Vitamin D for Human Health

Dr Linda Browning

What is vitamin D?

Vitamin D is a fat soluble vitamin which is essential for strong bones, healthy skin and a healthy immune system. The vitamin D metabolite known as vitamin D_3 is primarily sourced from sunlight acting on the skin of vertebrate animals and it has been called the sunshine vitamin. Vitamin D_3 is the metabolite of vitamin D found naturally in animals. Vitamin D_3 is naturally present in animal sourced vitamin D rich foods. Therefore, vitamin D_3 can be provided from sunshine acting on skin or from vitamin D_3 rich foods.

Vitamin D_3 is transferred via blood serum to the liver where it is changed into the more active 25-hydroxyvitamin D_3 (25(OH) $D_{3)}$. The level of 25(OH)D_3 is used to measure the status of vitamin D in humans. From the liver 25(OH)D_3 is transferred to the kidney via serum where it is further changed to an even more active form of vitamin D known as 1,25dihydroxyvitamin D_3 (1,25(OH)$_2D_3$).

1, 25-dihydroxyvitamin D_3 is a highly active hormonal form of vitamin D and functions in most cells of the body by attaching to vitamin D receptors within each cell. Vitamin D receptors can be found in bone, skin, muscle and brain cells. A schematic diagram of vitamin D metabolism in the human body is found in Figure 1. The term vitamin D is a collective term for all vitamin D_3 metabolites. Vitamin D_2 is the vitamin D metabolite of plants and fungi such as mushrooms. Vitamin D_2 has significantly lower levels of vitamin D potency in human nutrition.

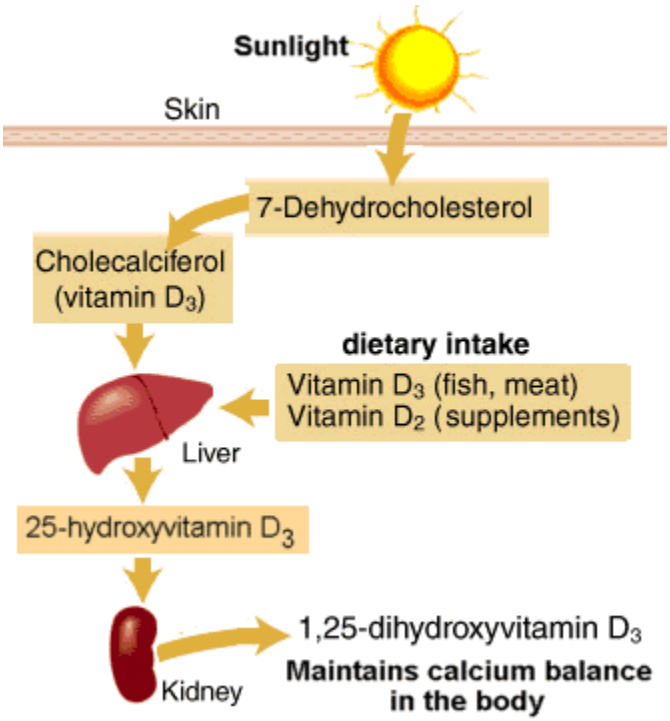


Figure 1:
Sunshine produces vitamin D_3 in the skin which is converted into more active vitamin D metabolites in the liver and kidney

Although vitamin D is formed within human skin from sunlight, many people in our modern society do not have access to sufficient sunshine because they live and work predominantly indoors. Furthermore, when people are outdoors they frequently protect their skin from sunshine by wearing sunscreens and clothing and they do not have the opportunity to make sufficient vitamin D on their skin. They need to obtain their essential vitamin D requirements from their diet.

Sunscreens work by absorbing UVB (290-315 nm) and some UVA (321–400 nm) radiation before it enters the skin. Therefore, it is not surprising that a sunscreen with a sun protection factor (SPF) of 8 reduces the capacity of the skin to produce vitamin D_3 by 95%; properly used sunscreen with a SPF of 15 reduces the capacity by 98% (Matsuoka et al. 1987). This fact is illustrated in Figure 2 below.

