VITAMIN D PRODUCTION
BY NATURAL AND ARTIFICIAL SOURCES

Presenters:
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ABSTRACT

Vitamin D production in human skin is a beneficial effect of sunlight exposure. In this study we examine the vitamin D effectiveness spectra of sunlight at various solar altitudes and compare these results with several clinically available sources.

At the latitudes of Boston and points north, there is insufficient UVB from low angle sunlight to produce adequate vitamin D for several months each year. Populations in northern latitudes benefit from dietary vitamin D supplementation. In individuals with limited intake or utilization of dietary vitamin D, supplemental UV exposure may be prescribed.

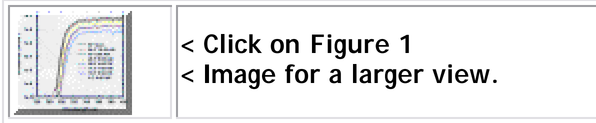
Supplemental UV exposure must include sufficient UVB radiation to produce the required photo-transformation of 7-dehydrocholesterol to pre-vitamin D. While all sources emitting UVB can produce Vitamin D in human skin, emission of UVA or UVC can make using some sources less desirable because of additional confounding effects.

Our survey suggests that a simple filtered intermediate pressure mercury source may be optimal for home or clinical Vitamin D therapy.

METHODS

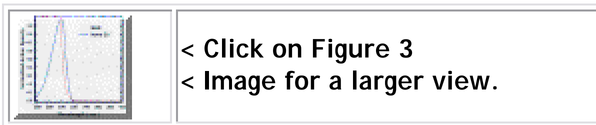
Solar spectra were collected in Kuwait City at the Al Sabah Hospital using an Optronic Laboratories OL-742 Spectroradiometer. The spectroradiometer was cooled and protected from the heat when not in use.

Spectra were collected from 260 nm to 400 nm in 2 nm increments and stored on magnetic media. See Figure 1 (below) for a portion of one day's measurements.



Spectra of two additional sources were obtained by measuring those sources at normal use distance. Because these sources may have spectral lines present, they were measured at I nm increments. See Figure 2 (below). The additional sources are the SPERTI PH 36 Phototherapy unit and a KBD 8 bulb PUVA/Tanning Unit. The bulbs in this unit are standard 2.5% UVB PUVA bulbs which are also used in some indoor tanning units.

Spectral Analyses were performed by multiplying each solar spectrum with either the CIE Erythemic Action Spectrum or a Vitamin D3 Response Spectrum.[1] See Figure 3 (below). The resulting effectiveness spectra, summed over contributing wavelengths, is expressed as an effectiveness fluence rate (W/cm2).



The ratio of Vitamin D3 effective fluence rate divided by the Erythemic effective fluence rate is an index of benefit to risk. The higher this index the greater the relative D3 benefit -vs-risk of injury from the exposure. The lower the index the greater the risk of sunburn.

RESULTS

Figure 4, shows how the Vitamin D3 Effective fluence rate and the Erythemic Effective fluence rate change throughout the day. In all 166 solar spectra were analyzed collected over 14 days in 7 months throughout the year. The solar altitudes examined were from -10 degrees to 80 degrees an altitude at which the sun was approximately as high as it may get at 30 degrees North latitude.

Figure 5. Shows the Vitamin D3 fluence rate and the erythemic fluence rate for each solar spectra measured. Note that below 30 degrees altitude, the two fluence rates are equivalent. Above 30 degrees the Vitamin D3 fluence rate is greater than the Erythemic Risk fluence rate.

Figure 6 shows the Ratio of the Vitamin D3 fluence rate divided by the Erythemic Risk fluence rate. At high solar elevations the ratio favors vitamin D3 formation. At lower solar altitudes, it may be impossible to form Vitamin D without sun-burning. The two artificial sources are shown on this Figure. Note the standard Tanning/PUVA unit has a lower ratio than does the SPERTI PH 36 Phototherapy unit.

