Factors

Though exposure to sunrays and foods are the key sources of vitamin D, according to various studies, genetic influences are also vital for the difference in vitamin D concentration in plasma (Lu *et al*., 2012). Major genes for vitamin D include "group-specific component" (GC), "Cytochrome P450, family 2, subfamily R, polypeptide 1 (CYP2R1)", and "7-dehydrocholesterol reductase/nicotinamide-adenine dinucleotide synthetase 1" (DHCR7/NADSYN1) (Zhang, 2012). *Kurylowicz et al. (2006)* studied "vitamin binding protein gene," also called as GC gene, which encodes the vitamin D-binding protein (DBP) that binds to vitamin D metabolites and carries them to the target cells and establish a link between rs4588 and vitamin D deficiency among patients in Poland (n=110) with "Graves' disease" (Kurylowicz *et al*. 2006). Further, a similar study on CYP2R1 gene polymorphisms revealed a significant association

between rs10741657 and 25(OH)D levels among individuals with type-I diabetes (Bailey *et al*., 2007). Wang *et al*., in a genome-wide association study (GWAS), discovered multiple single nucleotide polymorphisms (SNPs), rs12785878 in the DHCR7 gene and rs2282679 in the CYP2R1 gene, which were significantly associated with 25(OH)D levels in subjects (n=30000) of European descent from 15 cohorts (Wang *et al*., 2010).

CONCLUSION

The prevalence of vitamin D deficiency is reported high in many regions of the globe. There are many factors like dietary patterns, cultural and social lifestyles, traditional cooking practices, poverty, and lack of awareness are responsible for this. Multiple consequences of vitamin D deficiency have a considerable burden on the development of the country. Among Indians, the necessity for enhancement in vitamin D status is vital and urgent. The government of India must take essential measures in this dimension. National level population-based programs need to be implemented to elevate awareness, to provide affordable vitamin D supplements as well as to provide vitamin D fortified diets. Research in this area needs to be continued to provide a broad image of the continuing vitamin D problems intended at elevating the vitamin D status in India.

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