PREVALENCE OF VITAMIN D DEFICIENCY IN SOUTH ASIA

Syed Hassaan Masood¹, M. Perwaiz Iqbal²

ABSTRACT
Vitamin D, also described as ‘the Sun Vitamin’ is a steroid with hormone-like activity. It regulates the functions of over 200 genes and is essential for growth and development of the body. Vitamin D deficiency is quite prevalent throughout the world, but it appears to be much worse in the countries of sunny South Asia, especially among children, women and elderly. Poor diet, cultural practices of the region and poverty are some of the important reasons for vitamin D deficiency. Hypovitaminosis D (vitamin D deficiency) is considered responsible for rickets, birth defects, osteoporosis, osteoarthritis, osteomalacia, chronic pain and muscle pain. Recent research has associated vitamin D deficiency as a contributing factor in diseases, such as heart disease, hypertension, neurological disorders, autoimmune disease, depression and cancer. This paper reviews the problem of vitamin D deficiency with special reference to South Asia and recommends that education regarding adequate exposure to sunlight, proper diet and fortification of selected foodstuff with vitamin D may be helpful in reducing vitamin D deficiency in this part of the world.

KEY WORDS: Vitamin D deficiency, South Asia.
serum levels of 25(OH) D are greater than 150ng/ml.

In many of the Asian countries, vitamin D deficiency has been found to be rampant. Rickets, a consequence of vitamin D deficiency, is still widespread in regions, such as northern China where 42% of infants were found to suffer from this disease during the winter/spring period.\textsuperscript{5} Sunlight exposure promotes vitamin D synthesis and given the number of days the sun shines in South Asia, one would expect the region to be free from vitamin D deficiency. Unfortunately, there is high prevalence of vitamin D deficiency due to lack of proper diet, poor calcium intake, social customs and remaining confined to the four walls of primitive housing that deprives the elderly, children and female population of the benefit of the sunshine.

Sachan et al.,\textsuperscript{6} investigated hypovitaminosis D in Lucknow, India and found that eighty-four percent of pregnant women had 25(OH) D values below 22 ng/ml (the cut-off point in their research). Siddiqui and Rai\textsuperscript{7} found that in Northern Pakistan where sunlight was available in abundance, rickets was a common problem in infants and children. They attributed the hypovitaminosis D to malnutrition, lack of awareness and antenatal factors.

Atiq et al\textsuperscript{8} investigated hypovitaminosis D in healthy breast-fed children and nursing mothers at a major teaching hospital in Karachi, Pakistan, and found that 55% of infants and 45% of mothers had very low serum 25(OH)D levels (<25 nmol/l or 10 ng/ml). This paper highlights the contribution of vitamin D to human growth, impact of vitamin D deficiency on human health and reviews the research work done on vitamin D deficiency in South Asian populations. Suggestions have also been made to overcome this problem which is acquiring epidemic proportions in this part of the world.

**Biological functions of vitamin D:** Before describing the prevalence of vitamin D deficiency, it is appropriate to understand the functional importance of this vitamin in our body. Vitamin D is actually a steroid that has a hormone-like function. It facilitates calcium and phosphorus absorption through the small intestine. Vitamin D from dietary sources and from sun exposure of skin is stored in fat cells and is brought into circulatory system by vitamin D binding protein. Vitamin D3 (cholecalciferol) is biologically inactive and must be metabolized to 25-(OH) D3 in the liver and then to its biologically active form 1,25-dihydroxycholecalciferol [1,25-di (OH)D3] in kidney.\textsuperscript{9,10} In this form, vitamin D has been found to regulate functioning of over 200 genes, including the genes involved in cellular proliferation, apoptosis, differentiation and angiogenesis.\textsuperscript{1,11,12} However, 25(OH)D3 [25(OH)D] is the predominant form of vitamin D in plasma and the major storage form as well.\textsuperscript{10}

**Vitamin D deficiency in South Asian population:** The most important and freely available source of vitamin D is exposure to sunlight. Skin contains 7-dehydrocholesterol which on exposure to UV light in sunshine gets converted to cholecaliferol (Vitamin D3).\textsuperscript{10} The dietary intake is also an important source of vitamin D but poverty, poor choice of diet and excessive cooking do not make this source as abundantly available as the sunlight.

