

PROFESSIONAL LIGHTING DESIGN



Magazine for professional lighting design

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Vitamin D

**The truth about Vitamin D and sun exposure demystified.
Finding the balance for personal health.**

Text: Dr. Karolina M. Zielinska-Dabkowska M.Sc. Arch., Dipl. Ing. Arch. (FH), Ph.D., architectural lighting designer and researcher



If you ask someone: "What is it most essential to have in life?" you will undoubtedly receive the response: "good health". New findings in the medical field show that we need to review our commonly shared understanding of the fear of exposure to sunlight and its association with carcinogenesis (creation of cancer). There is a strong indication that inadequate levels of vitamin D in the human body can be the cause of some terminal illnesses and contribute to poor health.



Figure 1: Sol lucet omnibus. The sun shines upon us all.⁽¹⁾ Copyright: Mary Camomile/Fotolia.

Why this topic?

Some people reading this article may ask themselves why an article on health-related aspects which are more likely to be addressed in a medical publication is included in a lighting design magazine. It is not quite as straightforward as that. Firstly, as professional lighting designers who plan with both artificial light and daylight, we should be capable of understanding certain interdependencies between sunlight and health. On the other hand, who is qualified to design safe, human-friendly daylit environments? The effect of light on humans is a crucial part of lighting design, which is becoming an increasingly more complex and interdisciplinary field. But who has the knowledge and tools to be able to handle such tasks? Medical doctors? Daylight engineers? Architects? Building engineers? Sustainability consultants? Thermal engineering consultants? Or maybe architectural lighting designers?

Almost everyone, including myself in the past, has read something about vitamin D deficiency. More often than not, most of us believe that this problem only affects a small minority of people living in countries located in north, such as Iceland, Sweden, Finland or Norway. Far from it! Geographical location does play a role, but altogether 40 to 75 per cent of the world's population is vitamin D deficient^[2].

Sun is indispensable for life on planet earth. It has accompanied us human beings for hundreds of thousands of years and we have developed our existence in a very close relationship with it. It influences our daily rhythms, patterns of activity, behaviour, and more. In evolutionary terms, humans as a species have only "recently" changed their outdoor, agrarian lifestyle due to the invention of artificial

light. Before the Industrial Revolution in the second half of the 18th century, and development of the first electric light bulb in 1880, the majority of the people living in cities were still spending most of the daytime in the open air, so lack of exposure to sunlight was not an issue. Later, due to air pollution from the factories in the cities, very little daylight was able to penetrate the atmosphere. Also the towns were densely populated and the streets were narrow and received little daylight. Children began to develop visible bone deformation (rickets) and many believed it was a disease. The first to discover the relationship between rickets and lack of sunlight was the Polish medical practitioner Jędrzej Sniadecki, who was already curing children from the industrialised area of Warsaw/PL by exposing them to sunlight in 1822 and sending them to rural regions outside the capital, where their illness improved drastically. Today we sit in enclosed offices under artificial lighting from early in the morning until late at night to perform the visual tasks expected of us. We thus extend day into night day after day, week after week, season after season. As time passes by we reduce the number of hours of exposure to sunlight that our evolution has stipulated and still requires.

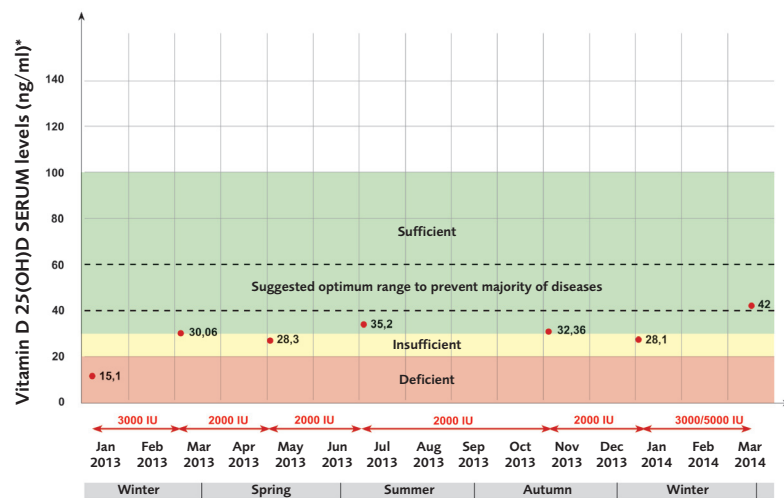
The reason I am so passionate about this topic is that around two and a half years ago in October 2012 I was invited as a speaker to the Light Symposium in Wismar/Germany (www.lightsymposium.de) and after listening to Dr. Renate Hammer's lecture "Daylighting in an Indoor Society", where she mentioned the relationship between the number of hours spent in indoor environments and the increase in skin cancer and vitamin D deficiency, I decided to check my vitamin D levels. In the months prior to the Light Symposium

I was working long hours on my Ph.D. research in an indoor environment and when outdoors I used sun screen on the exposed parts of my body. In January 2013 I received the lab results (table1) I was suffering from severe vitamin D deficiency, with levels of 15.1ng/ml.

As you can see from the diagram (Table 1), it took me more than one year to increase my vitamin D levels by taking 2000 to 3000 IU doses orally, but I still could not manage to get above 40ng/ml. Doctors should know that higher doses do not have any toxic effect if controlled on a regular basis. I was able to improve my vitamin D levels and the quality of my life more quickly by taking

5000 IU per day. Only when I went above this level did my symptoms disappear. The severe, unrelated deep bone pain felt in my arms and legs was a symptom of osteomalacia, the adult version of rickets but without bone deformation. This was completely reversed when my levels were above 40ng/ml.