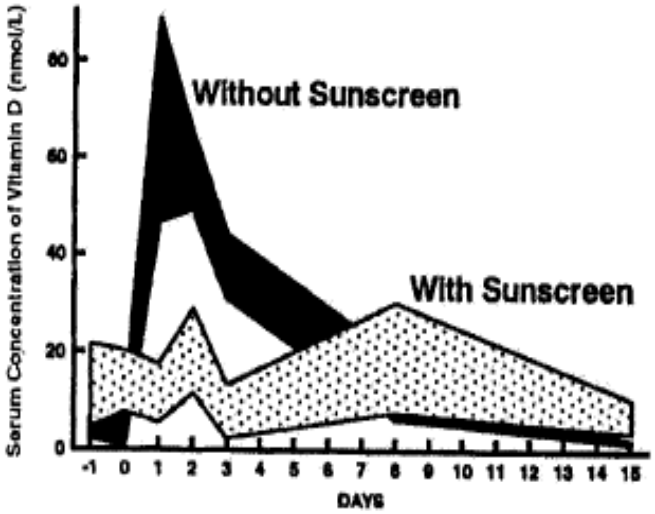


Figure 2.
Graph shows the effect of sunscreen on vitamin D levels in serum (Matsuoka et al. 1987).

The amount of vitamin D_3 in the epidermis of the skin is relatively constant until later in life, when it begins to decline (17, 18). A person 70 years of age exposed to the same amount of sunlight as a 20-year-old person makes 25% of the vitamin D_3 that the 20-year-old person can make (Matsuoka et al. 1987).

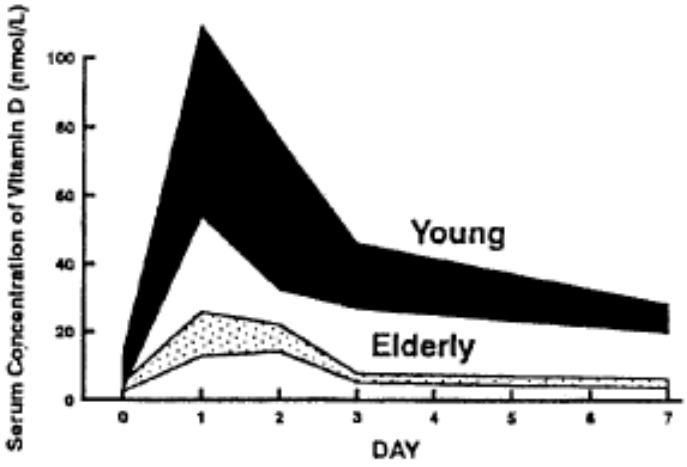


Figure 3.
Graph how age decreases the ability of skin to produce vitamin D_3 (Matsuoka et al. 1987).

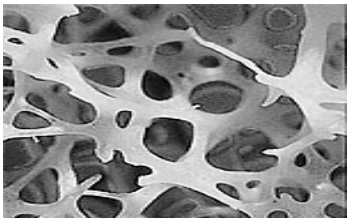
Role of Vitamin D in bone health

A major function of vitamin D is to maintain calcium levels within blood at correct levels for bone mineralization and cellular function. In children, a deficiency of vitamin D will cause bone tissue not to correctly mineralize and this disease known as rickets. Rickets was very widespread in industrial countries in the late 19th and 20th centuries due to lack of sunshine as a result of pollution (Holick 2004).

Figure 4.
This photo provides typical presentation of 2 children with rickets. The child in the middle is normal; the children on both sides have severe muscle weakness and bone deformities, including bowed legs (right) and knock knees (left).

In adults, a deficiency of vitamin D may produce a disease known as osteoporosis, in which bone strength is reduced and bone fractures are more frequent. Osteoporosis is widespread with approximately 47% of women and 22% of men, aged 50 years and older, sustaining an osteoporotic fracture in their remaining lifetime (Holick 2007). The increase in osteoporosis with age corresponds to the reduced ability of older skin to metabolize vitamin D_3.

