Vitamin D and sun exposure: Balancing risks and benefits

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The potential myriad effects of vitamin D in human health and disease have led to popular interest in vitamin D inadequacy and the best method to normalize suboptimal levels.

Serum 25(OH)D is considered the best marker for assessing vitamin D status, and reliably reflect the free fraction of the vitamin D metabolite.

There is no consensus on the optimal 25(OH)D concentration for skeletal or extra skeletal health[1] and the cut off values for vitamin D deficiency have been debated long. Experts generally agree that levels lower than 20ng/mL (50nmol/L) are suboptimal for skeletal health. International Osteoporosis Foundation suggest that a minimum level of 30ng/mL is necessary in older adults to minimize risk of falls and fractures.

The role of vitamin D in the prevention of non-skeletal disease remains highly controversial[6].

In 2011, the Institute of Medicine (IOM) has defined Vitamin D deficiency as a 25(OH)D of less than 20ng/ml and Vitamin D insufficiency as a 25(OH)D of 21-29ng/mL[2,3,4].

The global consensus 2016 on prevention and management of rickets defined vitamin D deficiency as 25(OH)D level <30nmol/L (12ng/ml) and insufficiency as 30-50nmol/L (12-20ng/mL). The vitamin D sufficiency was defined as >50nmol/L (20ng/mL)[5].

Local data on vitamin status

Sri Lankan data on vitamin D status is limited. A study population with mixed ethnic and social characteristics from an urban setting close to Colombo showed very high cumulative estimated community prevalence of vitamin D deficiency and insufficiency [90.2 (87.2-93.2)%.] across all age strata[9]. This is comparable with South Asian regional prevalence (70-100%)[9]. A prevalence study on the vitamin D status in school children of 10-18 years revealed vitamin D deficiency in 13.2% (95% CI:11.9-14.5%) and vitamin D insufficiency of 45.6% (95%CI: 43.7%-47.5%). The prevalence of VDD was highest in the central province (32.2%) and lowest VDD and VDI were seen in the North Central province (0.7% and 34.7%)[10].

However, the clinical significance of these low biochemical values of vitamin D is not well established in Sri Lanka[9].

Sources of vitamin D

There are only a few natural sources of vitamin D, which include cod liver oil, cheese, egg yolks, mackerel, salmon, tuna fish, and beef liver. As it is not feasible for many individuals to obtain adequate vitamin D intake from natural dietary sources alone, many countries, including the United States and India, fortify foods such as orange juice, milk, yogurt, and cereal with vitamin D.

Global concern about vitamin D deficiency has fueled debates on the importance of solar exposure to meet vitamin D requirements.