It is also worth mentioning that I was not aware of what the safe sunbathing protocol was. Every time I went outside in the summer months while living in Switzerland I used sunscreen on exposed parts of my skin. This meant I was blocking the infiltration of UVB radiation, which produces vitamin D (Figure 2). I had been repeatedly warned by a



Legend

- 15,1 Blood serum level measured in Poland or Switzerland in independent medical laboratories
- ← 3000 IU Oral supplementation with vitamin D₃ (Cholecalciferol) with 2000 IU or 3000 IU or 5000 IU

* Levels recommended by The Endocrine Society, published in 2011 in Endocrine Society Clinical Practice Guideline.

[The Endocrine Society was founded in 1916 and is the world's oldest, largest, and most active professional, international medical organization in the field of endocrinology and metabolism, devoted to research on hormones and the clinical practice of endocrinology.]

Table 1: My own blood serum level test results of vitamin D 25(OH)D (25-hydroxy-vitamin D) over one year duration period showing also amount of oral supplementation with vitamin D₃.

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**Figure 2: By applying broad spectrum sunscreen all over the body, UVB rays are blocked and there is no production of vitamin D through the skin. Sun cream with SPF30 factor already reduces vitamin D production by more than 95 per cent⁽⁶⁾.
Copyright: Dmitry Naumov/Fotolia.**

dermatologist friend of mine of the harmful consequences of exposing myself to high doses of UV radiation and fed with information which was based on dated and thus incorrect scientific evidence. Malignant tumours or melanomas – deadly cancers which can metastasize quickly to different organs – occur in people who work indoors in areas least exposed to the sun. Lifetime exposure to the sun appears to be associated with a lower risk of this type of cancer⁽³⁾. It is also known that melanomas are more common at higher latitudes (50°-70°) where there is less sunlight available during the year⁽⁴⁾.

So why did I not have these problems while I was living in the UK? The answer is: every summer I spent around two weeks in sunny Greece on holiday, where I "recharged" myself with vitamin D by sunbathing without using sunscreen. After exposure to the sun I would go into the shade or wear long-sleeved linen clothes and a hat. Later on during the winter time I used up the reserves of vitamin D stored in my body fat⁽⁵⁾.

In the last 100 years or so people have been exposed to sunlight far more than they are today. So why has skin cancer increased over the years? As a child I used to play a lot outside and never suffered from sunburn. As a teenager I was a swimming instructor and worked as a lifeguard on the Baltic Sea coast. I remember being in the sun from morning to early evening, without sunscreen protection (it was not readily available) and only once during the entire summer did I get mild sunburn on my back.

Also my grandmother, who died at the age of 100, enjoyed being out in the sunshine, and was in good health until the last days of her life. She showed no signs of skin cancer and exposed herself to the sun for moderate periods of time. We observed that when she was in her 90's her good health improved from the middle to the end of the summer and she was capable of walking up steep hills, which I have to admit I found difficult. So what is the problem nowadays? Why the increase in skin cancer? There are different aspects that need to be taken into account.

Firstly, over the last few decades the amount of ultraviolet (UV) radiation reaching the earth's surface has increased significantly, the reason being that the layer of stratospheric ozone which absorbs UV radiation is slowly but surely being depleted: we are subjected to increased UV exposure due to ozone depletion. The increase is occurring primarily in the mid and high latitudes (35° to 70°), with little or no increase in tropical regions (0° to 23°). The signing of The Montreal Protocol on Substances that Deplete the Ozone Layer (worldwide agreement that limited the release of ozone-depleting gases) in 1987 was an important step towards improving the thickness of ozone layers and stabilizing the levels⁽⁷⁾. But is this really the reason why cancer rates have not increased in countries such as Greece, Portugal, Southern Spain or Italy? The skin of the people who live in these regions is slightly darker and acts as a natural sunscreen. They need more time to tan and also to get burned. Furthermore, they are used to being outside. In countries where the weather is warm the people tend to take a siesta or short nap early in the afternoon. This "midday rest" tradition means that people are not exposed to the sun when it is at its strongest.

Secondly, the first sunscreens on the market blocked out UVB radiation (which supports the production of vitamin D) but not UVA rays, which we now know can penetrate deeper into the dermis, the layer of skin between the epidermis and subcutaneous tissues, and therefore increase the chance of skin cancer⁽⁸⁾. For years misinformed individuals believed that they were safer using such sunscreen products, but as a consequence they were in fact more exposed to harmful UVA. Until quite recently (late 1990s) there were no sunscreens commonly available on the market providing protection against UVA and UVB radiation.

Thirdly, our lifestyle is taking its toll on modern society – coupled with the lack of continuous, steady exposure to sunlight. According to studies in Europe we spend over 90 per cent of our time indoors⁽⁹⁾. Many adults working in office

environments have no chance to be exposed to UVB rays during the daytime. Children and teenagers play video games, or surf and watch movies on their laptops and mobile devices instead of playing outdoors. Therefore during recreational exposure to UV (often only once a year when on holiday in warm climates, lying horizontally on highly reflective surface such as white sand) our skin is not prepared for higher doses of UV. If we do not sunbathe in a controlled, moderate manner we run the risk of severe sunburn, which causes stress and mutation to our body cells. However, once the skin is exposed to UV slowly and regularly – for example for a few minutes longer each day from spring and on through the summer – the skin develops a protection factor which doubles or quadruples the time we can be exposed to solar radiation without burning.