Figure 5. Bone under electron microscope

Healthy bone 

Osteoporotic bone 

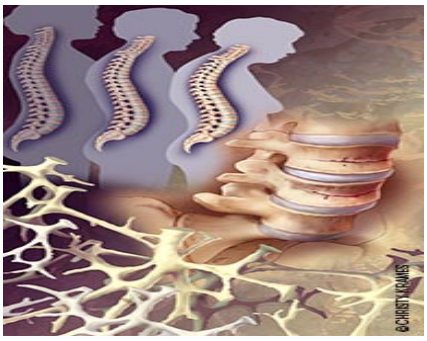


Figure 6.
Osteoporosis is a loss of bone mineralization caused in part by a vitamin D deficiency which affects more than 200 million women worldwide and men also.

Role of Vitamin D in cancer

Research has indicated that adequate levels of vitamin D may help prevent colon, breast and breast cancers. Population studies have indicated that blood or serum levels of $25(OH)D_3$ less than 50 nmol/L are to be associated with a 30 to 50% increased risk of incident colon, prostrate and breast cancer and high associated mortalities from such cancers (Gorham et al. 2005, Giovannucci et al. 2006, Garland et al. 2006). In addition recent research has shown higher levels of $25(OH)D_3$ in serum has a positive effect in preventing lung cancer development (Chen et al. 2015).

Role of Vitamin D in diabetes

Several studies suggest vitamin D supplementation early in life may reduce the development of type 1 diabetes. A study in Finland with 10,366 children found that those children given 2000 IU of vitamin D_3 each day in their first year of life and followed for 31 years thereafter, had approximately 80% reduction in Type 1 diabetes.(Hyppönen et al. 2001).

Another study in America in women showed that a combined intake of 1200mg of calcium and 800 IU of vitamin D lowered the risk of type 2 diabetes by 33% as compared to a daily intake of less than 600 mg of calcium and less than 400 IU of vitamin D (Pittas et al. 2006).

Role of vitamin D and depression

Vitamin D has also been linked to depression one of the most common mental disorders (affecting about one in five adults). However, the various research experiments have produced variable results. One reason for this is that people who exercise outside may have higher levels of vitamin D but any improvement in their level of depression may result from the increased activity itself.

One study in Europe, examined 1283 community-based elderly residents (65-95 years). Those residents who had higher levels of depression had significantly lower levels of $25(OH)D_3$ (Hoogendijk et al. 2008). As discussed previously $25(OH)D_3$ is the vitamin D metabolite used to assess vitamin D status

Another large population based survey of 2070 elderly participants aged 65 years and older, found there was a significant increased risk of depressive symptoms in those with vitamin D deficiency (Hoogendijk et al. 2008).

In addition, a very large study with 81,189 women found that those women with the highest score on depressive symptoms over a 3 year period, had the lowest intake of dietary vitamin D (Bertone-Johnson et al. 2011).These findings persisted after adjustments for a range of potential confounding factors.

In respect to children, a United Kingdom study of approximately 2700 children found a significant association between low serum vitamin D measured at 9 years of age and higher scores on depressive symptoms assessed at age 11 -14 years (Tolppanen et al. 2012). Again this association persisted when controlled for a range of potential compounds.

Role of Vitamin D in autism

Recent Australian research was undertaken with 4229 pregnant women. It was shown that there was a significant increase in autism-related traits in those children (tested at approximately 6 years of age) born from mothers who were vitamin D deficient during pregnancy (Vinkhuyzen et al. 2016). In other words those women who had vitamin D levels in their blood greater than 50 nmol/L (vitamin D sufficient) had significantly fewer children with autism-related traits.

Role of Vitamin D and cardiovascular disease

A growing body of evidence suggests that vitamin D deficiency may adversely affect the risk of cardiovascular disease (heart disease and stroke). A major study conducted over 5 years in the United Kingdom with 1739 men and women (with an average age of 59) showed that a deficiency of vitamin D was associated with a significant increase in cardiovascular disease (Wang et al. 2008). In this study moderate to severe vitamin D deficiency had a greater effect on cardiovascular disease than even hypertension. In addition, in this study those people with hypertension plus a vitamin D deficiency produced a further increase in cardiovascular disease.

