

Vitamin D Deficiency: Shining New Light on the Sun Nutrient

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During the past two decades, research on vitamin D has increased exponentially. Healthcare practitioners have learned vitamin D plays a much more important role in disease prevention and well-being than was ever suspected. This new information comes in stark contrast to behavioral trends. In the 1980s, sun exposure was demonized and we became an indoor society. Because sun exposure is one of the best ways to obtain vitamin D, the lack of sunshine plus zealous use of sunscreen has contributed to a vitamin D-deficient society.

Vitamin D deficiency is now regarded as a global health problem, but despite an abundance of media attention, many physicians and their patients remain unaware of the possible ill effects of vitamin D deficiency. Current estimates are that 50% to 78% of the population has inadequate stores of vitamin D and the incidence is even greater in high-risk groups, such as African Americans and homebound elderly.¹

Forms of Vitamin D

Vitamin D actually refers to a pair of inactive precursors to a critical hormone. Cholecalciferol, more commonly known as D₃, is produced in the skin after exposure to ultraviolet B light (UVB) or from foods we consume. Ergocalciferol, also known as D₂, is produced in plants and enters the body through diet. Once D₂ and D₃ are present in circulation, they are bound to vitamin D-binding proteins (VDBP) and hydroxylated in the liver to form 25-hydroxyvitamin D (25[OH]D) or calcidiol. A further conversion in the kidney changes the calcidiol to 1,25-dihydroxyvitamin D (1,25[OH]₂D) or calcitriol.

Calcidiol is the main circulating and storage form of vitamin D in the blood, with a half-life of approximately 3 weeks. This is the preferred form to evaluate vitamin D status in patients. Because the production of calcitriol is tightly regulated with a half-life of only 4 to 6 hours, its measurement is usually only of interest in renal disease or primary hyperparathyroidism.²

Vitamin D Deficiency

Numerous risk factors may predispose an individual to vitamin D deficiency³:

- Limited sun exposure, including constant use of sun-

screens when outdoors. Sunscreens with a sun protection factor (SPF) of 15 block 99% of the UVB rays that make vitamin D in our skin;

- Cultural dress, such as hijabs or burkas worn by Muslim women⁴;
- Limited intake of foods that provide vitamin D, such as fortified milk, fortified cereal, and fatty fish. Table 1 lists the vitamin D content of the best food choices and select supplements;
- Living 40° north of the equator. The farther a person lives from the equator, the less his/her exposure to UVB rays and the less vitamin D produced by the body;
- Limited use of vitamin D supplements. Typical multivitamins do not provide an adequate amount of vitamin D for optimum health if other sources are not present;
- Dark complexions. Persons with darker complexions (eg, individuals from Africa, East India, and the Caribbean) may require up to six times the amount of sun exposure to form the same amount of vitamin D from the sun as light-skinned or Caucasian people;
- Aged skin. In general, people >60 years of age have a 25% reduction in cutaneous formation of vitamin D. Senior citizens who are homebound or in long-term care facilities are at very high risk for vitamin D deficiency;
- Obesity. Because vitamin D is fat-soluble, it appears to be sequestered in adipose stores and not released easily into the blood for use by the body;
- Malabsorption disorders, including Crohn's disease, celiac disease, and cystic fibrosis. Patients who have undergone gastric bypass surgery for weight loss also are sometimes at risk;
- Kidney disease. Supplementation of the calcidiol form of vitamin D often is started too late in many patients with renal disease. A 20% increase in mortality is seen in patients not given vitamin D⁵;
- Infants breastfed exclusively who are not receiving a vitamin D supplement, unless the mother is on a high dose of supplements herself;
- Certain medications that can impair absorption (eg, phenytoin and cholestyramine). Other medications necessitate limited sun exposure because of photosensitiv-

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ity — for example, amiodarone, tetracyclines, and sulfonamides.

Evaluating these risk factors is important for every patient, because the list of diseases and health problems caused or worsened by vitamin D deficiency is extensive. This includes rickets, osteoporosis, osteomalacia, frequent bone fractures, frequent falls, muscle pain and weakness, heart disease, congestive heart failure, hypertension, diabetes, some types of cancer, fibromyalgia, preeclampsia in pregnancy, autoimmune disorders such as rheumatoid arthritis and multiple sclerosis, depression, brain development, migraines, flu, pneumonia, tuberculosis, and periodontal disease.³

Adequate Intake Guidelines

For most adults, the recommended daily adequate intake (AI) is 400 international units (IU). For those >70 years of age, the current recommendation is 600 IU. Research now is showing the inadequacy of these current government recommendations. The general conclusion is that these amounts are inadequate if not supplemented with sun exposure. Vitamin D researchers have appealed to the government to make changes to both the AI recommendations and the tolerable upper-limit (UL) levels. Researchers want to make these changes a priority for both public health and research reasons.⁶

The Institute of Medicine of the National Academies recently appointed the next Food and Nutrition Board to establish new dietary reference intakes (DRIs) for vitamin D and calcium.⁷ This is a time-consuming process considering the vast number of new studies. Persons with an interest in vitamin D are watching closely to see if the recommendations are modified based on what we have learned from recent research.