South Asian population seems to be especially prone to vitamin D deficiency and its consequences. Table-I shows the serum/plasma levels of 25(OH)D in different South Asian populations. It is evident that as much as 69%-82% of the South Asian populations in India had 25(OH)D levels in plasma less than the minimum acceptable levels of 20 ng/ml\textsuperscript{13-15} This deficiency/insufficiency is not confined to the South Asians living in India and Pakistan,\textsuperscript{8,13-15} but even the immigrants of South Asian origin in UK, Denmark and Norway have been found to be having very low serum/plasma levels of 25(OH)D.\textsuperscript{16-21} This indicates that poverty alone can not be the major reason for hypovitaminosis D in South Asians. Therefore, other causes, such as use of unbalanced diet, excessive cooking of food and limited exposure to the sunshine must be taken into account.
Powell and Greenberg\textsuperscript{22} have pointed out some of the secondary causes. These include: decreased synthesis from skin due to dark skin pigmentation or excessive clothing, gastrointestinal problems leading to malabsorption, impaired hepatic 25 hydroxylation of vitamin D3 (due to anticonvulsant drugs, theophylline, isoniazid or severe liver disease), impaired

<table>
<thead>
<tr>
<th>Area/Country/Population</th>
<th>Study Population</th>
<th>Age Gender</th>
<th>Serum 25(OH)D Level Variations</th>
<th>Study Group &amp; Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>South India</td>
<td>Postmenopausal women</td>
<td>59 ± 8</td>
<td>-</td>
<td>164</td>
</tr>
<tr>
<td>Lucknow, India</td>
<td>Healthy hospital staff</td>
<td>Working age adults</td>
<td>92</td>
<td>-</td>
</tr>
<tr>
<td>South India</td>
<td>Rural &amp; urban South Indian population of Tirpurti</td>
<td>Working age adults</td>
<td>407</td>
<td>-</td>
</tr>
<tr>
<td>South Asian immigrants in Manchester, United Kingdom</td>
<td>South Asian women</td>
<td>18-36 year</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pakistani immigrant men in Denmark</td>
<td>Pakistani men</td>
<td>Mean age: 38.3 years (17.9-63.5 years)</td>
<td>-</td>
<td>Mean 25(OH)D level, 8.3 ng/ml.</td>
</tr>
<tr>
<td>Pakistani immigrant women in Denmark</td>
<td>Pakistani Women</td>
<td>Mean age: 36.2 years (17.9-63.5 years)</td>
<td>-</td>
<td>Mean 25(OH)D level, 4.8 ng/ml.</td>
</tr>
<tr>
<td>Pakistani immigrant girls in Denmark</td>
<td>Pakistani girls</td>
<td>Mean age: 12.2 years (10.1-14.7 years)</td>
<td>-</td>
<td>Mean 25(OH)D level, 4 ng/ml.</td>
</tr>
<tr>
<td>Pakistan</td>
<td>Infants on breast milk</td>
<td>&lt; 6 months</td>
<td>65</td>
<td>-</td>
</tr>
<tr>
<td>British Hindu Asians</td>
<td>Punjabi and Gujarati adults</td>
<td>Healthy adults (25-75 years)</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Oslo, Norway immigrants</td>
<td>Pakistani</td>
<td>31-60 years</td>
<td>94</td>
<td>97</td>
</tr>
<tr>
<td>Oslo, Norway immigrants</td>
<td>Pakistani</td>
<td>Premenopausal women</td>
<td>-</td>
<td>Mean level of 25(OH)D being 9ng/ml (6-11 ng/ml)</td>
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<tr>
<td>Oslo, Norway immigrants</td>
<td>Pakistani</td>
<td>Adults</td>
<td>-</td>
<td>117</td>
</tr>
</tbody>
</table>

* Vitamin D insufficiency and deficiency ranges refer to those reported in these papers.
renal hydroxylation of 25-hydroxy vitamin D3 due to chronic renal failure or hypoparathyroidism. Major causes of vitamin D deficiency, which could be specific to South Asian populations, must be highlighted.

