Overview

Measurements and units
(i) Vitamin D3 supplements are measured in either international units (IU) or micrograms (mcg). For vitamin D3 one microgram = 40 international units. The ratio is different for other substances, according to the substance’s molar mass.

(ii) Blood/serum vitamin D3 levels are measured in either nanograms per millilitre (ng/ml) or nanomoles per litre (nmol/L). For vitamin D3 one nanogram per millilitre equals 2.496 nanomoles per litre. The ratio is different for other substances.

Green Health Watch Magazine is based in the UK, where it encourages:

► sensible sunbathing’ whenever possible, without using sunscreens or creams. ‘Sensible sunbathing’ may be defined as ‘sunbathing for up to fifteen minutes a side, dependent on skin type, between the hours of 10am and noon, and 2pm and 5pm, without using sunscreen

Direct sunlight on the skin and through the eye (i.e. not through glass or transparent plastic) when the sunlight is sufficiently strong (from May to September) is the major source of the ultraviolet B (UVB) light the body needs in order to generate its own vitamin D3.

Most sunscreens block UVB for good reason. They are intended to allow people to sunbathe safely for longer periods, and over-exposure to UVB has been linked to:

► the most common forms of skin cancer, (i) squamous cell carcinoma, which can spread, becoming lethal, and (ii) basal cell carcinoma

► eye lens damage and cataracts

Whether the cancer risks from the contents of most sunscreens outweigh the cancer risks from UVB is another matter!

► regular walks on sunny days, especially from May to September, exposing as much skin as possible, and without the use of sunscreen or sunglasses

How important is D3?
As our knowledge has grown, it has become evident that D3 is essential for the optimum functioning of most of the body’s systems. Originally it was thought that the kidneys provided the body’s needs. Now we know that many individual organs produce their own supplies (perhaps these are ‘back-up supplies’) as well. The body needs adequate levels of D3 in order to absorb calcium from food. The growing list of illnesses linked to inadequate blood levels of D3 now includes osteomalacia (rickets), periodontal (gum) disease, osteoporosis, rheumatoid arthritis, high blood pressure, colon, breast, prostate and ovarian cancers, heart disease, multiple sclerosis, atherosclerosis, tuberculosis, seasonal affective disorder, depression, obesity and type 1 diabetes. Enough said? And see ‘Cost-effective Solutions’ below.

Are there different forms of vitamin D?
There are five forms of vitamin D, but we are only concerned with two here:

► Vitamin D3, also known as cholecalciferol, is the animal form of vitamin D. It is made when cholesterol (via 7-dehydrocholesterol) in the skin reacts with ultraviolet light

► Vitamin D2, also known as ergocalciferol, is the plant form of vitamin D, and is found principally in fungi. In order to use D2 the human body has to convert it into D3. Food scientists state that it converts 3,000 international units (IU) of D2 into around 1,000IU of D3 (see also ‘Vitamin D3 more effective than vitamin D2’ below)
How much vitamin D3 do I need?

This is controversial.

- The minimum daily intake often recommended by researchers investigating vitamin D3’s role in preventing illness, for example, is 800IU. However, many now recommend that adults take between 2,000IU and 3,000IU. Interestingly, one study found that ‘healthy men’ used 3,000-5,000IU a day.2
- The US Institute of Medicine recommends a daily intake of ...
  - People aged 1-69 years - 600IU/15mcg
  - People aged 70+ years - 800IU/20mcg
  - Breastfeeding mothers - 600IU/15mcg
- The UK Department of Health seems to know very little about vitamin D. It recommends a daily intake of ...
  - all infants and children aged between six months and five years (unless they are drinking at least 500ml/one pint of vitamin D-fortified infant formula a day at any time during this age range) - 280-320IU/7.8-8.5mcg a day

Children aged six plus - none required
Adults aged up to 64 - none required
(both, the Department of Health tells us, should get sufficient from sunlight and diet)
Adults aged 65+ - 400IU/10mcg
People not exposed to much sun - 400IU/10mcg
Breastfeeding mothers - 400IU/10mcg

See also the section ‘Children’s health’ below.

- The human body appears to think that it needs significantly more than either Governments or researchers recommend. Within 37° latitude of the equator (i.e. south of Athens (Greece) or Malaga (Spain) in the northern hemisphere, north of Melbourne (Australia) or Buenos Aires (Argentina) in the southern hemisphere) the body of a fair-skinned person sunbathing at sea level for just 20 minutes during the four hours the sun is at its highest should generate around 20,000IU/500mcg of D3.3 Once 20,000IU/500mcg have been generated, production is closed down for that day (but see ‘Living far from the equator’ below).