The main causes of vitamin D deficiency / Factors affecting vitamin D levels

⇒ reduced production through the skin given the geographical location (the further you live from the equator, the less sun there is available to support the production of vitamin D during the winter months and the higher the likelihood of becoming vitamin D deficient) and/or avoidance of exposure to the sun
 ⇒ obesity: vitamin D is metabolized in the adipose tissue of obese people, thus reducing its bioavailability
 ⇒ incidence of gastrointestinal diseases which impair the absorption of nutrients from the digestive tract, such as Crohn's disease, cystic fibrosis and other diseases
 ⇒ incorrect nutrition (low-fat, fat-free diet and no or very little vitamin D in food such as oily fish) especially during the winter months and/or limited diet of vegetarians and vegans
 ⇒ liver failure, which can lead to reduced production of 25 (OH) D
 ⇒ age-reduced synthesis of the active form of the vitamin in the kidney, especially in persons over the age of 60. The older you get, the more difficult it is for your skin to synthesise vitamin D from the sun
 ⇒ changes in the work environment: from being outdoors (agriculture) to being indoors (modern

office), where most glazing blocks out UVB radiation with the result that even daylight spaces do not promote the production of vitamin D
 ⇒ changes in lifestyle – holidays of two weeks only
 ⇒ wearing clothing that conceals your body from sunlight: the majority of Muslim women in Gulf Arab states tend to be vitamin deficient even though they live in climates where vitamin D can be synthesised in the skin all year long. This is due to the fact that they spend a lot of time in indoor air-conditioned environments and if they go outside they are obliged to cover their entire body in an abaya, sometimes combined with a head scarf (hijab) or face veil (niqab)
 ⇒ pregnant and breastfeeding women, women with twin and multiple pregnancies, since they require more vitamin D for the developing foetus
 ⇒ breast fed infants are at risk when their mothers do not have sufficient levels of vitamin D.
 Recommended level: 40ng/ml
 ⇒ people with skin type IV, V and VI (see table 3 below) need more sunshine to produce vitamin D, and they are at a much higher risk of becoming vitamin D deficient because they have more melanin in their skin, which is a natural sunscreen and it blocks UVB
 ⇒ the excessive use of makeup and sun block creams while outdoors – most sunscreens block out UVB more than UVA radiation, although it is UVA which is the main cause of skin cancer
 ⇒ globalisation/migration: people live in different geographical locations from what their body is designed for. People with skin types V and VI live at higher latitudes.

What is vitamin D?

Vitamin D is in fact not a vitamin but a fat-soluble hormone and belongs to a family of chemical substances called steroids^[10]. Vitamins cannot be created by the human body. They come from dietary sources. Hormones like vitamin D are produced in the body itself^[11].

Vitamin D is responsible for enhancing the intestinal absorption of calcium and phosphorus and transporting it to the bones and teeth, and regulates how much

calcium remains in the body. Vitamin D also plays a role in strengthening our immune system and helps regulate cell growth. Vitamin D is produced naturally when our skin is exposed to invisible ultraviolet B (UVB) radiation from the sun.

"Ultraviolet radiation is part of the spectrum of invisible electromagnetic radiation emitted by the sun. It is divided into three bands of different wavelengths"^[12]. It is worth noting that the exact wavelengths differ in the literature of different disciplines, which may lead to some confusion^[13].

The different regions or divisions were first proposed by the members of the Second International Congress on Light in Copenhagen in 1932, were later adopted by the Commission Internationale de l'Éclairage (CIE) and are still widely used to this day.

- UVA = 400 - 315 nm
- UVB = 315 - 280 nm
- UVC = 280 - 100 nm

That said, photobiologists working in the field of dermatology and environmental medicine, as well as the cosmetic industry, define the regions slightly differently and in a way that is more related to the biological effect of the different wavelengths:

- UVA = 400 - 320 nm
- UVB = 320 - 290 nm
- UVC = 290 - 200 nm

UVC rays are completely absorbed by the atmospheric ozone layer and do not penetrate to the surface of the earth. On the other hand, two other forms of ultraviolet radiation have an effect on human health.

UVA passes through the earth's atmosphere completely unchanged. On the other hand, 90 per cent or more of the UVB radiation, which is responsible for vitamin D synthesis, is absorbed by the atmospheric ozone layer (Figure 3).

Sources of vitamin D

⇒ Moderate exposure to sunlight: According to the World Health Organization it is estimated that approximately 80 to 100 per cent of the vitamin D in our bodies is produced in the skin when it is exposed to UVB radiation^[14]. Through expo-

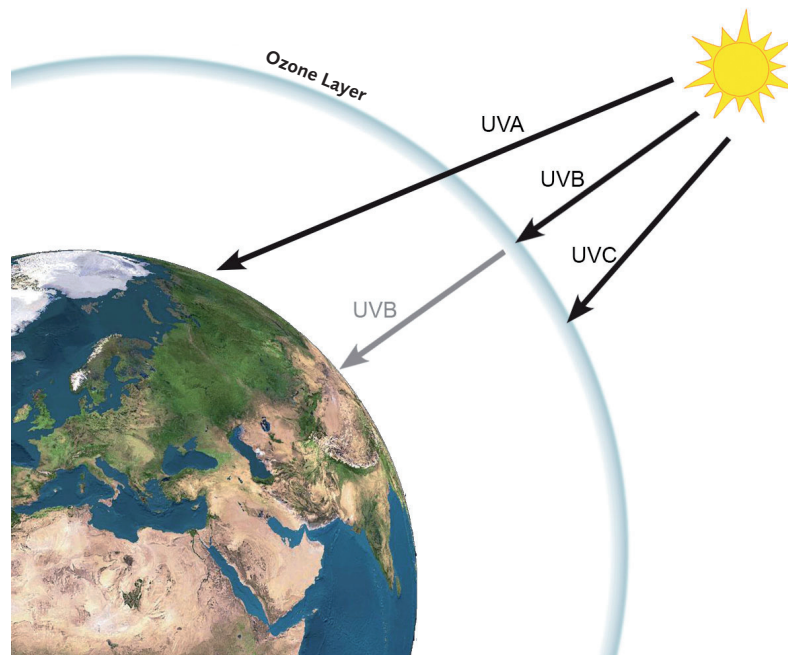


Figure 3: Diagram showing how different types of UV radiation penetrate or interact with the ozone layer. The specific wavelength composition of sunlight, as well as of the layers of the atmosphere, determine the quality of the natural light entering the skin.

