

## Review: The relationship between UV exposure and vitamin D status

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**Abstract** We review the main factors influencing the vitamin D status with a particular focus on ultraviolet radiation exposure and associated variables. Gaps of knowledge are discussed. Vitamin D is important for bone health, and may prevent some cancers e.g. in breast, prostate and colon. It may also inhibit some autoimmune diseases such as multiple sclerosis, diabetes-1, rheumatoid arthritis, etc. On the global level, the main source of vitamin D is the sun. Solar rays are in principle free, and toxic vitamin D levels from the sun are not possible. The effect of solar radiation on vitamin D synthesis depends to some extent on the initial vitamin D status. At moderate to higher latitudes diet becomes an increasingly important source of vitamin D because the sun is less intense and cold temperatures require more clothing. During winter, the UVB radiation is not strong enough to sustain any vitamin D synthesis at all. This period is referred to as the vitamin D winter. Despite this, the vitamin D status appears to improve with latitude in Europe, probably due to fair skin complexion and a generally higher vitamin D dietary intake. Only a few sources of food contain vitamin D, and those types of food are more part of the traditional diet in the north. For high latitudes and elevated desired levels of vitamin D intake the balance between skin burn and adequate vitamin D synthesis is not straightforward. Future projections of increased cloudiness, more migration of individuals with darker skin towards higher latitudes, as well as trends towards less outdoor work and leisure activities form additional risk factors for vitamin D insufficiency.

Online calculators for computation of vitamin D synthesis in human skin are freely available on the internet (e.g.

<http://nadir.nilu.no/~olaeng/fastrt/VitD.html> and

[http://nadir.nilu.no/~olaeng/fastrt/VitD\\_quartMED.html](http://nadir.nilu.no/~olaeng/fastrt/VitD_quartMED.html) ).

I present some new sample results from those.

### Vitamin D winter

Vitamin D synthesis in human skin occurs only when incident UV radiation exceeds a certain threshold [Webb et al., 1988]. From simulations of UV irradiances [Engelsen and Kylling, 2005] worldwide and throughout the year, we have studied the dependency of the extent and duration of dermal vitamin D synthesis in terms of latitude, time, total ozone, clouds, aerosols, surface reflectivity and altitude [Engelsen et al., 2005]. For clear atmospheric conditions, no cutaneous vitamin D production occurs at 51 degrees latitude and higher during some periods of the year. At 70 degrees latitude, vitamin D synthesis can be absent for 5 months. Clouds, aerosols and thick ozone events reduce the duration of vitamin D synthesis considerably, and can suppress vitamin D synthesis completely even at the

equator. A web page allowing the computation of the duration of cutaneous vitamin D production worldwide throughout the year, for various atmospheric and surface conditions, is available on the Internet at <http://zardoz.nilu.no/~olaeng/fastrt/VitD.html> and <http://zardoz.nilu.no/~olaeng/fastrt/VitD-ez.html>.

Figure 1 shows sample results for standard conditions in the northern hemisphere. The effective vitamin D winter as observed on humans is likely to last longer than in figure 1 [Edvardsen et al., 2007].

### Calculations of vitamin D synthesis

The harmful effects of overexposure to UV radiation has been studied extensively, but less attention has been given to an acknowledged benefit of exposure to sunlight; that being the synthesis of vitamin D in skin. We have defined a standard vitamin D dose on the basis of recently recommended requirements for vitamin D that account for its risk reduction role in a variety of diseases [Webb and Engelsen, 2006], and present web-based tools that enables the reader to calculate associated exposure times for any time and place using either default values or user-selected conditions. Either it is not possible to synthesize vitamin D at high latitudes in winter, or the exposure time required to reach a standard dose is sometimes impractical [Mei et al., 2007].

To explore the required exposure times for different conditions, including various levels of ozone, cloud, aerosol, surface albedo and surface elevation, skin exposure, desired vitamin D doses, etc. the reader is directed to

[http://nadir.nilu.no/~olaeng/fastrt/VitD\\_quartMED.html](http://nadir.nilu.no/~olaeng/fastrt/VitD_quartMED.html) and

[http://nadir.nilu.no/~olaeng/fastrt/VitD-ez\\_quartMED.html](http://nadir.nilu.no/~olaeng/fastrt/VitD-ez_quartMED.html)

where user selected inputs can be applied to the calculations. For example, we show the required exposure to obtain the officially recommended dose (400 IU, figure 2). Adequate vitamin D is readily available from relative short, casual sun exposures during summer or at low latitudes in the midday lunch hour. For moderate to high latitudes unrealistically long exposure times would be necessary during spring and autumn. Also, we show the required exposure to achieve a recently proposed dose for optimal health in the case of dark skin individuals (4000 IU, figure 3). Interestingly, this generally require unrealistically long exposure times for normal skin exposure, i.e. face, neck and hands (11.5%), and would most likely cause erythema for the exposed skin areas (not shown here). For much of the globe, and much of the year, and for all skin types, the equivalent of 4000IU is not achievable in a lunchtime hour, and where it is possible large areas of skin must be

exposed to prevent erythema.