- A person with black skin appears to need six times as long, a person with a brown skin somewhere in between, to generate 20,000IU/500mcg, which lends some support to the hypothesis that peoples which migrated to less sunny climes evolved lighter skins to maximise D3 production.

Setting recommended daily Vitamin D dietary intakes
To set a recommended daily vitamin D dietary intake one has to:

- Decide one’s aim. That could be, for instance, to help bring the health of the population up to (i) an optimum level, (ii) a level where the population is protected to some degree against other illnesses, (iii) a level which prevents embarrassing rates of an embarrassing disease (e.g. rickets), or (iv) survival levels (the origin of the US’s recommended daily allowances (RDAs).

One’s aim would be stated in terms of achieving an ‘average blood vitamin D3 level within the population’ and what that average blood vitamin D3 level was. This is more difficult than one might suppose. Vitamin D is a relatively new science. What blood vitamin D3 levels correspond to the four example aims above is controversial (see below)

- Establish one’s starting point, i.e. the population’s current average blood vitamin D3 level

- Estimate the population’s likelihood of raising its average blood vitamin D3 level by increasing its skin exposure to sufficiently strong sunlight. As there are no practical food sources of vitamin D3, dietary changes are not relevant in this case (see ‘Other sources of vitamin D3’ below)

As the latitude band within which the population lives and the weather the population enjoys/endures are what they are, this is down to changes in lifestyle (e.g. less indoors and more outdoors activities, ‘sensible sunbathing’ whenever possible) during the months when sunlight is
sufficiently strong to trigger the body’s production of vitamin D3).

n.b. (i) In some countries (e.g. Scotland) the latitude band and weather are such that lifestyle changes have little blood vitamin D3 level raising potential

(ii) In some large countries the latitude band is so wide and the weather so varied (e.g. USA) that separate recommended daily vitamin D dietary intakes need to be set region by region

Contra-indications
There are several illnesses where taking high levels of vitamin D3 may be inadvisable, e.g.:

- anyone with kidney stones, hypercalcaemia (a disturbance of the body’s calcium equilibrium leading to excessive blood calcium levels and the calcification of soft tissue, like artery walls), hyperparathyroidism
- anyone taking diazpyrazide diuretics
- anyone with sarcoidosis, any granulomatous malignancy such as lymphoma, oat-cell lung cancer, or when cancer has spread to the bone

There are other instances where high levels of vitamin D may be inadvisable, and where Green Health Watch Magazine strongly advises anyone considering a high daily dosage of vitamin D3 to first consult their doctor. S/he can also prescribe a test to determine your blood vitamin D3 level.

- The US campaigning organisation The Vitamin D Council also warns that anyone who has had radiotherapy should avoid exposing sensitive skin to the sun, and that some drugs may cause photosensitivity, so it is important to consult your doctor.

The herb St. John’s Wort also causes photosensitivity

- Do not try to meet vitamin D3 needs by consuming cod liver oil. The amount you would need to consume daily would bring you to the very edge of pre-formed retinol (a form of vitamin A) toxicity (see ‘Cod liver oil not a useful source of vitamin D’ below)

There is no point, anyway, in taking a vitamin D3 supplement if one consumes significant amounts of pre-formed retinol (e.g. in cod liver oil and in all vitamin supplements containing retinyl palmitate or retinyl acetate). Preformed retinol antagonises (counteracts) the action of vitamin D3.

Vitamin D3 may be usefully taken in the presence of beta carotene (another form of vitamin A), which does not have this effect.

What are healthy blood vitamin D3 levels?
Nutritional scientists continue to debate what the level of blood serum vitamin D3 should be to make a healthy human. Some argue that it should be at least 20 nanograms per millilitre (ng/ml) because 20ng/ml is generally sufficient to suppress the production of parathyroid hormone (which erodes bone). Others plump for 30ng/ml because the absorption of calcium in the gut (and in bone) is maximised at that level.

Still others (like Bruce Hollis, Robert Heaney and Neil Binkley) argue that 50+ng/ml should be the minimum. They note that:

- below 50ng/ml the body uses up vitamin D3 faster than it makes it
- when a young mother’s blood serum contains 50+ng/ml her breast milk contains enough vitamin D3 to ensure adequate levels of the vitamin in the blood serum of her baby.