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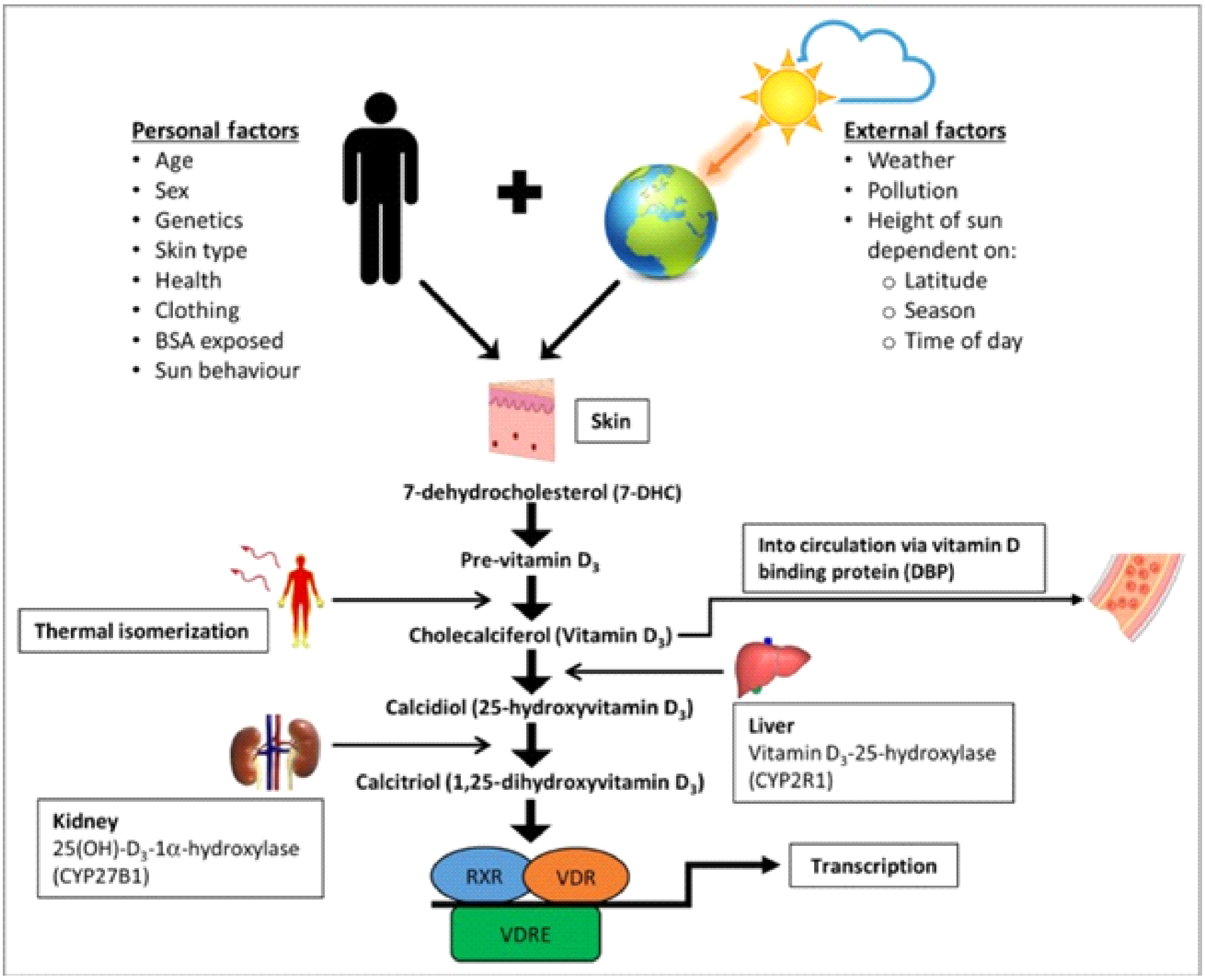
Photobiosynthesis of vitamin D



Terrestrial UVR typically contains ≤5% UVB (~295-315nm) and ≥95% UVA.

The UV-B action spectrum of vitamin D biosynthesis is the same as that responsible for the sunburn response and photo carcinogenesis. The conversion of previtamin D_3 to the inactive photoproducts lumisterol and tachysterol balances the cutaneous bio-synthesis of vitamin D_3 as a feedback loop. This mechanism ensures that one cannot "overdose" on vitamin D_3 by photo exposure alone. After less than 1 minimal erythema dose (MED) the concentration of previtamin D_3 reaches maximal levels and further UV radiation merely results in the production of inactive metabolites.

The photosynthesis and bioavailability of vitamin D is influenced by variation in sun exposure due to latitude, season, time of day, atmospheric components, clouds, clothing, sunscreen use and skin pigmentation, as well as age and obesity. Melanin absorbs and scatters UVB, resulting in a less efficient conversion of 7-dehydrocholesterol to previtamin D_3. There is an inverse association between skin pigmentation and serum 25(OH)D levels.

Exposure of the whole body in a bathing suit to 0.5 MED of UVB radiation is approximately equivalent to ingesting about 7000-10,000IUs of vitamin D. Therefore exposing 20% of the body surface to an amount of sunlight equal to 0.5 MED is equivalent to ingesting approximately 1400-2000 IUs of vitamin D_3. This is effective for all skin types and the increase in serum 25(OH)D attained from exposure to UVB radiation is often more effective than ingesting 1000 IU vitamin D daily[12].

