

Vitamin D: Deficiency, Relevant Health Issues and Major Sources

Vitamin D is an important nutrient that helps keep bones healthy and allows muscles and nerves to work properly. Vitamin D also supports immune system function and is involved in a variety of cells within our body. Vitamin D can be sourced through foods and supplements, as well as sun exposure [1]. Inadequate intake or deficiency of vitamin D can be a risk factor for chronic diseases such as cardiovascular disease, cancer, and osteoporosis [2-6]. Researchers have focused on the role and function of vitamin D in the context of obesity, the prevention of cancer, hypertension, and type II diabetes.

How Common is Vitamin D Deficiency in the United States?

Vitamin D status in the body can be assessed by measuring blood levels of 25-hydroxy vitamin D. In 2019, Herrick, et al. [7] found that about 75% of the population in 2011-2014 had sufficient serum 25-hydroxy vitamin D levels. However, about 20% of the population were at risk of inadequacy, and another 5% were at risk of deficiency.

Although there is still considerable discussion of the appropriate serum 25-hydroxy vitamin D level, a committee of the Institute of Medicine (IOM) concluded that individuals with blood serum levels of:

- < 30 nmol/L (12 ng/mL) = deficient;
- 30 to < 50 nmol/L (12 and 20 ng/mL) = possibly deficient or at risk of deficiency;
- ≥ 50 nmol/L (20 ng/mL) = sufficient vitamin D levels;
- (50 nmol/L is the level that covers the needs of 97.5% of the population); and
- >125 nmol/L (50 ng/mL) = potential adverse effects to high levels.

Vitamin D deficiency can vary based on several factors, such as race, age, and sunscreen use, because of differences in both the need and ability to produce or absorb it [8].

What are the Causes and Symptoms of Vitamin D Deficiency?

Vitamin D deficiency is commonly caused by the following reasons [9]

- Insufficient dietary vitamin D intake;
- Inadequate sun exposure;
- Inability of kidney and liver to produce active vitamin D;
- Interference of some drugs with vitamin D absorption.

Symptoms in individuals suffering from vitamin D deficiency might go unnoticed in the initial stages. In adults, vitamin D deficiency can lead to osteomalacia (weak bones).

The following signs and symptoms can indicate inadequate vitamin D levels [10].

- ▶ Bone & joint pain (especially in your back);
- ▶ Muscle cramps & muscle weakness;
- ▶ Fatigue;
- ▶ Fragility fractures may result from chronic vitamin D deficiency.

In children, symptoms of vitamin D deficiency include irritability, lethargy, developmental delays and bone changes or fractures.

How does Vitamin D Affect Health?

Bone health - Vitamin D plays a critical role in building and maintaining strong bones. It aids in the absorption of calcium,

another critical nutrient, and a key component of bones. People who do not get enough vitamin D may develop bone deformities. In children, this condition is known as rickets, while adults may develop osteomalacia [2]. Osteoporosis is most often associated with insufficient calcium intake, but inadequate vitamin D intake also contributes to osteoporosis. Long-term calcium and vitamin D insufficiency are likely to cause osteoporosis.

Cancer - Research indicates that higher vitamin D levels may be linked to lower risk of colorectal cancer. However, the role of vitamin D in other types of cancers such as breast, prostate, and pancreatic cancers remains unclear [5]. Due to a lack of conclusive data, the National Cancer Institute does not presently recommend using vitamin D to reduce cancer risk. Because sun exposure has been linked to increased risk of skin cancer, the IOM did not integrate recommendations regarding sun exposure with dietary recommendations for vitamin D [1].

Other health conditions - A growing body of studies suggests that vitamin D deficiency might be associated with several diseases and health conditions including diabetes, hypertension, and rheumatoid arthritis [8]. For example, obese individuals tend to have lower levels of vitamin D. Being fat-soluble, vitamin D may become sequestered in adipose tissue and be unavailable for use by the body [3]. Recent findings also suggest that vitamin D deficiency may be linked to heart disease. A higher intake of vitamin D was associated with a lower risk of cardiovascular disease in men, but not in women [4]. Most evidence comes from laboratory, animal and observational studies. Except the relationship between vitamin D and bone health, other relationships have not been supported by studies.

daily recommended amounts of vitamin D for healthy individuals are provided in international units (IU) or micrograms (mcg).

Dietary sources and vitamin D supplements can meet the daily requirement though dietary sources are more commonly preferred. Increasing intake of vitamin D-fortified foods such as milk and orange juice, and increasing fatty fish consumption are common ways to meet vitamin D requirements.

There is evidence that older adults’ skin is less efficient at producing vitamin D and that the kidneys are less efficient at converting vitamin D to its active form. Thus, the recommended intake of vitamin D is increased for older adults to 800 IU [11].