(One could claim that breast milk is not supposed to have vitamin D3 in it, and that primitive woman was supposed to expose their infants to predators (which I find unlikely). Besides, we know that any woman receiving consistent full body sun exposure would have vitamin D3 in her breast milk)

Editorial
The Vitamin D Council supports an aim of 50-70ng/ml for four further reasons:

- the average vitamin D3 level of humans who work in the sun in reduced clothing, such as builders and lifeguards, is between 40ng/ml and 60ng/ml
- the average vitamin D3 level of people who begin to store vitamin D3’s parent compound (cholecalciferol) in their fat and muscles is around 40ng/ml
- the Endocrine Society recommends that healthy vitamin D3 levels are somewhere around 50ng/ml
- the average vitamin D3 level of our closest simian relatives, such as chimpanzees living wild in Africa, is between 40ng/ml and 60ng/ml. This, by itself, does not prove we need such levels, but it certainly raises that question

(15153) Vitamin D Council 3.5.2011

See also the sections ‘Government advice’ and ‘Vitamin D3 - more science’, the article ‘Raising breastmilk D3 levels’ in the section ‘Children’s health’ and the article ‘What are the vitamin D experts missing?’ in the ‘Heart disease’ part of the section ‘Illnesses of our time’ below.

What is a safe daily intake of D3?
Again controversial.

The US Department of Health accepts that 2,000IU/50mcg a day is completely safe for adults and children (1,000IU/25mcg for infants below age 12 months) providing they do not have a medical condition (e.g. hyperparathyroidism, sarcoidosis) that may be worsened by high vitamin D3 levels, or are taking a synthetic drug (e.g. warfarin, combined HRT) which makes them hypersensitive to vitamin D.

Citing a 1999 study, a vitamin D expert Geoff Venning states that there has not been any evidence of adverse effects in normal people from supplementation with up to 10,000IU/250mcg a day. The lowest level of supplementation ever shown clinically to have an adverse effect was 40,000IU/1,000mcg a day.

See also the section ‘Vitamin D3 Safety’ below.

Living far from the equator
For people living further than 37° from the equator, getting enough D3 is much more difficult. At sea level, half an hour’s sunbathing when the weather permits during the months of May to September will generate similar levels to 20 minutes sunbathing
UVB Emission from sunlight and commercial sunlamps

<table>
<thead>
<tr>
<th>Source/Sunlight or type of lamp/study</th>
<th>Distance from centre of lamp (centimetres)</th>
<th>Irradiance of sun/lamplight (microwatts per centimetre)</th>
<th>Time required for 5 min of UVB light at noon from the equator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equator, noon, solar elevation angle 0.0</td>
<td>n/a</td>
<td>265.00</td>
<td>5.0 minutes</td>
</tr>
<tr>
<td>Midlands, England (53 N), sunny, July 28, peak intensity SEA 30°</td>
<td>n/a</td>
<td>178.00</td>
<td>7.2 minutes</td>
</tr>
<tr>
<td>Duro-Test Vita-Lite; 20 watt, 12&quot; (30.5 cm)</td>
<td>12&quot; (30.5 cm)</td>
<td>1.10</td>
<td>20.0 hours</td>
</tr>
<tr>
<td>Sylvania F20T12/350 BL; 20 watt, 12&quot; (30.5 cm)</td>
<td>12&quot; (30.5 cm)</td>
<td>2.60</td>
<td>8.4 hours</td>
</tr>
<tr>
<td>Westinghouse FS20 Sunlamp; 20 watt, 12&quot; (30.5 cm)</td>
<td>12&quot; (30.5 cm)</td>
<td>66.00</td>
<td>20.0 minutes</td>
</tr>
</tbody>
</table>


nearer the equator. From October to April, however, the angle of the sun’s rays to vertical is so oblique that virtually all UVB is blocked by the Earth’s atmosphere.

Although excess D3 from summer exposures is stored in the body fat, approximately 60% of Britons are deficient by the end of the winter. The deficiency is not usually so severe as to cause the bone-softening condition osteomalacia (rickets), but could damage bone as well as increase the risk of developing one of the wide variety of illnesses listed above.

OTHER SOURCES OF VITAMIN D3

Skin exposure to sufficiently strong sunlight is the best way to boost your blood vitamin D3 level. The second best way is careful use of a or a sun bed/lamp. The third best way is a dietary supplement. Although technically a source of vitamin D, food is not a practical source (see below).

Artificial sunlight

There are two artificial sources of UVB, and thus D3, to consider - full spectrum lighting and sun lamps/beds.

Full spectrum lighting

Full spectrum lighting has been used for many years to provide caged tropical bird and reptiles with the UVB they need to thrive. To give benefit, the lighting source has to be within a foot or two of the animal. The bulbs have to be renewed fairly frequently because the UVB emissions they emit diminish after a few months’ use.

