

## REVIEW

## Vitamin D deficiency and insufficiency in Africa and the Middle East, despite year-round sunny days

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Exposure to sunlight, specifically ultraviolet B (UVB), is essential for cutaneous vitamin D synthesis. Despite significant daily sunlight availability in Africa and the Middle East, persons living in these regions are frequently vitamin D insufficient or deficient. Vitamin D insufficiency (25-hydroxyvitamin D (25(OH)D) between 15 and 20 ng/mL (37.5 - 50 nmol/L)) has been described in various population groups, ranging from 5% to 80%. Risk factors include traditional dress and avoidance of sunlight exposure, and multiple dietary factors as a result of specific cultural beliefs. Vitamin D resistance due to calcium deficiency mechanisms has been described in similar population groups, which may lead to hypovitaminosis D.

Should the new diseases related to hypovitaminosis D prove to be truly associated, Africa and the Middle East will become an epicentre for many of these conditions. Urgent attention will need to be paid to cultural dress and dietary behaviours if hypovitaminosis D is to be taken seriously. Should such factors not be correctable, new strategies for supplementation or food fortification will have to be devised.

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The subject of vitamin D insufficiency has become topical since an increase in the number of reports in the medical literature of health-related problems in children and adults with vitamin D insufficiency. It is important to assess vitamin D status before frank deficiency, because many conditions are linked to this condition. Vitamin D insufficiency and deficiency are extremely common in Africa and the Middle East, despite these regions having high levels of sunlight exposure in summer and winter. This important paradox may have many explanations, which need to be defined for corrective action to be taken for children and adults at risk of hypovitaminosis D.

### Vitamin D metabolism

Exposure to sunlight, specifically ultraviolet B (UVB), is essential for cutaneous vitamin D synthesis; UVB radiation is higher at midday than at other times of the day. During spring, summer and autumn, 10 - 15 minutes of sun exposure between 10h00 and 15h00 are sufficient for adequate vitamin D synthesis in light-skinned individuals.<sup>[1]</sup> However, most Asian Indians require three times as much sun exposure as light-skinned individuals to achieve equivalent vitamin D concentrations, and individuals with very dark skin pigmentation (e.g. some with African ancestry) require 6 - 10 times as much exposure as light-skinned individuals.<sup>[2,3]</sup> The use of sunscreens and sunblock with a sun protection factor of 30 may decrease vitamin D synthetic capacity by as much as 95%.<sup>[4]</sup> Staying indoors for long periods can also cause reduced vitamin D synthesis,<sup>[5]</sup> which may lead to low vitamin D levels in disabled children and those who stay primarily indoors.<sup>[6]</sup>

Less than 10% of vitamin D is derived from dietary sources in the absence of food fortification or use of supplements. Both the D<sub>2</sub> and D<sub>3</sub> forms are used for food fortification. The primary natural (unfortified) dietary sources of vitamin D are oily fish (salmon, mackerel, sardines), cod liver oil, liver and organ meats, and egg yolk. Children typically consume few of these sources consistently.

Because of the scarcity of natural dietary sources, vitamin D is fortified in many foods, particularly milk and milk products, orange juice, bread and cereals. Infant formulas in the USA are required to contain 40 - 100 IU vitamin D/100 kcal (usually providing at least 400 IU/L), and milk and orange juice that are labelled vitamin D fortified are required to contain at least 400 IU/L.

The third trimester in pregnancy is a critical time for vitamin D transfer, because this is when the fetal skeleton becomes calcified, requiring increased activation of 25-hydroxyvitamin D (25(OH)D) to 1,25(OH)<sub>2</sub>D in the maternal kidneys and placenta. Vitamin D levels are particularly low in premature infants, who have less time to accumulate vitamin D from the mother through placental transfer.<sup>[7]</sup>

The vitamin D content of breastmilk is low (15 - 50 IU/L), even in a mother with sufficient vitamin D, and exclusively breastfed infants consuming an average of 750 mL of breastmilk daily ingest only 10 - 40 IU vitamin D in the absence of sun exposure or

supplement use. Vitamin D content of breastmilk is even lower in dark-skinned mothers or mothers with other causes of vitamin D deficiency.<sup>[8]</sup> A study that included black and white infants estimated that most breastfed infants need to be exposed to sunlight for at least 30 minutes/week while wearing only a nappy in order to maintain 25(OH)D levels at >20 ng/mL (50 nmol/L).<sup>[9]</sup> This amount of sun exposure is unlikely, given current recommendations to limit sun exposure in infants <6 months old.

