NUMBER 297

PEAK PERFORMANCE

The research newsletter on stamina, strength and fitness

NUTRITION

Vitamin D: Let the sunshine in!

At a glance

This article
- Explains the importance of vitamin D for health and performance and the role of sunshine in maintaining vitamin D status
- Makes a number of practical recommendations for athletes seeking maximum health and performance

The risk of cancer from excessive UV radiation is well documented. But startling new research suggests that not only could avoiding sun exposure be harmful to your long-term health, it might also blunt your sport performance too. Andrew Hamilton explains…

I still remember as a kid being force-fed cod liver oil on a teaspoon by my granny. "All that vitamin D is good for your bones and teeth!" she exclaimed as I tried not to gag. She was right of course, but it's only very recently that we've begun to fully appreciate just how important vitamin D nutrition is for human health.

What is vitamin D?

Before we go on to look at some of the fascinating new research on vitamin D that has been emerging of late, it's worth taking a moment to look a little more closely at this substance. Vitamin D is actually a **hormone**-like substance in the body and belongs to a group of fat-soluble steroid-like compounds of

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Table 1: Selected Food Sources of Vitamin D

Food	IUs per serving*	Percent DV**
Cod liver oil, 1 tablespoon	1,360	340
Salmon (sockeye), cooked, 3 ounces	794	199
Mackerel, cooked, 3 ounces	388	97
Tuna fish, canned in water, drained, 3 ounces	154	39
Milk, nonfat, reduced fat, and whole, vitamin D-fortified, 1 cup	115-124	29-31
Orange juice fortified with vitamin D, 1 cup (check product labels, as amount of added vitamin D varies)	100	25
Yogurt, fortified with 20% of the DV for vitamin D, 6 ounces (more heavily fortified yogurts provide more of the DV)	80	20
Margarine, fortified, 1 tablespoon	60	15
Sardines, canned in oil, drained, 2 sardines	46	12
Liver, beef, cooked, 3.5 ounces	46	12
Ready-to-eat cereal, fortified with 10% of the DV for vitamin D, 0.75-1 cup (more heavily fortified cereals might provide more of the DV)	40	10
Egg, 1 whole (vitamin D is found in yolk)	25	6
Cheese, Swiss, 1 ounce	6	2

Source: U.S. Department of Agriculture, Agricultural Research Service. USDA Nutrient Database, Release 22, 2009
*** DV = Daily Value. DVs were developed by the U.S. Food and Drug Administration to help consumers compare the nutrient contents among products within the context of a total daily diet.*

which there are two major physiologically relevant forms: vitamin D2 (ergocalciferol) and vitamin D3 (cholecalciferol). Vitamin D without a subscript refers to either D2 or D3 or both.

Vitamin D3 is the most active form in the body and is produced in the skin of vertebrates (including ourselves!) after exposure to **UVB rays** from the sun. Vitamin D also occurs naturally in a small range of foods such as fatty fish, eggs, milk and some meats (table 1 overleaf shows some good dietary sources). Your body's 'store' of vitamin D therefore is a function of both your dietary intake and sun exposure.

A gross vitamin D deficiency, especially during childhood, can impair bone mineralisation, leading to a number of 'soft bone' diseases of which rickets is probably the best known. Rickets is a childhood disease characterised by impeded growth, and deformity, of the long bones[1]. In the late 19th and early 20th centuries, German physicians noted that consuming 1-3 teaspoons per day of cod liver oil (rich in vitamin D) could reverse rickets, and the fortification of milk with vitamin D beginning in the early 20th century1930s has made rickets a rare disease in Western countries such as the UK and US[2]. However, it is still occasionally reported, more particularly amongst communities of African or Asian descent where individuals spend a lot of time indoors and whose traditional dress covers most or all of the body[3].