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sure to sunlight/UVB radiation the human body can produce up to 20,000 IU. Human bodies cannot become intoxicated with vitamin D from the sun. Should excess vitamin D₃ build up in the skin, ultraviolet light breaks this down into three other substances. Vitamin D derived from sunlight is stored in the human body two to three times longer than supplements taken orally.

Unfortunately it is not possible to produce vitamin D at high latitudes in winter – the essential exposure time for achieving a typical dose is impractical^[15]. Therefore at moderate to higher latitudes diet is an even more significant source of Vitamin D given that the sun is less concentrated and cold temperatures require additional clothing. Throughout the winter months the UVB radiation is insufficient to sustain any vitamin D production. The period described is known as the "Vitamin D winter"^[16].

⇒ Food: In food, vitamin D is found in two chemically different forms. Vitamin D₃ (cholecalciferol) is found primarily in animal products (Table 2), especially fish liver oils and also some saltwater fish such as salmon, mackerel, tuna, sardines,

eel. Due to the pollution of the seas through heavy metals and other toxic waste, it is not advisable to eat large amounts of fish. Vitamin D₂ (ergocalciferol) is contained in some plant-based products such as shiitake mushrooms. The human body makes Vitamin D₃ naturally through exposure to the sun, which is why this is more recommended in dietary recommendations.

Dietary sources as shown in table 2, can contribute substantially to the vitamin D status in the human body. On their own they are, however, not adequate to provide sufficient amounts of vitamin D to cover daily requirements, especially in people with a vitamin D deficiency.

⇒ Vitamin D₃ supplements: In situations where it is impossible to provide adequate exposure to solar radiation (UVB wavelength), it is also impossible to provide adequate amounts of vitamin D₃ through dietary sources only. Complementary vitamin D₃ supplements then become indispensable. This is more effective at raising and maintaining the vitamin D levels in blood. Vitamin D₃ is more likely to remain active for an extended period of time even when exposed to diffe-

Food type	Amount per serving	Vitamin D ₃ amount in IU
Cod liver oil	1 teaspoon	ca. 400-1000*
Wild salmon fish, fresh	100g	ca. 600-1000
Farmed salmon fish, fresh	100g	ca. 100-250
Mackerel fish, cooked	100g	ca. 345
Mackerel fish, canned	100g	ca. 250
Sardines fish, canned in oil	100g	ca. 300
Tuna fish, canned	100g	ca. 236
Eel, cooked	100g	ca. 200
Liver, beef cooked	100g	ca. 30
Egg yolk	1	ca. 20

**Table 2: Percentage of Vitamin D in selected food sources according to Holick⁽¹⁷⁾.
* According to Cancer Research UK, supplements that contain vitamin A, including cod liver oil, are unsuitable for elderly people or pregnant women.**

rent conditions (temperature, humidity and storage) and is the most utilized form of vitamin D in medical research and trials.

So far, in many countries recommended intake levels are inadequate and too low since there is fear that an overdose may lead to hypercalcemia (increased calcium levels in the blood) but latest research shows that only levels above 150ng/ml can be regarded as being toxic.

⇒ Artificial sources of UVB radiation (sun beds and special luminaires with UVB lamps).

Sun beds use UVA and UVB radiation and it is very difficult to control the degree of exposure and sunburn. The outcome of the research done at the Department of Dermatology at Bispebjerg Hospital, University of Copenhagen/Denmark states that sun bed use as a source of vitamin D is not generally to be recommended due to their carcinogenic effect and the high frequency of acute side effects⁽¹⁸⁾.

How does it work?

The process involved is quite complicated. Until the mid 1990s, there was a different theory of how vitamin D was created in the human body, namely through the kidneys. Today we know that skin uses the ultraviolet B (UVB) radiation in the sun's rays to trigger the production of vitamin D. It is actually a precursor of cholesterol (provitamin D)

that absorbs UV energy, which is converted into previtamin D₃ and then gradually converted to vitamin D₃ in warm skin. When this process is completed it is released from the skin into the plasma and transported to the liver via the blood circulation where is changed to vitamin D₃ – 25(OH)D₃ – the major circulating form of vitamin D in the body. This is what is measured in laboratories and taken as supplements orally. The researchers from the Vitamin D, Skin and Bone Research Laboratory at the Boston University Medical Centre have discovered that the supply of activated vitamin D (1.25(OH)₂D₃) that the kidneys produce is actually very small and that a variety of cells also have this ability. When 25(OH)D₃ reaches and enters these cells, it is converted into activated vitamin D. This discovery is extremely significant because now we know that by increasing vitamin D levels in our bloodstream via sun exposure we can help to lower the risk of several diseases, especially those caused by abnormal cell growth, such as cancer. Also, the human immune system has the ability to make activated vitamin D⁽¹⁹⁾.

How much sun is enough?