The advantage of sun exposure in providing vitamin D needs to be balanced against the potential risk of skin cancer from excessive exposure to UV radiation, particularly melanoma, which is one of the most common forms of cancer among young adults - especially light-skinned individuals. These concerns have led to recommendations that direct sunlight exposure should be avoided in infants <6 months old, and that sun exposure should be limited in older children through the use of protective clothing and sunscreen.<sup>[10]</sup>

### High-risk groups

A number of previously recognised risk factors for vitamin D deficiency and insufficiency are listed in Table 1. These factors, however, fail to emphasise the problem of insufficiency in regions with high sunlight exposure.

Based on many considerations, currently accepted standards for defining vitamin D status in children and adolescents are as follows:<sup>[11-13]</sup>

- Vitamin D sufficiency: 25(OH)D ≥20 ng/mL (50 nmol/L)
- Vitamin D insufficiency: 25(OH)D between 15 and 20 ng/mL (37.5 - 50 nmol/L)
- Vitamin D deficiency: 25(OH)D ≤15 ng/mL (37.5 nmol/L).

**Table 1. Known risk factors for vitamin D deficiency and insufficiency in children**

- Exclusively breastfed infants, particularly if the mothers were vitamin D deficient during pregnancy
- Premature infants
- Children with chronic illnesses, especially liver and kidney disease
- Malnourished children
- Dark-skinned children
- Living at higher latitudes
- Limited sun exposure
- Developed nations; if sufficient vitamin D intake is not ensured through the use of supplements and fortified foods, particularly if exposure to sunlight is limited
- Use of certain medications, e.g. anticonvulsants or antiretrovirals
- Malabsorptive conditions
- Children on glucocorticoid treatment, which inhibits intestinal vitamin D-dependent calcium absorption

## Prevalence of vitamin D insufficiency in Africa and the Middle East

Vitamin D insufficiency and deficiency are common across these regions, with studies in South Africa (SA) reporting insufficiency in 19% of 10-year-old children and deficiency in 7%.<sup>[14]</sup> In Nigeria, 83% of Fulani women were reported to be deficient<sup>[15]</sup> and in the United Arab Emirates (UAE) a study reported 50% of pregnant women being deficient.<sup>[16]</sup> In Saudi Arabia, a study found 59% of healthy 4 - 15-year-old schoolchildren to be deficient and 28% insufficient in vitamin D.<sup>[17]</sup> Studies in every country in this region reveal significant numbers of individuals with vitamin D insufficiency and deficiency.

## Aetiological factors for vitamin D insufficiency and deficiency in Africa and the Middle East

The following factors have been reported to be associated with vitamin D insufficiency and deficiency in Africa and the Middle East: black race and seasonality in SA children;<sup>[14]</sup> inactivity; smoking; injectable progestin contraceptive use; high alcohol consumption and diets low in calcium and high in animal protein; phosphorus and sodium intake in SA adults;<sup>[18]</sup> diets rich in corn and cassava;<sup>[19]</sup> diets rich in unfortified dairy products in Nigerian adults;<sup>[15]</sup> fast-food diets in the UAE;<sup>[20]</sup> women in purdah;<sup>[21]</sup> traditional or religious dress;<sup>[15,21]</sup> socioeconomic status in Nigerian adults;<sup>[22]</sup> exclusive breastfeeding in Nigerian children;<sup>[15,20,21]</sup> indoor lifestyle in Nigeria;<sup>[15,20]</sup> chronic disease in Egyptian adults,<sup>[23]</sup> and adolescent girls in Iran and Saudi Arabia;<sup>[24,25]</sup> anaemia in a group of adults living in Riyadh, Saudi Arabia;<sup>[26]</sup> lack of sunlight exposure<sup>[16]</sup> and body mass index in the UAE.<sup>[27]</sup>

## Conclusion

Should the new diseases related to hypovitaminosis D prove to be truly associated, then Africa and the Middle East will become an epicentre for many of these conditions. Urgent attention will need to be paid to cultural dress and dietary behaviours if hypovitaminosis D is to be taken seriously. Should such factors not be correctable, new strategies for supplementation or food fortification will urgently need to be devised.

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