**Acknowledgments** The papers below describe the background methods which forms the basis for the results shown here. I acknowledge the contributions of my co-authors to ideas and text.

**References**

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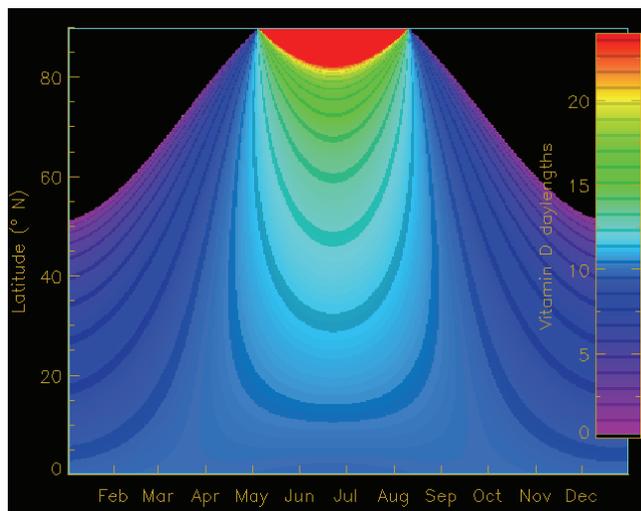
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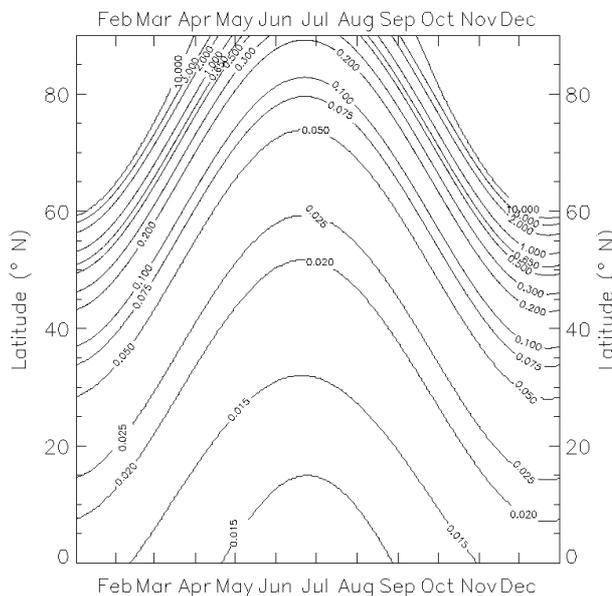
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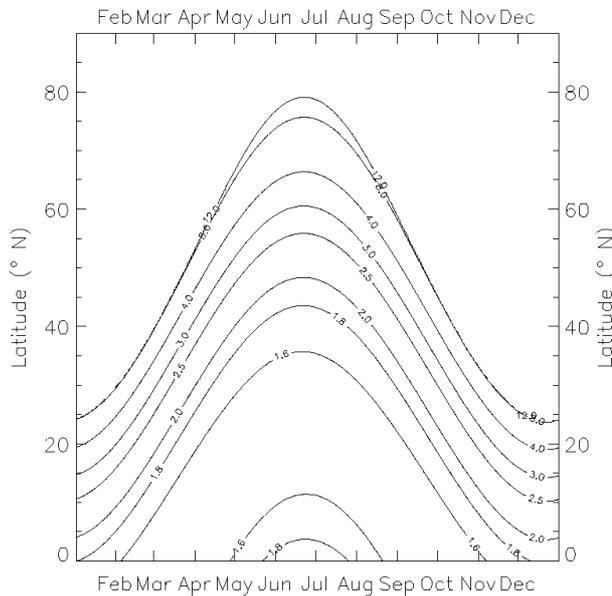


**Figure 1.** Daily period (in hours) of vitamin D production in terms of time and latitude for a clear atmosphere and no surface reflection and for a typical level of total ozone (300 DU). Black

areas constitute the vitamin D winter. Based on the method of Engelsen et al. [2005].



**Figure 2.** Time in hours required to synthesize the oral equivalent of 400 IU vitamin D for skin type 2 (fair) exposing hands, face, neck, arms and legs. 400IU is the officially recommended dose for children and the elderly.



**Figure 3.** Time in hours required to synthesize the oral equivalent of 4000 IU vitamin D for skin type 5 (dark) exposing hands, face and neck. 4000IU has been suggested by some scientists for optimal health.