DISCUSSION

Our work suggests that when the sun is low in the sky (early or late in the day or in the winter) the production of Vitamin D3 will be limited by the length of exposure time needed and by the occurrence of sunburn. In the summer, when the sun is high in the sky, little exposure will be required to produce Vitamin

D3, less than required to produce sunburn. These results contradict current wisdom about sunlight exposure.

However, one caveat needs to be considered. The Erythemic response spectrum was developed and validated in about 20 laboratories. The Vitamin D3 action spectrum is based only on the work of a single laboratory. A small change in the wavelength or energy to produce Vitamin D3 could significantly alter the interpretation of solar and other spectra. The erythemic response spectrum extends over 4 orders of magnitude from 290 - 400 nm. The Vitamin D3 response spectrum ranges over 2 orders of magnitude from 290-320 nm. In fact the response would appear to be 0 (nil) at wavelengths beyond 320 nm.

Our literature search for quantitative studies on vitamin D3 production was disappointing. We could not find quantitative data on D3 produced per square centimeter of skin irradiated with either monochromatic or polychromatic UV. While the literature suggests that aged skin is less effective at producing D3 than younger skin, no data was found to substantiate this. In the literature, it is claimed that the cheeks of children outdoors produces all the D3 they require, yet no details on solar elevations or exposure times or actual skin surface area irradiated were found.

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ABOUT VITAMIN D

Vitamin D is a vital nutrient that is unique, both in terms of its physiology and because humans rely on both endogenous skin production and exogenous sources to meet biological requirements. Vitamin D is commercially available as vitamin D2, (ergocalciferol) made from plant products, and vitamin D3, (cholecalciferol) made from animal products. Cholecalciferol is also made naturally in the skin by the action of a specific wavelength of ultraviolet light (UVB) interacting with precholesterol.

Cholecalciferol is then transported to the liver and turned into calcidiol [(25(OH)D]. In turn, the calcidiol is transported to the kidney and transformed into the steroid calcitriol which is excreted into the blood to help regulate calcium in the body. This is the main endocrine function of vitamin D.

Meanwhile, many tissues other than the kidney turn calcidiol into calcitriol to help regulate gene expression locally; this is the newly discovered autocrine (inside the cell) and paracrine (surrounding the cell) functions of vitamin D. This autocrine and paracrine function is impaired in vitamin D deficient subjects and all studies show many Americans are vitamin D deficient, especially Blacks. This use of calcitriol by other tissues as an autocrine and paracrine hormone is a relatively new discovery that explains its role in human development as well as the many health benefits of vitamin D in other illnesses such as diabetes, hypertension, heart disease, autoimmune illness, various cancers and, perhaps, some mental illness, to name a few.

The single most important scientific fact about vitamin D is that young adult Whites make about twenty thousand units of vitamin D in their skin within minutes of whole-body, summer-sun. This is one-hundred times the Adequate Intake (AI) recommended by the Institute of Medicine's Food and Nutrition Board for young adults. Therefore, many Americans greatly exceed the IOM's safety recommendations by simply spending a few minutes outside in their swimming suits! This extraordinary rate of natural vitamin D production in the skin (20,000 IU) leading to the production of a potent endocrine, paracrine and autocrine steroid hormone leads one (as T.S. Eliot once said), "to an overwhelming question." Why did Nature design such a complex system resting on bountiful natural skin production of cholecalciferol? Answer, "Probably for a very good reason."

Because low calcidiol [25(OH)D] levels (less than 35 ng/ml) are associated with so many chronic illnesses, calcidiol levels are an important part of any laboratory health evaluation and should be routinely checked by physicians. Unfortunately, few physicians are aware of this so perhaps as many as 70% of the U.S. population has calcidiol levels below 35 ng/ml. Even when asked to check vitamin D levels, physicians often order calcitriol levels, instead of calcidiol levels, an error which greatly misleads both the physician and the patient.