Sunshine and vitamin D

Vitamin D can be synthesised from a natural substance in the body (derived from cholesterol and called 7-dehydrocholesterol) when skin is exposed to sunlight. However, it's important to note that it's the UVB rays in sunshine that are needed for this reaction to occur. When the sun is high in the sky, for example during summer months or all year round in the tropics, the sunlight contains sufficient UVB to enable the synthesis of vitamin D. However, when the sun is low in the sky, its rays have to pass through a greater volume of atmosphere to reach the surface, significantly

Jargonbuster

Hormones
Molecules that act as chemical messengers in the body and so exert powerful effects on cells

Figure 1: UVB irradiation (index) and vitamin D synthesis at different latitudes

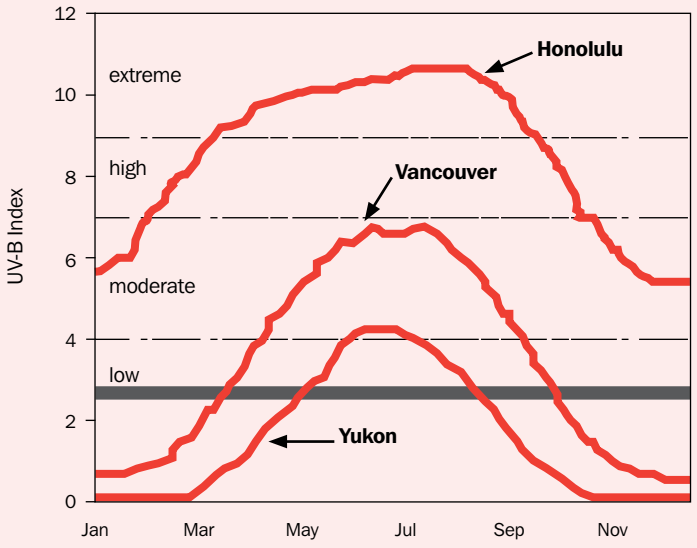
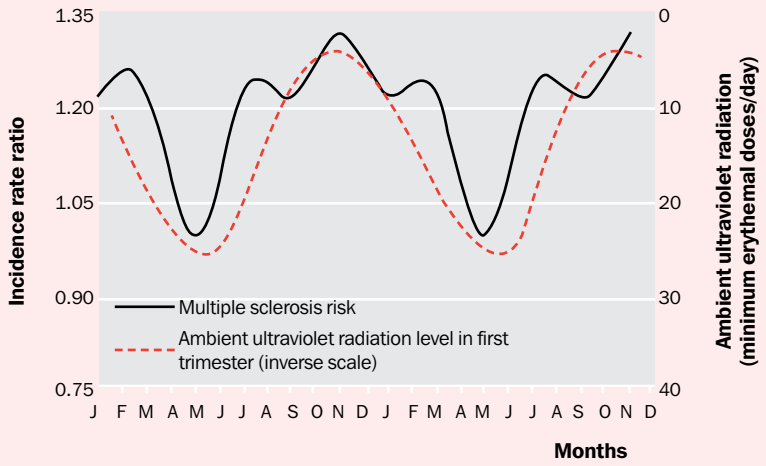


Figure 2: Risk of MS (solid line) plotted against month of birth overlaid with ambient UVB levels in the first trimester (dotted line)



NB - UVB line is on an inverse scale – ie troughs on graph correspond to peaks in UVB

attenuating the UVB content.

Indeed, studies have shown that from November through to February, when human skin is exposed to sunlight on clear sunny days at latitudes of around 42˚N (the same latitude as cities such as Boston, Rome and Marseilles), the UVB content of that sunshine is so low that no vitamin D can be synthesised even around midday when the sun is highest in the sky[4]. Move up to around 52˚N (for example London, Amsterdam and Berlin) and vitamin D synthesis in the skin becomes impossible from October right through to March!

The relationship between latitude and UVB irradiation is shown in figure 1 below for three different latitudes: Honolulu at 21˚N, Vancouver at 49˚N and Yukon at 63˚N. Note how the threshold for vitamin D synthesis (a UV index of 3 - shown by thick black line) is reached in Vancouver only from March to October an in Yukon only from May to August.