Many human health benefits are claimed for full spectrum light bulbs and fluorescent tubes. Some of these may be true, and full spectrum lighting in the home is certainly uplifting (‘My spirit riseth with the sun’, etc.), but any benefits are extremely unlikely to be due to increased vitamin D production in everyday living conditions. And by the way, full spectrum lighting is not needed to treat seasonal affective disorder, it is the brightness of the light that counts - a light source with a brightness exceeding 10,000 lux.

A 1995 study measured the UVB emissions of (i) sunlight in different parts of the world at different times of year and various makes of (ii) full spectrum lighting and (iii) sun lamps.

Tanning lamps/beds

Research has shown, however, that close exposure to the light produced by sun lamps/beds provides sufficient UVB to trigger D3 production and increase blood vitamin D levels, leading to health benefits.

- A recent study at Boston University School of Medicine (US), for instance, found that blood levels of D3 were almost twice as high in sunbed users as in non-users. Sunbed users’ bone densities at the hip were also significantly higher.

- Chron’s disease can lead to D3 deficiency and therefore to osteoporosis (the body needs a good level of D3 to absorb calcium from food). A woman with Chron’s was exposed to ultraviolet B (UVB) radiation on a tanning bed wearing a one-piece bathing suit for 10 minutes three times a week.

After four weeks, her blood D3 level had quadrupled from seven to 32 nanograms a millilitre and her blood calcium level had increased by 10%. After six months treatment, her levels had returned to the normal healthy range and she had become free of muscle weakness and bone and muscle pain.

But, like the sun itself, sunbeds and sun lamps must be used with extreme care. In the UVB emission study quoted above, it took a Westinghouse 20 watt sunlamp just 8.3 minutes to produce the same amount of UVB as five minutes noonday sunbathing at the equator.

As with the sun, it appears that people often overdo it in search of a tan:

- A Cancer Research UK study found that people using sun beds or sun lamps had more than doubled their risk of developing squamous cell carcinoma. They had also increased their risk of developing basal cell carcinoma by 50%. The more years people had used sun beds or sun lamps, the greater their risk had become.

- Three case-controlled studies suggested that using...
a sun lamp might increase the risk of eye cancer between twofold and fourfold. On top of all that, the ends of the fluorescent tubes used in sunbeds often emit both X-rays and high levels of electromagnetic frequency radiation, BUT

► It is now possible to buy ‘Vitamin D sun lamps/beds that reduce the risk of sunburn and developing skin cancer from over-enthusiastic use/vanity by providing only the wave lengths of light needed to trigger the body’s vitamin D3 production.

See also the section ‘Lifestyle’ below.

Food supplements

**Vitamin D2 versus vitamin D3**

To get the most for your money, make sure that the vitamin D supplement that you are considering buying is ‘food state’, and that it is D3 (cholecalciferol) not D2 (ergocalciferol). It has been generally accepted for some time that:

► treating a patient with either of the two calciferol forms of vitamin D (ergocalciferol (vitamin D2) or cholecalciferol (vitamin D3) raises blood vitamin D levels

► it takes roughly three and a half times as much D2 as D3 to achieve the same rise

See also ‘Vitamin D2 versus vitamin D3’ in the section ‘Vitamin D3 - More Science’

Diet

There are no practical food sources of vitamin D3. Here are the richest according to the US Institute of Medicine (IOM) of the National Academy of Sciences

<table>
<thead>
<tr>
<th>Dietary source</th>
<th>International units (IU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cod liver oil, 1 tablespoon</td>
<td>1,360</td>
</tr>
<tr>
<td>Salmon, cooked, 3½ ounces</td>
<td>360</td>
</tr>
<tr>
<td>Mackerel, cooked, ¾ ounces</td>
<td>200</td>
</tr>
<tr>
<td>Tuna fish, canned in oil, 3 ounces</td>
<td>200</td>
</tr>
<tr>
<td>Sardines, canned in oil, drained, 1½ ounces</td>
<td>250</td>
</tr>
<tr>
<td>Egg, 1 whole (vitamin D3 is found in egg yolk)</td>
<td>20</td>
</tr>
<tr>
<td>Liver, beef, cooked, ¾ ounces</td>
<td>15</td>
</tr>
<tr>
<td>Cheese, Swiss, 1 ounce</td>
<td>12</td>
</tr>
</tbody>
</table>

So, if someone living in the UK was aiming at a daily D3 intake above 1,000IU from October to April, the only feasible food source would appear to be cod liver oil (one tablespoon delivers 1,360IU).