Healthful blood levels of calcidiol [25(OH)D] are between 35 and 60 ng/ml although commercial labs usually report "normal" or Gaussian distributions of between 8-72 ng/ml depending on the latitude of the lab's population. Therefore, commercial reference laboratories also mislead physicians and their patient by reporting "normal" (Gaussian distributions of a deficient population) instead of healthful calcidiol levels. Patients need to know these facts before asking their physician for the calcidiol [25(OH)D] blood test. Until the medical profession becomes educated on this matter, patients need to become educated, educate their physicians, get the proper blood test and then take steps to raise your calcidiol level if it is less than 35 ng/ml.

Persons with low levels have three choices: the sun, a sun lamp or vitamin D

supplements. At most latitudes in the USA, little or no vitamin D is made in the skin in the late fall and early winter. In our most northern states the vitamin D blackout lasts for about six months. In the spring and summer, Whites can make large amounts (20,000 IU) by sunbathing on both sides, without sunblock, for a few minutes (about 1/3 the time it takes for you skin to begin to slightly redden). Darker skinned persons need 5 to 10 times longer depending on the amount of melanin pigment in the skin. Vitamin D production occurs within minutes and is maximized long before your skin turns red or begins to tan. One does not have to get repeated blood tests when using sun exposure to obtain vitamin D because toxicity does not occur even with heavy and continuous sunbathing. Ultraviolet light begins to degrade vitamin D after making about 20,000 IU, thus reaching a steady state. Overexposure, e
specially sunburns, is damaging to the skin, dangerous, and should be entirely avoided.

Some sunlamps contain significant amounts of UVB and have been shown to raise calcidiol levels into the healthful range and have the added benefit of not having to worry about toxicity or obtaining repeated blood levels. Again, care must be taken not to overexpose the skin. Sunburns must be avoided. One manufacturer with some vitamin D data is Sperti. (http://www.sperti.com/products.htm)

Many people are beginning to rely on supplements to raise their calcidiol levels as they have been told (usually erroneously) to avoid the sun entirely. However, in the absence of any sunlight, one must consume 3,000 to 5,000 IU of cholecalciferol a day to maintain healthful calcidiol levels. Similar studies have not been done with ergocalciferol but current data indicates that even more ergocalciferol would be needed. Vitamin D repletion is best done under a physician's care so calcidiol levels (and perhaps calcium levels) can be monitored. Persons diagnosed with sarcoidosis, other granulomatous disease, cancer (especially lymphoma) or hyperparathyroidism should not take vitamin D unless they are under the care of a knowledgeable physician (and would be well advised to find one). Patients with these conditions may develop a vitamin D hypersensitivity syndrome which is different than vitamin D toxicity.

Persons who do not want to have blood tests would be best advised to rely on prudent sun exposure. If such persons choose to avoid the sun, they should never exceed 2,000 IU of cholecalciferol a day which is the Institute of Medicine Food and Nutrition Board's NOAEL (No Observed Adverse Effects Level).

Cholecalciferol can be obtained at most health food stores and on the internet. (http://www.lef.org/newshop/items/item00251.html) Cod liver oil contains about 1200 IU of vitamin D per tablespoon but also contains about 14,000 IU of vitamin A. Therefore, persons with no sun exposure may exceed safe intakes of vitamin A in order to replete the vitamin D system. (We know omega-3 nutrition is very important but believe fish oil to be a safer alternative than cod liver oil).

Vitamin D can be toxic in overdose (probably more than 20,000 IU a day over a prolonged period of time). We are not aware of any reports in the literature of deaths from acute overdose, such as a suicide attempts, leading to death. In fact, a 150 pound

human would have to take more than 100,000 capsules of the 1,000 IU cholecalciferol capsules to approach the LD50 for the most sensitive mammal (the male rat at 40 mg/kg). Such patients would be more likely to die from gastric bloating leading to asphyxiation than from vitamin D toxicity. In mammals, signs of toxicity short of death can first be seen at .5mg/kg (20,000 IU/kg or 1,400 capsules at one time for a 150 pound adult human).