If you asked me for the perfect formula, after studying all the literature and research available I have to say that unfortunately there is none. Each of us reacts to sunlight slightly

differently, also given that the level of UVB radiation from the sun depends on so many of the aspects listed below:

- ⇒ latitude: UVB radiation is most intense at the equator, slowly diminishing towards higher latitudes
- ⇒ altitude: solar UVB radiation increases about seven per cent per kilometre in altitude under clear sky conditions; the higher it gets, the more intense the UVB radiation is, because there is less atmosphere to absorb the UVB radiation
- ⇒ atmospheric conditions: thickness of the ozone layer, cloud cover and air pollution can absorb UVB radiation
- ⇒ time of the year: the angle of the sun changes with the seasons; UVB radiation is less intense over the winter months and very intense in the summer months
- ⇒ time of day: the strongest UVB levels are at noon (figure 4a); early in the mornings and late in the afternoons UVB levels are less intense (figure 4b) due to the distance UVB has to travel through the atmosphere
- ⇒ skin type: skin pigmentation impacts the absorption of UVB and the synthesis of vitamin D (table 3)
- ⇒ surface reflectivity: different materials can enhance the reflection of UVB radiation – 95 per cent on snow, 17 per cent on sand and three to five per cent on water
- ⇒ posture/ orientation of the body towards the sun: when lying horizontally at noon sun rays strike the surface of the skin at an angle of 90 degrees
- ⇒ presence of the shading structure:

sunshades or umbrellas can provide protection from UVB radiation

⇒ surroundings of where people live: open areas have a higher UVB irradiance than built-up urban areas

Based on two studies I was able to create map of the world indicating latitude and lack of UVB and vitamin D production in the skin during the winter months (Figure 4).

According to research performed in Norway, under clear atmospheric conditions, no dermal vitamin D production is possible at 51° latitude and higher latitudes (red colour on the map) during some periods of the year⁽²⁰⁾.

Based on Harvard Medical School data: apart from during the summer months, the skin produces little if any vitamin D from the sun at latitudes above 37° north or below 37° south of the equator (orange band shown on the map). People living in these areas are at a greater risk of becoming vitamin D deficient⁽²¹⁾.

According to Dr. Holick, the most influential person in the field of vitamin D research, at latitudes of between 35 to 50 degrees from November to February there is insufficient UVB to allow for vitamin D synthesis in the skin. At higher latitudes of 50 to 75 degrees, this period extends from October to March.

Dermatologists often warn the general public about being outside from 11 a.m. to 1 p.m. in order to reduce the risk of skin cancer and ageing. This would appear to be another misconception. Firstly, because around noon, when the

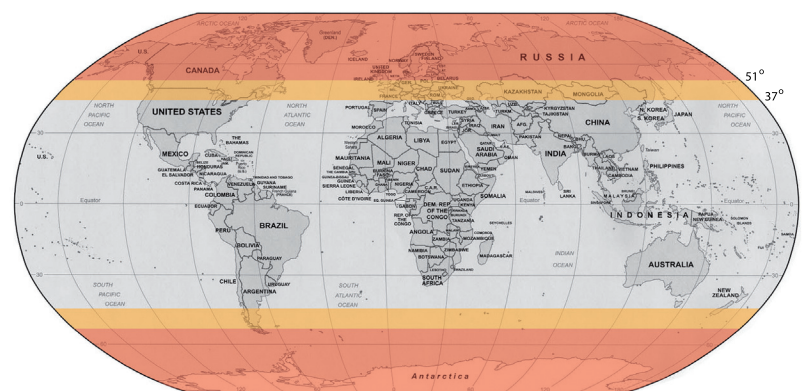


Figure 4: Map of the world indicating latitude and lack of UVB and vitamin D production in the skin during the winter months. Copyright: Dr. Karolina M. Zielinska-Dabkowska.

sun is at its highest point, the path the UVB rays have to travel to enter the earth's atmosphere is at its shortest (Figure 5a), meaning less exposure to sunlight can produce quicker results and more vitamin D. It is known that UVA radiation is more harmful to human skin, since it penetrates the skin deeper than UVB, so it is advisable to reduce the amount of exposure to UVA radiation by spending shorter amounts of time without sun protection than basking in the sun for hours^[22]. In the early morning and late afternoon the sun's rays must pass through the stratosphere at a low angle and therefore UVB intensity is largely reduced (Figure 5b). We also know that additional, long exposure to UVA delivers no extra vitamin D but linearly raises the chance of DNA damage and the risk of sunburn and danger of skin cancer.

When it comes to sun exposure: little and frequently is to be recommended. During the first few days of late spring / early summer, exposure should be limited to a few minutes a day to allow the melanocyte cells in the skin to begin to create pigmentation that serves to provide protection against over exposure to the sun. White-skinned people develop a visible light tan. Different skin types react differently to sunlight. With respect for the limits of your own body, exposure time can be gradually increased.

Most of us only need a few minutes of sun exposure a day during the summer months to maintain healthy vitamin D levels throughout the year.

Dr. Holick estimates that exposing your entire body in a bathing suit to one minimal erythemal dose (1 MED) is defined as the threshold dose that may create mild sunburn. Your skin will turn a light "pink" colour, which is the equivalent of ingesting 10,000 IU of vitamin D. Thus exposure of six to ten per cent of the body surface to 1 MED is the equivalent of ingesting 600-1000 IU^[23]. In pharmacology, the International Unit (IU) is a unit of measure for the amount of a substance.

Given that the skin around the eyes and on the face is usually thinner, it has very little cholesterol compared with other areas on your