Jargonbuster

UVB (ultraviolet B) rays
electromagnetic waves emitted by the sun whose wavelengths (280-315nm) are shorter the shortest visible light waves (violet) and are powerful enough to stimulate vitamin D synthesis in skin

Sunshine and health

Why is the link between sunshine and vitamin D important? Well, a number of recent studies have shown that all other things being equal, there's a clear and linear relationship between latitude/UVB exposure and the risk of developing a number of cancers and other serious diseases such as heart disease and **multiple sclerosis**. For example, an Australian study found that there was an inverse association between ambient UVB radiation received by mums in the first trimester of pregnancy and subsequent risk of multiple sclerosis in the offspring[5]. In short, children born in May/June (ie where the first trimester fell within the Australian summer where ambient levels of UVB are higher) were significantly less likely to develop MS than those born in November/December (whose first trimester fell within the Australian winter period) – see figure 2.

More generally, a number of studies have noted a strong relationship between latitude/UVB exposure and risk of diseases such as cancers, MS and heart disease. Taking MS again, a simple plot of incidence across the globe and latitude shows a clear relationship between latitude and prevalence – the further away from the equator, the higher the risk (see figure 3)[6]. Similar relationships (ie higher latitudes/less UVB resulting in higher incidence) have been established for prostate cancer[7], lung cancer[8,9] as well as **all-cause mortality**[10].

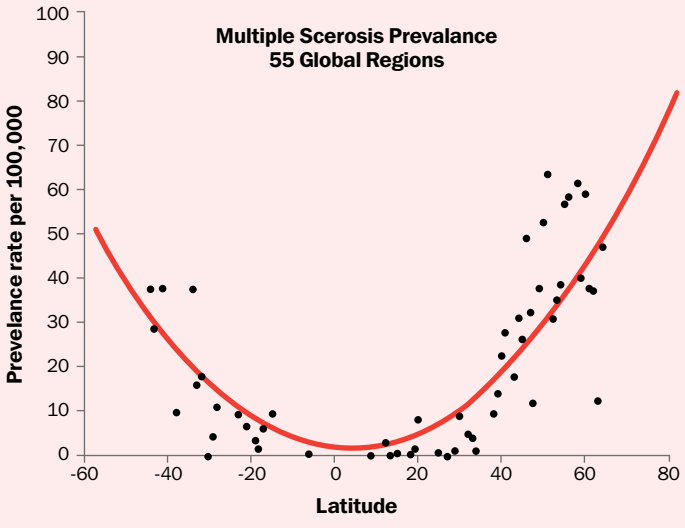
Sunshine, vitamin D and health

Why has sunshine/UVB exposure been correlated so closely with health? Well, the evidence is now overwhelming that high levels vitamin D in the body provide significant levels of protection from a number of diseases[11]. Put simply, the further away from the equator you live, the higher the risk of these diseases because your lower exposure to UVB exposure means lower levels of vitamin D in your body.

The evidence emerging between higher levels of vitamin D and health is so strong that some countries such as the US have recently amended their guidelines on dietary vitamin D intake (*see box 1*) because it's becoming very clear that the amount of vitamin D you need simply to ensure healthy bone formation is actually a long way short of the optimum intake for health.

To compound the problem, there's plenty of evidence that (especially in northern latitudes), sub-optimum vitamin D levels are widespread among the general population. For example, a German study last year concluded that vitamin D levels were insufficient in nearly half of the general German population and an additional 15-30% were actually vitamin D deficient – *ie* only a quarter of the population had adequate vitamin D levels[12].