Causes of vitamin D deficiency in South Asians:

Social and religious customs: The women folks largely stay at home which is almost closed to sunlight. The Muslim women of the region wear clothes which apart from face and hands cover all other parts of their bodies. Even if they go out, opportunity to expose their bodies in sunlight is not available in the all encompassing “Burqa” (a head to toe covering which only has small openings for the eyes). Infants dependent on their mothers also stay indoors and receive little or no exposure to sunlight. The old and weak also have no exposure to sunlight as they spend almost all of their time inside the tiny huts or houses. The middle class urban population is now increasingly living in densely populated apartment blocks with very little natural light.

Poverty and illiteracy: Poverty is one of the major reasons for most of the ills of the society including poor health. The governments’ claims of only a third of the population being below the poverty line in this region are doubtful. Even those who actually live above this arbitrary line cannot afford to eat a proper diet due to the high cost of foods rich in vitamin D. A vast majority of people are illiterate and are not aware of the importance of balanced diet. Moreover, the dietary habits are also to blame as food is often overcooked destroying most of the vitamins and micronutrients in it.

Skin pigmentation of South Asian population: The color of skin of South Asian population varies from light brown to almost dark. Dark pigmentation has been found to decrease skin synthesis of vitamin D because UV light cannot reach the appropriate layer of the skin. Compared to the Caucasian population, healthy African Americans have also been found more likely to be vitamin D deficient regardless of age.

Addictive Habits: A recent study on South Asian communities in UK by Ogunkolade et al has shown that chewing betel nut (Areca catechu), an addictive habit common among South Asians, contributes to hypovitaminosis D by modulating the enzymes which regulate circulating levels of 1,25di(OH)D.

Impact of vitamin D deficiency on South Asian population

Vitamin D deficiency and bone mineral density: Vitamin D deficiency is associated with secondary hyperparathyroidism with consequent ill effects on bone mineral density. Marwah et al studied vitamin D deficiency and its effects on bone mineral density in Indian adolescents of 10-18 years of age and concluded that metabolic bone disorders secondary to vitamin D deficiency continue to be prevalent in the Indian subcontinent and are more prevalent in lower socio economic population.

Vitamin D deficiency and osteoporosis: Postmenopausal women are known to be prone to vitamin D deficiency causing an early onset of osteoporosis. The tendency to the deficiency is universal as 28.4% post-menopausal women have been found to be deficient in vitamin D [25(OH)D, < 20 ng/ml] in most part of the world. However, this percentage increased to 30% in a population from Southern India. Osteomalacia and rickets due to vitamin D deficiency: While rickets is a consequence of vitamin D deficiency in infants and children, older adults can suffer from osteomalacia due a loss of bone density causing pain and soft bones. The problem of rickets among infants and children is widespread in cooler northern areas of South Asia. Rickets remains one of the major causes of infant mortality in South Asia.

Vitamin D deficiency in infants can often be traced to maternal nutritional status. Neonatal concentrations are normally 60-70% of maternal vitamin D levels. In case of maternal deficiency, the neonate’s low reserves of vitamin D can cause hypocalcaemic symptoms in the first six months of infant’s life. Pregnant women in South Asia are advised 400 IU (10µg) daily intake of vitamin D but compliance to this recommendation is often very
Experience with Indian and Pakistani populations in developed countries and in India and Pakistan suggests that for conventionally dressed pregnant women receiving insufficient sunlight, a 1000 IU (25 µg) daily intake of vitamin D is more appropriate.32

Due to low level of compliance to recommended daily intake of vitamin D, Lawson and Thomas33 advocate an annual intramuscular booster of 150,000 IU for children of Asian origin up to the age of five years. In order to build vitamin D store of infants, it is now a standard practice in France is to give pregnant women a single large intramuscular dose of vitamin D of 100,000 to 150,000 IU during the 7th month of pregnancy.34 A similar policy for children and pregnant women in India and Pakistan needs to be considered.

Roy et al16 have reported that in South Asian women, a decrease in serum 25(OH)D level <15 ng/ml is associated with a progressive reduction in bone mass at the hip and wrist. Finch et al35 claimed that osteomalacia was under-diagnosed in South Asians living in UK. They found that 22% of subjects in their study had varying degrees of osteomalacia.