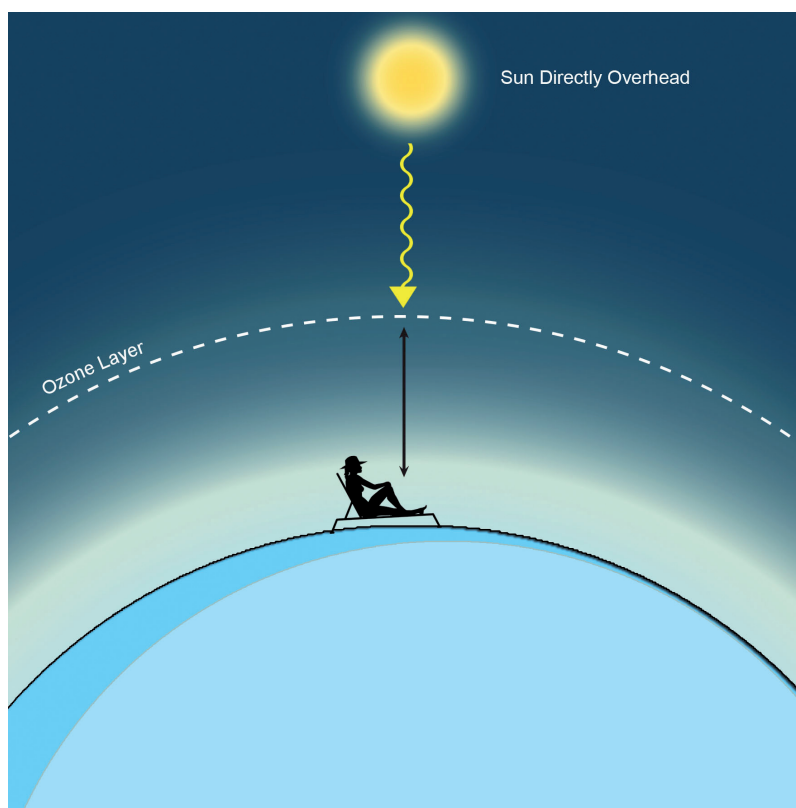


Figure 5a: Around noon, the path the UVB rays have to travel to enter the earth's atmosphere is at its shortest; less exposure to sunlight can produce more vitamin D over a shorter period of time.

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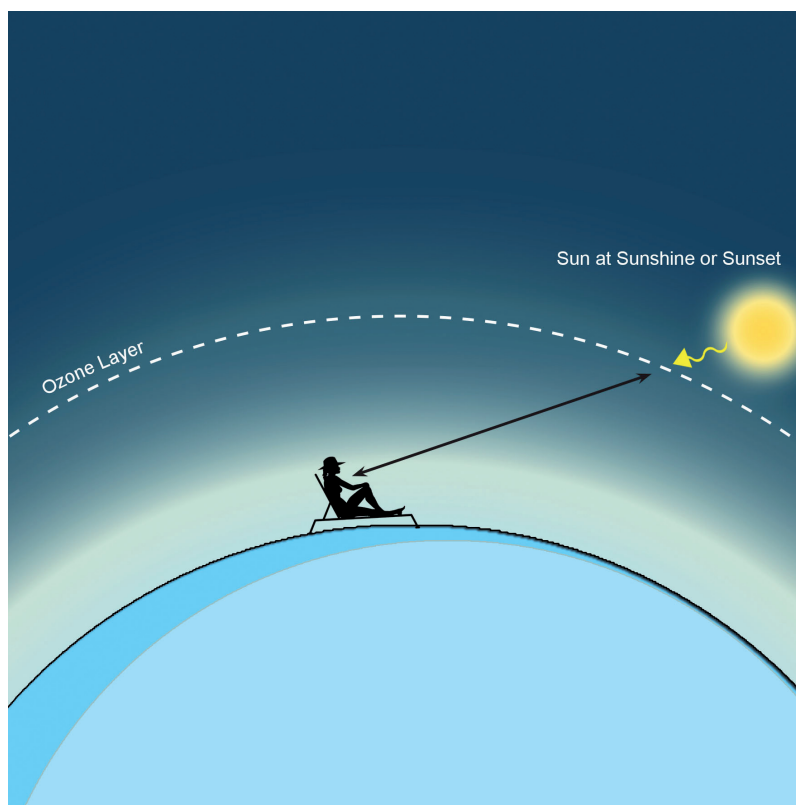


Figure 5b: In the early morning and late afternoon the sun's rays must pass through the stratosphere at a lower angle and therefore UVB intensity is largely reduced.

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body and as a relatively small area it will not contribute significantly to the production of vitamin D. It is therefore advisable to protect this part of the body from premature wrinkling and photo damage by using a safe sun blocker or wearing a hat.

The more skin you expose, the more vitamin D you will produce. Our body is so intelligent that the processing of previtamin D₃ to produce vitamin D₃ in the skin is closely controlled, so the extended exposure to UV light does not give rise to toxic effects.

I have established that in order to produce adequate levels of vitamin D the solar azimuth angle/the angle of incidence of solar radiation should be $45^\circ < \alpha < 90^\circ$. UVB rays will only penetrate the atmosphere when the sun is above an angle of around 45 degrees from the horizon. A useful observation when you are outdoors is to evaluate the length of your own shadow. If it is longer than you are, you are not producing any vitamin D (Figure 6).

To define exact latitude, you can search for the name of the town/ place of interest in google/wikipedia.

To check the altitude and azimuth of the sun, use the calculator under: www.aa.usno.navy.mil/data/docs/AltAz.php

To check the time zone use the following link: www.aa.usno.navy.mil/graphics/TimeZoneMap0913.pdf

There are two further websites designed by the Norwegian Institute for Air Research which calculate the time required for exposure to ultra-violet radiation levels in order to trigger vitamin D production based on: the time of the day, the geographical location, skin type, amount of body surface exposed and atmospheric conditions. It is not necessarily user-friendly but it can provide an overview.

www.nadir.nilu.no/~olaeng/fastrt/VitDez_quartMEDandMED_v2.html;
www.nadir.nilu.no/~olaeng/fastrt/VitD_quartMEDandMED_v2.html

Why is sunlight and vitamin D so important for human health?