Figure 3: Prevalence of MS plotted against latitude



Box 1: New US guidelines on vitamin D intakes

In the US, new reference intakes were introduced on 30th November 2010. These are:

- 1–70 years of age: 600IU per day
- 71+ years of age: 800IU/day
- Pregnant/lactating: 600IU/day

In the EU, the recommended daily allowance is set at just 5mcg per day (equivalent to just 200IU). However, as we shall see later, even the higher US recommendations may be woefully inadequate during the winter months when there's little ambient UVB to top up body stores.

Importantly, the researchers pointed out that adherence to present 'sun safety' policy (avoidance of the sun between 11 am and 3 pm) and dietary recommendations (5-10mcg daily for adults) will '*unavoidably and definitively lead to a vitamin D deficiency*'. They went on to calculate that the estimated cost savings in healthcare from improving vitamin D status in Germany might be up to €37.5 billion each year!

Vitamin D and athletic performance

So far we've established that plenty of vitamin D through sun exposure and dietary sources is vital to health and that sub-optimum vitamin D levels are widespread. But what are the implications for athletes? Back in the early 20th century, encouraging exposure to UVB was commonplace because many coaches and athletes believed that this was beneficial for performance despite the limited scientific evidence for this practice[13].

However recent advances in molecular biochemistry have identified that human muscle tissue contains specific receptors for vitamin D and that through its action as a steroid-like hormone, vitamin D appears to be able to enhance protein synthesis (by boosting the activity of genes) within muscle tissue[14]. As yet, no specific studies on athletes have been carried out see whether enhancing vitamin D status leads to higher strength levels but what has been well established is that significant vitamin D deficiency leads to a condition of muscle weakness known as myopathy[15,16]. Given that anything that could impair maximum muscular strength places an athlete at a potential disadvantage compared to his or her peers, optimising vitamin D status seems like a no-brainer, especially considering the health benefits it also confers.

Another reason why vitamin D status is important to athletes is its short-medium term health effects. The role of vitamin D in calcium metabolism and bone health has been known for years. However, there's also evidence that sub-optimum vitamin D status increases the risk of stress fractures from overuse injuries. For example, in a study of 800 young Finnish military recruits who underwent 90 days of vigorous training, researchers found that the main risk factor for those who went on to suffer stress fractures was a below average vitamin D status – not age, body mass index or whether the subject smoked[17]. Given that stress fracture is a serious and potentially career-threatening injury, these results are significant.

Another key reason why vitamin D status matters to sportswomen is immunity. No matter how well you plan and execute your training, it won't amount to a hill of beans if you become poorly. While you can shrug off a mild cough or cold, more serious infections such as influenza or bronchitis can devastate even the best-laid plans. We now know that adequate vitamin D is essential for a healthy immune system and in a recent review of the latest evidence on vitamin D and immunity, researchers from the University of California concluded that: *"The ability of vitamin D to influence normal human immunity is highly dependent on the vitamin D status of individuals, and may lead to aberrant response to infection or autoimmunity in those who are lacking vitamin D."*[18]

Jargonbuster

Nanogram
A billionth of a gram

All-cause mortality
The overall death rate regardless of the cause of death

Vitamin D status

To recap briefly then, we've seen that vitamin D status is incredibly important for health and well being and that an optimum status is also vital for athletes. Moreover, we also know that vitamin D levels in the body are intimately linked to sunshine exposure and that those living in higher

Box 2: Sun risk versus sun benefits

In recent years, there's (rightly) been a concerted campaign to make people aware of the hazards of excessive sun exposure and more specifically, skin cancer. However, some researchers have questioned whether, in the light of recent evidence, the current advice is over cautious.

For example, Cancer Research UK's website[22] states (correctly) that: "From October to March our skin cannot make vitamin D because of low levels of UVB in winter sunlight" but then goes on to (incorrectly) state that: "For most people, if normal levels are built up in the summer, our bodies store enough of the vitamin to last us through winter." The evidence just doesn't support this; the fact is that studies from across the world indicate that sub-optimum vitamin D status is widespread and is re-emerging as a major health problem globally[23]. Excessive sun exposure is hazardous and should be avoided but judicious and sensible exposure seems to be entirely sensible because by helping to boost vitamin D levels in the body), it may actually protect you from a range of cancers and other degenerative diseases.