What are Some Major Sources of Vitamin D?

Sun exposure -- Vitamin D is sometimes called the “sunshine vitamin” because the body can make some vitamin D when the skin is exposed to direct sunlight. Most people meet some of their vitamin D needs through sun exposure [8]. Not everyone can make enough vitamin D from sunlight alone, however. Factors such as geographic location, time of day, season, sunscreen use, and skin pigmentation may affect how much vitamin D a person synthesizes. For example, exposure to direct sunlight between 10 am and 3 pm is more likely to result in an adequate synthesis of vitamin D [12]. Exposure to sunlight through a window does not result in production of vitamin D.

Some experts suggest that depending on the time of day, season, latitude and skin pigmentation, exposure of arms and

How Much Vitamin D do You Need?

The amount of vitamin D that people need each day varies depending on age, lifestyle, and certain health conditions (table 1). The current

Table 1. Recommended Dietary Allowance (RDA) of vitamin D

Age	Recommended Dietary Allowances
Birth to 12 months	400 IU (10 mcg)
Children 1 to13 years old	600 IU (15 mcg)
Teens 14 to18 years old	600 IU (15 mcg)
Adults 19 to 70 years old	600 IU*(15 mcg)
Adults 71 years and older	800 IU (20 mcg)

*Same for pregnant and breastfeeding women

legs to sunlight for 5 to 30 minutes twice a week without sunscreen may be sufficient to maintain adequate vitamin D status [6]. However, it is advisable to limit skin exposure to sunlight due to skin cancer risk. Adults, especially older adults with darker skin pigmentation or ethnic minorities are at higher risk for skin cancer. Greater amounts of melanin (a dark brown to black pigment occurring in the hair, skin, and iris of the eye) in the skin may result in decreased ability of the skin to synthesize vitamin D through exposure to sunlight [13].

A recent literature review shows that ethnic minorities who emigrated from developing to developed countries had significantly higher rates of vitamin D insufficiency than their white counterparts. High levels of vitamin D insufficiency and deficiency have been reported in Hispanic, African American and Asian migrants in the United States [14, 15].

Dietary Sources -- There are just a few natural sources of vitamin D in food. These include oily fish like herring, tuna, and salmon, egg yolk, beef liver, and some mushrooms (Table 2). Some commonly eaten foods are fortified with vitamin D and are good sources of the nutrient. These include vitamin D fortified milk and soymilk, fortified orange juice, and fortified breakfast cereals.

Supplements -- Vitamin D is also available as a supplement and may be found in two forms: vitamin-D₂ and D₃. Multivitamins typically contain 400 IU of vitamin D. Several manufacturers provide a vitamin D₂ or vitamin D₃ supplement as either 400 or 1000 IU. Although both forms increase vitamin

D levels in the blood, some recent evidence suggests that taking vitamin D₃ as a supplement may be more effective at improving vitamin D status [11]. As with all supplements, any individual should consult a healthcare professional before supplementing with vitamin D.

Can You Get Too Much Vitamin D?

Like many other nutrients, too much vitamin D can be harmful to your health. Excessive vitamin D intake may cause elevated calcium levels, leading to kidney problems and other complications. Vitamin D toxicity is usually related to the overuse of supplements, not to vitamin D obtained from food sources or synthesized by sunlight [16].

Summary

The prevalence of vitamin D deficiency has remained high, with 20% at risk of inadequacy and 5% at risk of deficiency since 2003. The role of vitamin D in the context of obesity, type II diabetes, heart diseases, and cancer, is still not clearly proved. However, an increasing body of studies provides evidence of vitamin D affecting health in general.

If you are at risk or already experiencing the signs of vitamin D deficiency, make sure to talk to your doctor and get a regular blood test for 25-hydroxyvitamin D during your routine physical examination. If needed, take vitamin D supplement after consulting with your physician and practice sensible sun exposure.

Table 2. Natural and fortified food sources of vitamin D

Food	Serving Size	IU
Cod liver oil	1tablespoon	1360
Trout (rainbow), cooked	3 ounces	645
Salmon, sockeye, cooked	3 ounces	570
Vitamin D-fortified 2% milk	1 cup	120
Vitamin D-fortified soy, almond milk	1 cup	100-144
Fortified ready-to-eat cereal	1 cup	80
Egg, scrambled (vitamin D is in the yolk)	1 large	44
Tuna, canned in water	3 ounces	40
Mushrooms, portabella, raw	½ cup	4

Source: <https://ods.od.nih.gov/factsheets/VitaminD-HealthProfessional/>

References

Ross, A.C., et al., The 2011 report on dietary reference intakes for calcium and vitamin D from the Institute of Medicine: what clinicians need to know. *The Journal of Clinical Endocrinology and Metabolism*, 2011. 96(1): p. 53-8.