The rule of thumb is to be exposed to an amount of sunlight that is about 50% minimal erythema dose followed by good sun protection i.e., clothing, hat and or sunscreen[12].

However, the duration of exposure to obtain this recommended UV dose depends greatly on skin type, time and location as well as ambient conditions and clothing.

Balancing the risks and benefits of sun exposure for vitamin D synthesis in pigmented skin

The benefits of photo exposure need to be balanced with the well documented risks of photodermatoses, photoaggravated dermatoses, photoaging, photo-keratosis and cataract.

There are limited data on the optimal duration of sun exposure required for adequate synthesis of vitamin D in the pigmented skin[13].

Individuals with skin type 5 need about 2.5-3 times as much simulated sun exposure as white-skinned individuals when delivered as small doses three times weekly, to enable equivalent vitamin D synthesis[14].

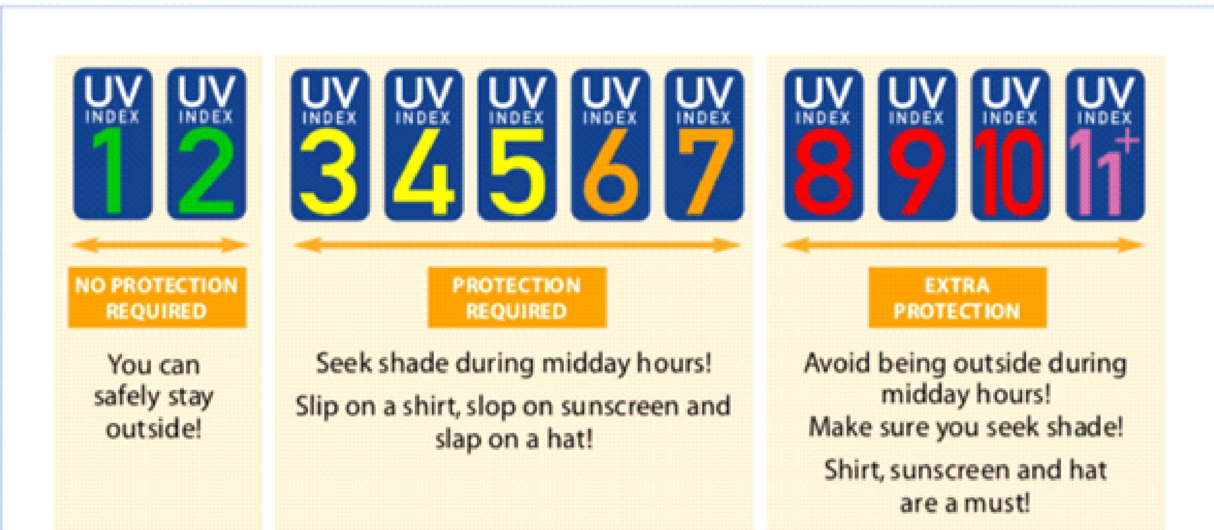
Kulkarni *et al* have calculated the required sun exposure times for adequate cutaneous synthesis of vitamin D for 10 Indian regions considering 10% body surface exposure, type V skin, accounting for 1000IU of vitamin D per day. After accounting for clouds, it has been estimated that adequate vitamin D can be acquired in a duration of around 30-35 minutes in locations lying within the tropics[15].

An ampoule model study conducted in India demonstrated that the percent conversion of 7-DHC to previtamin D_3 is maximum at solar zenith angle of 15° or lower with maximum formation of previtamin D_3 and vitamin D_3 between 11 a.m. to 2 p.m[16].

These demonstrate that longer exposure times are required for optimal vitamin D synthesis in the pigmented skin compared to that in white skinned individuals during hours of high UV Index.

The risk of exposure to high UV Index during these given times should be considered when applying such data in general practice.