Vitamin D status in Australia

Though the importance of the physiological role vitamin D is widely accepted there is also an increased recognition that the vitamin D nutritional status of the human population is lower than optimum (Chapuy et al. 1997). The Working Group of the Australian and New Zealand Bone and Mineral Society; Endocrine Society of Australia; Osteoporosis Australia 2005 has defined vitamin D nutritional status in the population as follows; (NHMRC 2006)

Not deficient vitamin D = blood serum 25(OH) D_3 greater than 50 nmol/L.
Mild deficiency vitamin D = blood serum 25(OH) D_3 levels between 25 - 50 nmol/L.
Moderate deficiency vitamin D = blood serum 25(OH) D_3 between 12.5 - 25 nmol/L.
Severe deficiency vitamin D = blood serum 25(OH) D_3 less than 12.5 nmol/L.

In Australia, a survey was undertaken within three regions located at different latitudes, Southeast Queensland region, Geelong region and Tasmania. They found a vitamin D insufficiency or mild deficiency (≤ 50nmol/L) in 40.5% of women in Southeast Queensland, 37.4% in the Geelong region and 67.3% in Tasmania. It was concluded that vitamin D insufficiency is common within Australia irrespective of the latitude (van der Mei et al. 2007). Van der Mei et al. suggested a need to pursue other means to achieve vitamin D adequacy in Australia. Details of this study are found in the diagram below.

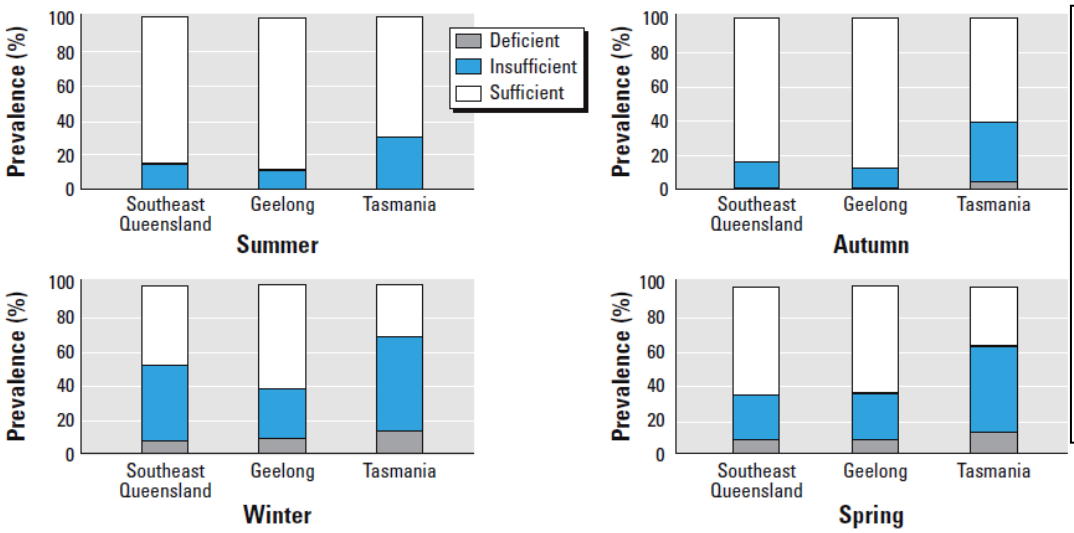


Figure 7.
Prevalence of vitamin D deficiency by season in women less than 60 years of age at 3 Australian locations;
Southwest Queensland (37°S)
Geelong (38°S)
Tasmania (41-43°S).

Measured by 25(OH)D_3
Vitamin D deficient < 25 nmol/L
Vitamin D insufficient = 26-50 nmol/L

Recommended vitamin D allowances in Australia

The Australian National Health and Medical Research Council (NHMRC) has published its recommendations for vitamin D intake based on life stage and gender (NHMRC 2006). For everyday usage dietary intakes of vitamin D are often expressed in terms of International Units (IU).

Age	**AI (Adequate Intake)**
0-12 months	200 IU/day
1-18 years	200 IU/day
19-50 years	200 IU/day
51-70 years	400 IU/day
>70years	600 IU/day

The NHMRC has also recommended upper levels of intake of Vitamin D based on studies studying the effect of vitamin D on serum calcium in humans. There is some animal evidence of oral Vitamin D causing non-calcified atherosclerosis of large arteries (Taura et al. 1979, Toda et al. 1985, Valdivielso et al. 2009). Therefore the NHMRC remain cautious in their recommendations for high doses of vitamin D.