If I told you that by exposing your skin to the sun in a moderate manner you could avoid diseases of

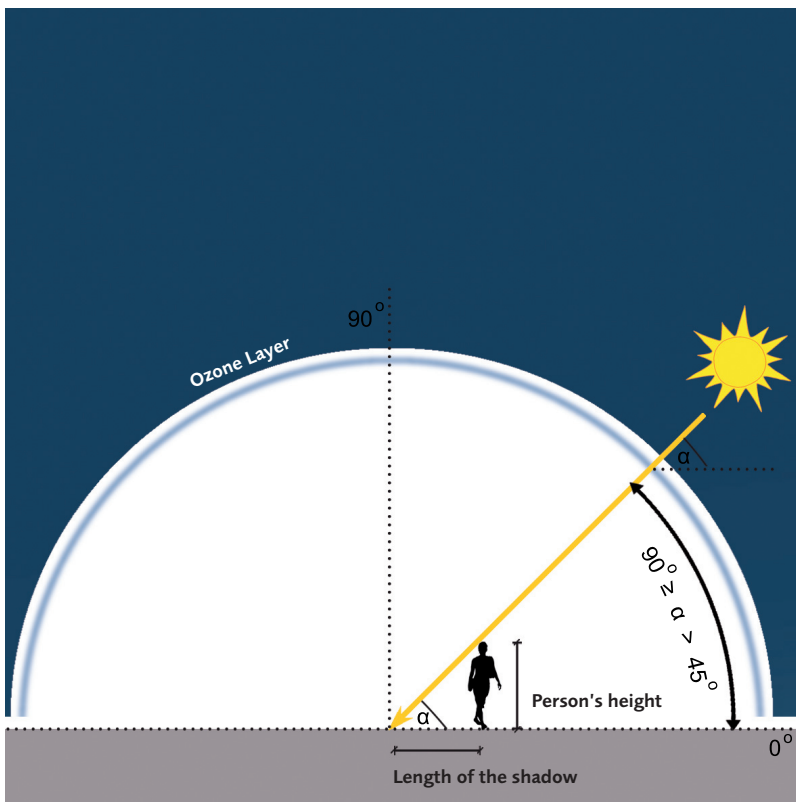


Figure 6: Diagram explaining the relationship between the azimuth angle of the sun and UVB rays entering the earth's atmosphere. In order to produce adequate levels of vitamin D the angle of incidence of solar radiation α should be $45^\circ < \alpha < 90^\circ$. Also, if your shadow is longer than you are, you are not producing any vitamin D.

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the colon, pancreas, breast, kidney, lungs, thyroid, bladder, gallbladder, leukaemia, or melanoma, non-Hodgkin lymphoma, endometrial, prostate and ovarian cancer, high blood pressure, cardiovascular disease, type 1 and 2 diabetes, multiple sclerosis, infertility, preeclampsia, C-section and premature birth in pregnant women, low birth weight, growth retardation, autism, colds, influenza, rheumatoid arthritis, tuberculosis, fibromyalgia, osteomalacia, myopathy, chronic fatigue syndrome, eczema, psoriasis, dental cavities, dementia, cognitive decline, schizophrenia, Seasonal Affective Disorder (SAD) and depression, would you believe me?

Vitamin D, like all steroid hormones, is involved in the creation of hundreds of proteins and enzymes which are essential for human health and for preventing a number of diseases. It has the capability to work together and affect more than 2,000 genes, since every tissue and cell in

the body has a vitamin D receptor (VDR). It improves muscle strength and helps to form bones. It has anti-inflammatory properties and can boost the immune system. It impacts insulin production and insulin levels and has anti-cancer properties. These qualities link vitamin D deficiency with so many of the illnesses of modern civilization (Figure 7). Because of its enormous range of benefits, keeping ideal levels of vitamin D is critical for human health^[24].

How do I know I am producing or getting sufficient vitamin D? What are the correct levels?

It is not possible to define the levels without undergoing blood tests. Nowadays there is a simple blood test called 25-hydroxy-vitamin D serum level test ("25-OH vitamin D"). In the 1970s, when the blood test for vitamin D became more accurate and widely utilized^[25], things started to change. This test, which requires about 2ml of serum, reflects the total amount of vitamin

D in the body derived from all sources such as sunlight, diet and dietary supplements.

The blood tests for vitamin D 25(OH)D levels are measured in nanograms per millilitre (ng/mL) in countries like the USA, Germany, Poland, UAE and China. In the UK, Australia, New Zealand, Canada, Switzerland and Japan they are measured in nanomoles per litre (nmol/L). Below the link to the conversion tool: www.vitamindsociety.org/resources.php#converter

The average requirement for vitamin D per day from all sources is approximately 75 IU/kg^[26]. The proposed optimum range recommended by The Endocrine Society to prevent the majority of diseases is 40 to 60ng/ml. See Table 1.

The Vitamin D-Estimator is a useful and user-friendly tool for assessing your own vitamin D levels. It can be downloaded for free under: www.vitaminD3-cholecalciferol.com/how-to-estimate-your-vitamin-d-level/

If people achieved adequate levels of vitamin D in the summer months from the exposure to sunlight, with some supplementation and a sound diet, they would be able to maintain these levels in winter^[27].

Have you ever asked yourself why humans have different skin

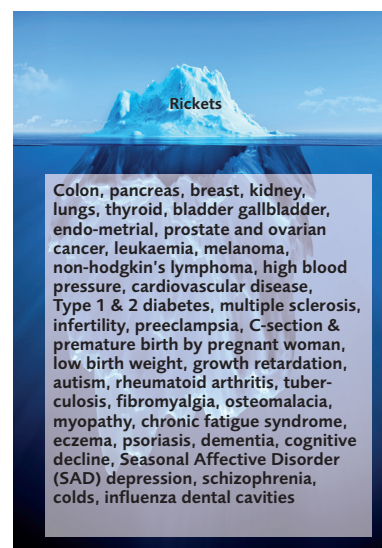


Figure 7: Vitamin D deficiency is like an iceberg, you only see the "top" of the issue, such as rickets in children. The rest is not visible to the human eye.