For those of you who resolutely refuse to go out in the sun, the findings from a brand new study make fascinating reading. Researchers studying the sunbathing habits of Swedish women found that women who got sunburned two times or more per year during adolescence had a reduced all-cause mortality, compared with women who had been sunburned one time or less[24]. Incredibly, they also found that women who went on sunbathing vacations more than once a year over three decades had a reduced risk for all-cause mortality and mortality due to heart disease. Does this mean we should all rush out and get sunburned? No. But it does indicate that some regular sun exposure is far from harmful and actually beneficial.

latitudes may struggle to maintain optimum levels, especially during winter months. So what does the research say about typical vitamin D levels in athletes?

The evidence is not encouraging. A study by researchers from Israel (a sunny country!) looked at the vitamin D status of 98 Israeli athletes and dancers and found that no less than 73% of the subjects were vitamin D insufficient (which they defined as a blood level of less than 30 **nanograms** (ng) per millilitre (ml) of blood)[19]. And while the insufficiency rates were higher among indoor sports, the rates for outdoor sportsmen and women were still 40%! Given that Israel is a sunny country, these results are surprising and suggest vitamin D deficiency could be even more widespread at more northern latitudes.

In a recent US study, researchers looked at how vitamin D levels in 41 athletes from Carolina (12 indoor, 29 outdoor) varied through the seasons[20]. In addition, bone density was measured by dual energy x-ray absorptiometry, and injury and illness were documented as part of their routine care. These researchers used 40ng per ml as the cut-off for optimal status and found that, 75.6%, 15.2%, and 36.0% of athletes had an optimal status in the autumn, winter, and spring, respectively. They also found that the low concentrations in the spring were correlated with frequency of illness and recommended vitamin D supplementation during the winter to prevent seasonal decreases.

In another US study reviewing evidence on the vitamin D status of athletes[21], the researchers concluded that: "It is likely that compromised vitamin D status can affect an athlete's overall health and ability to train, by affecting bone health, innate immunity, and exercise-related immunity and inflammation." They also argued that the optimum minimum blood levels of vitamin D for athletes need to be higher than the more conservative figure of 30-40ng per ml and recommended that athletes achieve a blood vitamin D status of at least 75ng per ml by:

Including regular safe sun exposure (twice a week between the hours of 10am and 3pm - ie when the sun is high in the sky) on the arms and legs for 5-30 minutes, depending on season, latitude, and skin pigmentation (*see box 2*);

When the above is not possible (eg from October to March at latitudes of 50o or more) dietary supplementation with 1,000-2,000 IU vitamin D3 per day.

Conclusion

Vitamin D is far more important for health and performance than we recently believed and many nutritional researchers now believe that vitamin D deficiency is perhaps the most widespread deficiency across the globe and the cause of many diseases and early death among those who are habitually deficient. Importantly for athletes (even those who train outdoors regularly)– studies also shown that many of us, whether through diet, lack of sunshine or both, don't get enough vitamin D with potentially serious consequences for performance.

Practical implications

Vitamin D deficiency appears to be far more widespread than previously believed with potentially undesirable performance consequences. Athletes should therefore:

- Aim to consume a vitamin D-rich diet all year round but especially during winter months;
- Consider supplementation of at least 600IU per day and up to 1000IU during the winter months;
- During spring, summer and autumn, try to expose the skin of the legs and arms to regular, sensible doses (5-30 minutes a day) of sunshine between the hours 10am and 3pm without the use of sunscreen;
- As an additional safeguard, vitamin D levels can be checked by blood tests; athletes should ensure blood levels of at least 40ng per ml.

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'Vitamin D is far more important for health and performance than we recently believed and many nutritional researchers now believe that vitamin D deficiency is perhaps the most widespread deficiency across the globe'

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