Age	**Upper Limit of Intake (UL) of vitamin D**
0 - 12months	1000 IU/day
1year to 18years	3,200 IU/day
Adults, including Lactation and Pregnancy	3,200 IU/day

What is the Vitamin D status of populations in other countries?

Australia is not alone with a chronic Vitamin D deficiency in its population. There are chronic Vitamin D deficiencies in most countries of the world. This fact has been illustrated by recent surveys conducted across Europe investigating the vitamin D status in individual developed countries as shown in Table 1.

Table 1: Vitamin D deficiency in Europe

Country Source	Number of participants	Age (years) (range or mean)	% < 25 nmol/L $25(OH)D_3$ Moderate to severe deficiency	% < 45/50 nmol/L $25(OH)D_3$ Mild deficiency
Austria (Austrian Nutrition Report 2012)	1002	7 - 14 F	22.3	40.0
		7 - 14 M	17.7	38.1
		18 - 64 F	11.6	28.2
		18 - 64 M	14.2	29.7
		65 – 80 F	19.9	42.4
		65 – 80 M	20.4	44.4
France (ENNS 2006-7)	2007	18 – 28	7.5	45.9
		30 - 54	5.2	41.4
		55 – 74	1.9	41.7
Germany (Hintzpeter *et al*.2008a)	4030	18 – 79 M	15.6	56.8
		18 – 79 F	17.0	57.8
The Netherlands (van der A D *et al*.2012)	2785	18+ M	10 (< 30 nmol/l)	39
		18+ F	8 (< 30 nmol/l)	34
Spain (Gonzalez-Molero *et al*.2011)	1262	20 – 83		33.9
Turkey (Helimsoy *et al*.2010)	391	45.1		74.9
Northern Europe* (Anderson *et al*.2005) Denmark, Finland, Poland, Ireland	420	12.6	37	92
		71.8	17	67

Who in your community is at extra risk of Vitamin D insufficiency?

- Darker skinned people have reduced levels of vitamin D synthesis in their skin.
- Older people have reduced ability to make Vitamin D in their skin. They need more in their diet.
- Pregnant women.
- People who are obese
- People who have liver or kidney disease.

Science today has shown us just how critically important vitamin D is for human health whether it be for bone disease, auto- immune diseases, cancers and even depression.

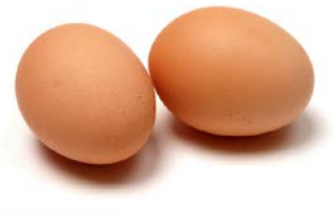
While at the same point in time we are finding there is global chronic deficiency of vitamin D in the population of both developed and developing countries.

What is simple, inexpensive and safe solution to this serious problem?

Ways to Increase Vitamin D Intake and solving the problem of chronic vitamin D insufficiency.

1. Increase exposure to limited daily sunlight. Optimum time of day for vitamin D synthesis on skin is 10 am to 2 pm. This is not always possible for people who work indoors or who are immobile.
2. Improving nutrition: consume foods that are high in vitamin D (fatty fish and eggs)
3. Supplementation of vitamin D with 1000 IU pharmaceutical capsules.

In respect to increasing vitamin D intake by consuming naturally rich in vitamin D foods, there are few naturally occurring foods which contain significant dietary levels of vitamin D. Foods which are naturally rich in vitamin D are fatty fish such as salmon, sardines, mackerel and eggs.



Australian research produces vitamin D enriched eggs

Eggs are a naturally rich source of vitamin D. Recent research at Sydney University has shown that by feeding laying hens higher levels of vitamin D, there was a significant increase in the amount of vitamin D deposited into the egg yolk (Browning and Cowieson 2014).

Vitamin D in standard Eggs	Vitamin D enriched Eggs
	
One standard egg contains approximately 20 – 60 IU vitamin D	One 60g enriched EGG could contain at least 150 IU of vitamin D

A non-enriched or standard egg may contain between 20 to 60 IU of vitamin D but eggs from laying hens fed higher levels of vitamin D could contain at least 150 IU of vitamin D. Therefore, a daily serving of 2 eggs from Nature's Best would readily satisfy the recommended daily intake of 200 IU Vitamin D for Australian children and adults less than 50 years of age as recommended by the National Medical Health Research Council.

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