The UV index[17] (UVI) is a numerical index of the erythemally weighted irradiance of terrestrial UVR defined by the WHO which allow comparisons of erythemal potential at various latitudes, seasons and the time of the day. Its primarily an index of UVB exposure irradiance and serves as an important vehicle to raise public awareness and to alert the public on sun protection measures for fair skinned individuals when the UVI is >3.



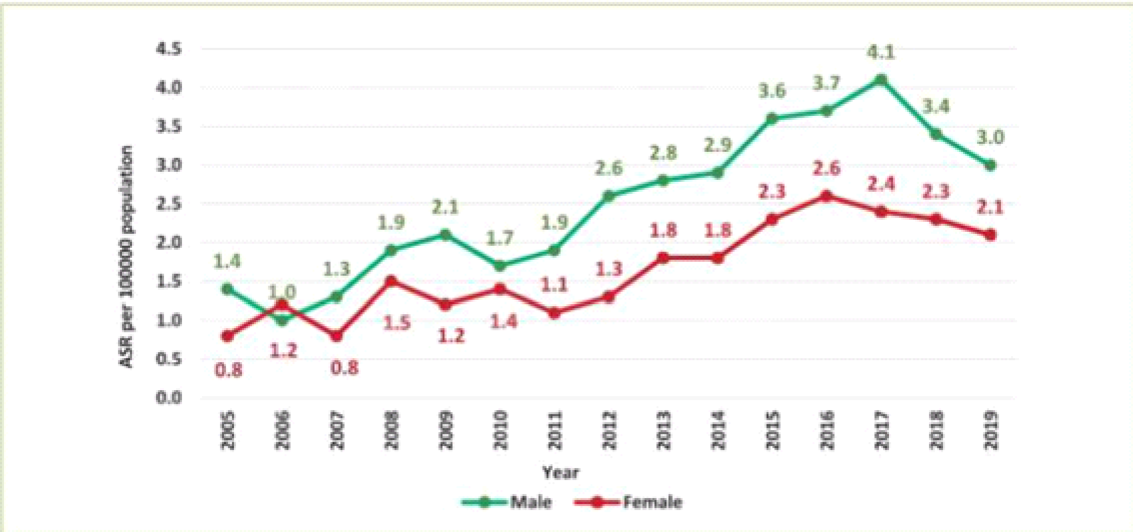
Recommended sun protection scheme with simple "sound bite" messages.

Although the Department of Meteorology, of Sri Lanka does not measure the UVI as of date, the forecasted UV index can be assessed through various mobile apps and via the UK Met office. https://www.metoffice.gov.uk/weather/forecast/tc0z3mxd1

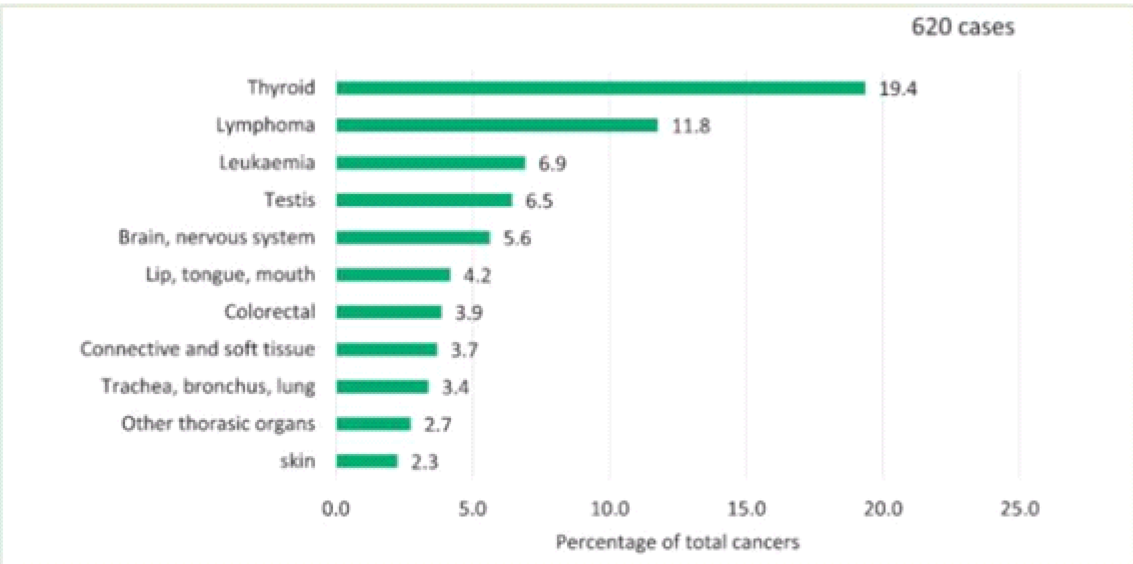
The average UV index of Colombo is 6-7 throughout the year and in many major cities the UVI is shown to reach 9-10 by the mid day, which is classed as very high exposure.