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types? A possible reason for the evolution of melanin pigmentation was to allow early humans who migrated north and south of the equator to produce adequate vitamin D in their skin to satisfy their requirements^[28].

The first human beings lived close to the equator and were thus exposed to extended periods of sunshine: They developed melanin-rich, dark skin that protected them from sunburn but nevertheless allowed sufficient sunlight to pass through their skin to produce vitamin D. As they began to travel away from the equator to areas where sunlight was less intense, and where for numerous months in the year the sun was (and still is) not strong enough for the human body to produce vitamin D, their skin changed and developed less pigmentation, thus promoting the absorption

of sunlight whenever it was obtainable. The further north humans drifted, the lighter their skin became to make use of accessible sunlight. In the end, they could not travel any further north since there was not adequate sunlight to create the vitamin D required for staying alive. These new conditions impacted their evolutionary disposition. They began to harvest the seas for vitamin D-rich fish and mammals, still consumed by Eskimos and Scandinavians, to allow them to exist in extreme climates with reduced sunlight^[29].

The most commonly used system for classifying a person's skin type through their response to sun exposure in terms of the degree of burning and tanning was developed in 1975 by Thomas B. Fitzpatrick, a medical doctor and Harvard dermatologist. The system is referred to as the Fitzpatrick Scale (also Fitzpatrick skin typing test or Fitzpatrick prototyping scale). Even today it remains an accepted tool for dermatologic research into the colour of skin^[30].

There is evidence that the evolution of skin colour aligns with geographical location:

- ⇒ high latitudes (50° to 70°) where the sun's rays are never so direct and penetrating – skin types 1 and 2
- ⇒ middle latitudes (35° to 50°) – skin types 3 and 4
- ⇒ subtropics (23° to 35°) and tro-

Skin type	Image	Ethnic group	Hair colour	Colour of eyes	Skin colour	Tanning ability
Type 1		Albinos, same redheads	red, blond	blue, grey, green	very pale white, pale white with freckles	Burns very easily, never tans
Type 2		People of northern European origin, such as Scandinavians or Celts	blond, red, light brown	blue, grey, green, hazel	pale white	Burns easily, rarely tans
Type 3		People of Mediterranean and Middle East origin	chestnut, dark blond	brown, blue, grey, green, hazel	white, light brown	Sometimes burns, gradually tans
Type 4		People of East Asian origin, such as Chinese, Japanese and some Indians and Pakistanis	brown, medium brown, dark brown	hazel, brown	medium brown, dark brown	Hardly ever burns, tans very easily
Type 5		People of African origin, South East Asians and some Indians, Pakistanis and Latin	dark brown	brown	dark brown	Really burns, tans easily and quickly darkens
Type 6		People with blue-black skin of African origin, Aborigines and dark-skinned Asians such as Tamils	black	brown	black	Never burns, tans, very dark

Table 3: Skin type and tanning ability based on the Fitzpatrick skin pigmentation scale. Copyright: juniart, Olga Ekaterincheva, Lars Zahner, yanmingzhang, Paul Hill, Burlingham /Fotolia.

pics (0° to 23°) where the sunshine is intense and the reflectivity of the ground is very high (deserts) – skin types 5 and 6

As shown in Table 3, skin types range from very little pigment (type 1) to very darkly pigmented (type 6). The whiter the skin type, the more prone the skin is to burning in sunlight, and thus the higher the risk of skin cancer. That said, the whiter the skin type, the greater the capability to produce vitamin D. And vice versa, the darker the skin type, the lower the risk of skin cancer and the lower the capability of producing vitamin D^[31]. To match the amount of vitamin D produced by a person with a light skin tone, people with a naturally dark skin tone require at least three to five times longer exposure to sunlight^[32].

Conclusion

During first Professional Lighting Design Convention (PLD-C) held in London in 2007 the Declaration of the Official Establishment of the Architectural Lighting Design Profession, was proclaimed. Please allow me to remind you of its important content: "Lighting Designers are responsible for the design of one part of the human environment [...] for the health and well-being of those using the designed spaces, for the way those people feel in that environment [...] for their safety and welfare [...]"

It is relatively rare that someone in our profession questions whether the way we design our environments is correct. So how can we advise others on creating healthy environments if we are not aware of

so many crucial aspects ourselves?

We are beginning to understand more and more that daylight is and should be part of our daily lives.

In lighting publications and conferences there is strong debate about the negative consequences of artificial lighting on human health and the human body, but we seem to overlook daylight. Not many architectural lighting designers are involved in daylight projects; we tend to leave it to architects. I strongly believe that this topic deserves attention in order to change our harmful design habits and improve our future health.

At the moment, designing with natural light is an added skill, but I believe this knowledge needs to become a part of our standard skill set as lighting designers. We need to

understand the significance of daylight for human wellbeing and become more familiar with new, independent research findings in the field of vitamin D, sun exposure and health, and as a consequence take control of natural light. Lighting should be regarded as a 24-hour system, consisting in the main of daylight and only supplemented with artificial lighting when necessary. Let us take these aspects seriously and ensure that the lighting design profession is acknowledged as being essential and indispensable.

I argue that in public institutional buildings there should be some open spaces such as atriums/ restaurants, cafeterias etc. designed with daylight where the glazing specified does not block out UVB

radiation and thus prevent our bodies producing enough vitamin D. It is essential that daylight technologies that do not change the spectral characteristics of daylight are developed for application in the buildings we live and work in.

Disclaimer

The above content has been gathered from the scientific publications available and is for basic information purposes only. In the case of health problems and vitamin D deficiency you should consult your doctor on exact doses and have your blood serum levels checked regularly.

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