But, ideally, this would be organic. Cod are high in the food chain so likely to contain significant levels of pollution. The cod liver oil would also have to be ‘virgin’ or cold-pressed and unprocessed. Various companies have tried to find ways to de-pollute and make cod liver oil palatable but, in all cases, these processes appear to have reduced the oil’s natural D3 content considerably. For instance, all but one of Nordic Naturals’ cod liver oil products, famous for their purity and an excellent source of essentially fatty acids, contain no more than 40IU/1mcg of D3 per teaspoonful. Their capsules never claim more than 20IU/0.5mcg. The one exception is their D3-fortified lemon-flavoured Arctic-D Cod Liver Oil. One teaspoon (5ml) contains 400IU/10mcg but, to date, we have not yet been able to find a source in the UK.

And there is another problem with cod liver oil that effectively rules it out ...

**Cod liver oil not a useful source of vitamin D**

Sixteen vitamin D experts warned against trying to get adequate supplies of vitamin D by taking cod liver oil. The problem is that:

► ‘adequate supplies of vitamin D’ for white-skinned people living more than 45° latitude north or south of the equator is now considered to be 1,000-2,000 international units (IU)/25-50 micrograms (mcg) a day from October to May, and

► for every one IU/0.025mcg of vitamin D in cod liver oil you also take in 10IU/3mcg of retinol (a form of vitamin A)

Achieving an intake of (e.g.) 1,000IU/25mcg of vitamin D from cod liver oil would therefore also supply 10,000IU/3,000mcg of retinol a day, right on the threshold of retinol toxicity.


**Sun-dried shiitake mushrooms**

Actually, there is one phenomenal plant source (of vitamin D2) - sun-dried Shiitake mushrooms (see ‘Shiitake mushrooms’ in the section ‘Diet’ below) but these are nigh impossible to find in practical quantities in the UK.

**TESTING YOUR VITAMIN D LEVEL**

Dr. John Cannell of the Vitamin D Council recommends that people wishing to test their levels of D3 request a 25-hydroxy-vitamin D blood test. He warns that many doctors will automatically order a test for activated vitamin D (1,25-dihydroxy-vitamin D or calcitriol) levels, but that calcitriol levels should never be used to determine adequate D3 levels because calcitriol is often elevated in cases of vitamin D3 deficiency. If your doctor insists on ordering a calcitriol level test, find another doctor.

However, the limitations of the current technology make even the correct test unreliable. (Different laboratories report different results from the same specimen of blood. The same laboratory will often report significantly different levels from the same specimen of blood at different times.) In general, low numbers are more reliable than high numbers because interfering substances can easily give falsely elevated results. One of the more reliable testing facilities is the Endocrine Laboratory in the Clinical Chemistry Department of Charing Cross Hospital (Fulham Palace Road, London, W6 8RF ☎0208 383 3645), but this service may only be accessed via your GP.

The Vitamin D Council has developed its own DIY vitamin D test because:

► some doctors refuse to order the correct test - the 25-hydroxy-vitamin D (25(OH)D) blood test

► other doctors order the wrong test - the 1,25-dihydroxy-vitamin D (1,25-vitamin D) blood test

The Council has commissioned ZRT Laboratory to carry out its test, which is available to people living in...
most countries worldwide, and may be ordered online via web page:
http://www.vitamindcouncil.org/health/
deficiency/am-i-vitamin-d-deficient.shtml

The Vitamin D Council’s test may also be ordered directly from ZRT. For more information contact:
ZRT, 8605 SW Creekside Place, Beaverton, OR 97008, USA  
☎ 00 1 503-466-2445  email: info@zrtlab.com

As at February 2011 the cost of the Vitamin D Council’s DIY in-home test was
one test = $65 +$25 p&p = $90; four tests ordered at the same time (e.g. for a family) = $220 +$25 p&p = $225

The Council receives 15% of all Vitamin D Council/ZRT vitamin D3 blood serum level test sales to fund its work.

3b US Institute of Medicine Food and Nutrition Board 1997
5 Stamets,P and Plotnikoff,GA. Int. Jnl Medicinal Mushrooms 2005;7(3):471-72
11 Dolin,P. British Medical Journal 1995;311:573

This may suggest a vested interest to some readers, but if you doubt your ability to get sufficient vitamin D3 from the sun for whatever reason, Green Health Watch Magazine’s online shop, Lifeworks Mail Order, sells tubs of 250 x 1,000IU/25mcg doses of vitamin D3 in vegetarian capsules for £13 + £4 p&p.

For more information contact:
Lifeworks Mail Order, Muir of Logie, Dunphail, Forres, Scotland IV36 2QG
☎: 01309 611200  email: contact@greenhealthwatch.com