The UV significance in the development of skin cancers by skin colour remains much under-researched.

Data from the National Cancer Control Programme (NCCP)[18] reveals a rising trend of skin cancers in Sri Lanka as depicted below. The reported incidence of Non Melanoma Skin Cancer and melanoma in 2019 was 2.8 and 0.4 per 100,000 population respectively.



Age standardized incidence rates of skin cancers in Sri Lanka, 2005-2019.



Leading cancers by 15-34 year age group among males in Sri Lanka, 2019.

According to the NCCP data in 2019, the commonest skin cancer reported was SCC followed by BCC and MM[18].

A recent retrospective study (2021) conducted in Central India of 66 cases of cutaneous malignancies revealed BCC (41%) as the commonest malignancy followed by SCC (30%), MM (9%) and cutaneous T cell lymphoma (1.5%). Prolonged sun exposure was found to be the major risk factor (n= 30, 46%) followed by genetic disorders, pre-existing dermatoses and systemic malignancies[19].

Photoaging is another consequence of cumulative UVR exposure with cosmetic implications.

It is globally emphasized that patients diagnosed with skin cancers, photo dermatoses and individuals on drugs causing phototoxic and photoallergic reactions avoid sun exposure and practice sun protection.

Thus, on the note of balancing the benefits with the risks, sensible sun exposure is what should be encouraged.

- General public should be advice to find the UV index before exposing to the sun and avoid high UV index exposures. Use of mobile apps can be advised.
- Physical activity is associated with increased vitamin D levels, so daily walks and being active while outside can be considered to reduce the length of the time required for vitamin D synthesis.
- Outdoor activities should be encouraged for who have a sedentary lifestyle and indoor office work but outdoor workers should not be recommended on additional sun exposure as prolonged sun exposure does not cause the levels of vitamin D to rise further.
- Sunscreen use can be encouraged as most studies published to date have shown no association between sunscreen use and vitamin D deficiency, even with regular use of SPF >15. Some studies have even reported a positive association between sunscreen use and $25(OH)D_3$, suggesting that their use may have increased sun exposure. Increasing the UVA-PF for a given SPF improves vitamin D_3 production[20]. However, studies on pigmented skin is limited in this regard.
- Since UVB is attenuated by glass, exposures to sunlight indoors through a window is not recommended.
- It is recommended that people who may be at risk of vitamin D deficiency discuss their vitamin D requirements with their medical practitioner to determine if vitamin D supplementation rather than sun exposure is appropriate.

In conclusion, although the benefits of photo exposure with regards to vitamin D synthesis is well established there is limited research available to determine exact UVB dose required to maintain adequate vitamin D levels and prevent adverse health outcomes. Synthesis of vitamin D is influenced by a number of factors including age, skin colour, latitude, season and time of day, making it difficult to provide advice to the population as a whole. The lack of local data on the effects of biochemically low vitamin D levels on bone health and also the sparsity of studies on the efficacy of sun exposure on inducing vitamin D levels in the local population should be born in mind when advocating behavioral changes to the public.

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