DeLuca, H.F., Overview of general physiologic features and functions of vitamin D. *The American Journal of Clinical Nutrition*, 2004. 80(6 Suppl): p. 1689S-96S.

Vimalaswaran KS, B.D., Lu C, Tikkanen E, Pilz S, Hiraki LT, Cooper JD, Dastani Z, Li R, Houston DK., Causal relationship between obesity and vitamin D status: Bi-directional Mendelian randomization analysis of multiple cohorts. *PLoS Med*, 2013. 10(2).

Sun, Q., Shi, L., Rimm, E. B., Giovannucci, E. L., Hu, F. B., Manson, J. E., & Rexrode, K. M. (2011). Vitamin D intake and risk of cardiovascular disease in US men and women. *The American Journal of Clinical Nutrition*, 94(2), 534-542. doi:10.3945/ajcn.110.008763

National Cancer Institute. *Vitamin D and Cancer Prevention*. 2013; Available from: <http://www.cancer.gov/cancertopics/factsheet/prevention/vitamin-D>.

Holick, M.F., Vitamin D deficiency. *The New England Journal of Medicine*, 2007. 357(3): p. 266-81.

Herrick, K. A., Storandt, R. J., Afful, J., et al. Vitamin D status in the United States, 2011–2014. *The American Journal of Clinical Nutrition*, 2019. 110(1), p. 150-157. Available from: <https://doi-org.proxy-um.researchport.umd.edu/10.1093/ajcn/nqz037>

Holick, M.F., Sunlight and vitamin D for bone health and prevention of autoimmune diseases, cancers, and cardiovascular disease. *The American Journal of Clinical Nutrition*, 2004. 80(6 Suppl): p. 1678S-88S.

Institute of Medicine (US) Committee to Review Dietary Reference Intakes for Vitamin D and Calcium; Ross AC, Taylor CL, Yaktine AL, et al., editors. *Dietary Reference Intakes for Calcium and Vitamin D*. Washington (DC): National Academies Press (US); 2011. 3, Overview of Vitamin D. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK56061/>

Sizar, O., Khare, S., Goya, A., et al (2020), *Vitamin D Deficiency*. Retrieved from: <https://www.ncbi.nlm.nih.gov/books/NBK532266/#:~:text=Patients%20with%20a%20prolonged%20and,D%20deficiency%20leading%20to%20osteoporosis.>

Tripkovic, L., Lambert, H., Hart, K., et al., Comparison of vitamin D2 and vitamin D3 supplementation in raising serum 25-hydroxyvitamin D status: a systematic review and meta-analysis. *The American Journal of Clinical Nutrition*, 2012. 95(6): p. 1357-1364.

National Institute of Health, Office of Dietary Supplements. *Dietary supplement fact sheet: Vitamin D*. 2011; Available from: <http://ods.od.nih.gov/factsheets/VitaminD-HealthProfessional/>.

Nair R, Maseeh A. Vitamin D: The "sunshine" vitamin. *J Pharmacol Pharmacother*. 2012;3(2): 118-126. doi:10.4103/0976-500X.95506.

Harris, S.S., Vitamin D and African Americans. *The Journal of Nutrition*, 2006. 136(4): p. 1126-9.

Renzaho AM, H.J., Nowson C., *Vitamin D, obesity, and obesity-related chronic disease among ethnic minorities: A systematic review*. *Nutrition*, 2011. 27: p. 868-879.

Marcinowska-Suchowierska, E., Kupisz- Urbańska, M., Łukaszkiwicz, J., et al., *Vitamin D Toxicity-A Clinical Perspective*. *Front Endocrinol (Lausanne)*, 2018. 9:550

Hee-Jung Song
 hjsong@umd.edu
 Mona Habibi
 mhabibi@umd.edu
 Dhriti Patel
 dhritip@umd.edu
 Haley Kappey
 hnkappey@umd.edu

This publication, *Vitamin D: Deficiency, Relevant Health Issues and Major Sources* (FS-1146), is a series of publications of the University of Maryland Extension and the Department of Agriculture and Food Science.

The information presented has met UME peer review standards, including internal and external technical review. For help accessing this or any UME publication contact: itaccessibility@umd.edu

For more information on this and other topics, visit the University of Maryland Extension website at extension.umd.edu

University programs, activities, and facilities are available to all without regard to race, color, sex, gender identity or expression, sexual orientation, marital status, age, national origin, political affiliation, physical or mental disability, religion, protected veteran status, genetic information, personal appearance, or any other legally protected class.