Vitamin D deficiency and other diseases: Over 200 of human genes have receptors for vitamin D, making vitamin D deficiency a contributory factor to a wide variety of other human diseases. Johnson argues “that vitamin D is important for much more than just bones; the vitamin seems to have a role in preventing colorectal and other cancers, diabetes, arthritis and even multiple sclerosis (MS).”36

In vitro studies have shown that the active vitamin D metabolite - 1,25 di(OH))D3 may arrest the cell cycle progression, induce apoptosis as well as regulate T cells and antigen presenting cells function.37 They point to the evidence that vitamin D deficiency accelerates development of autoimmune disease and cancers.

Recently, an inverse association between plasma 25(OH) D levels and risk of hypertension has been reported.38 Richard and his associates have shown beneficial effects of vitamin D against aging and inflammation.39 In a study at the Alzheimer’s Disease Research Center, St Louis, USA, vitamin D deficiency was found to be associated with psychiatric and neurological disorders.40 In another report, vitamin D deficiency was implicated in depression.41 Bottela-Carretero et al found an association between vitamin D deficiency and metabolic syndrome in obese patients.42 Patients with vitamin D deficiency had significantly lower levels of HDL-cholesterol and hypertriglyceridemia compared to patients with normal levels of vitamin D.42 Wang et al more recently, in a prospective study on 1739 participants and a mean follow-up of 5.4 years, showed vitamin D deficiency to be a risk factor for cardiovascular disease in participants with hypertension.43 Cardiomyopathy due to vitamin D deficiency in infants is a rare but potentially fatal manifestation of hypovitaminosis D.44

Adequate intake of vitamin D: The mean serum concentration of 25(OH)D of 30 ng/ml is considered desirable for health.1 A level of 20 ng/ml is considered as minimum acceptable.1,4 The recommended daily intakes for vitamin D for infants, children and adults up to 50 years is 200 IU (5 µg) per day, and for adults between 50-70 years, it should be 400 IU (10 µg).23,45 Several investigators have suggested that these values are insufficient especially for pregnant females, sick adults and older adults.46 Perhaps all the adults need 800-1000 IU daily.46

Toxicity of Vitamin D: Excess of vitamin D can cause hypercalcemia and hypercalcuria.23 However, these complications do not occur at the recommended intake amounts of vitamins D.23,47 Toxicity is not likely to occur at doses less than 2400 IU (60µg) per day.45 Studies have reported no observed adverse effects of vitamin D at an intake of 20µg/day.23

Conquering vitamin D deficiency: Vitamin D deficiency in South Asia has acquired epidemic proportions. It is surprising that in South Asia, where as much as 80% of the apparently healthy population is deficient in vitamin D (<20ng/ml) and up to 40% of the population is severely deficient (<9ng/ml),14 no public awareness program or mandatory supplemen-
tation of common foodstuff with vitamin D is being implemented by the governments. It is incumbent on the Scientific Community to impress upon the policy makers to advocate for fortification of grains with vitamin D. The fears related to vitamin D toxicity have proved unfounded and the daily nutrient intakes recommended by Food and Nutrition Board of the Institute of Medicine, USA are too conservative even for the Western societies. In South Asia, where social factors, skin pigmentation and cold winters in northern parts have resulted in mild to severe deficiency in almost total population, these recommendations need to be revised upward in order to improve the vitamin D levels of the population. It had been suggested that approximately thirty minutes of skin exposure (without sunscreen) to sunlight could provide all the daily needs of vitamin D to the human body. However, a recent study on Hawaiian population revealed that even 11.1 hour total body exposure to sunlight per week was not enough to prevent the development of “low vitamin D status”. This shows that vitamin D synthesis by skin could be affected by a number of factors, yet unknown. Therefore, supplementation with vitamin D would, perhaps, be necessary in populations at risk of developing hypovitaminosis D.

CONCLUSION

Recommendation: Vitamin D deficiency is wide spread in South Asian population and is contributing to burden of disease in this region. It is suggested that the governments in South Asia should implement a mandatory vitamin D supplementation program of selected foodstuff, at least during the winter months. Vitamin D supplement and an annual intramuscular injection of a large single dose of vitamin D need to be considered for the special risk groups. The program needs to be reinforced through a mass awareness campaign over the electronic media of the importance of absorbing direct sunlight for at least 30 minutes a day. The adequate vitamin D daily intake for South Asians also needs to be set at least twice that of the above mentioned recommended intakes for Western populations.

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