Vitamin D toxicity is rarely reported but has occurred. In general, toxicity is associated with quality control problems in either the fortification process or with powdered supplements. The UL, or the maximum level considered safe set by the government, is currently 2,000 IU. It is expected that with the evidence supplied by recent research, the level likely will increase to 10,000 IU/day.⁸

Supplementation and Repletion

Serum 25(OH)D levels <15 nanograms (ng)/milliliter (mL) are treated with much higher amounts of vitamin D than can be obtained in nonprescription supplements. In order to replete the deficiency quickly, prescription supplements containing 50,000 IU of vitamin D per week for at least 8 weeks are suggested.³ After 8 weeks, blood levels are retested to determine if this level of supplementation needs to be sustained. If the result is <30 ng/mL, continuation of prescription level supplementation is recommended. Once 30 ng/mL is reached, daily supplements of a lower dose are continued along with periodic monitoring of serum levels. Table 2 outlines the generally accepted assessment categories. Currently, over-the-counter products range from 400 to 2,000 IU; thus, it is important to read the product label carefully.

Table 1. Vitamin D Content of Foods and Supplements

Food	Amount	Vitamin D Content (IU)
Wild salmon ^a	3.5 oz	988
Farmed salmon ^a	3.5 oz	245
Light tuna ^b	3.5 oz	230
Fortified milk (dairy or soy) ^b	8 fl oz	100
Fortified orange juice ^b	8 fl oz	100
Fortified cereal ^b	1 serving (usually 1 cup)	40
Egg ^b	1 medium	20
General multivitamin	1 tablet	400
Cod liver oil ^c	1 tablespoon	1,360

Note: Cod liver oil is not recommended because of its high content of active vitamin A, which can harm bone health over time. Retinoic acid also may antagonize the action of vitamin D when the ratio is in excess.

Sources

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Table 2. Vitamin D 25(OH)D Assessment Categories^a

Classification	ng/mL ^b	nmol/L ^b
Deficient	<20 ng	<50 nmol/L
Insufficient	20-30 ng/mL	50-75 nmol/L
Sufficient	>30 ng/mL	>75 nmol/L
Projected ideal	50-80 ng/mL	125-200 nmol/L
Excess	>150 ng/mL	>375 nmol/L

ng = nanograms, nmol = nanomoles

- Subject to change as research continues. No formal guidelines are set at this time
- Serum concentrations of 25(OH)D are reported in both ng/mL and nmol/L. The conversion factor is 1 ng/mL = 2.5 nmol/L

Dr. Robert Heaney, a prominent vitamin D researcher, estimates that an intake of 3,000 IU (per day) of vitamin D is needed to bring 95% of the population out of the deficient range.⁹ It is important to note that researchers have not identified a universal vitamin D dosage that will consistently suit the needs of all patients. Individual medical history, lifestyle, geographic location, body composition, and other factors all play a role in determining the proper dose. Furthermore, some diseases limit the use of vitamin D supplementation, such as sarcoidosis, primary hyperparathyroidism, oat cell lung cancer, and non-Hodgkin's lymphoma. These considerations reinforce the need for a knowledgeable physician and registered

dietitian (RD) to ensure proper treatment and monitoring.³

Vitamin D and Wound Healing

New research has found that injury causes skin cells to require additional vitamin D. The genes controlled by vitamin D promote creation of an antimicrobial peptide called *cathelicidin*, which the immune system uses to fight infections. Skin wounds require vitamin D₃ to protect against infection and begin the normal repair process. A vitamin D deficiency may compromise the body's innate immune system, which works to resist infection, making a patient more vulnerable to microbes. These responses are a previously unrecognized part of the human injury response.¹⁰ This innate immunity process also links adequate vitamin D levels to the reduction in influenza and tuberculosis risk.

Rigorous studies on how the correction of a vitamin D deficiency may hasten wound healing still are needed. At this juncture, the evidence is anecdotal. A post on Dr. John Cannell's vitamin D website¹¹ describes how a pain management physician approached care of a 75-year-old female patient who weighed 250 pounds. The physician prescribed 50,000 IU of vitamin D per week for underlying osteoporosis. When he saw the patient for a follow-up exam, he discovered she had taken the vitamin D supplement daily instead of weekly. The physician then noticed that the patient had remarkable healing of venous stasis ulcers in her bilateral lower extremities. These ulcers previously had remained stagnant for more than 5 years, despite the best efforts of the local wound care clinic. Hopefully in the near future, we will see formal studies on this topic. Vitamin D just might take a place next to the other nutrients that are essential for wound healing.

Putting Research Into Practice

Dr. Michael Holick³ observed, "Rickets can be considered the tip of the vitamin D deficiency iceberg." The bulk of the problems are below the surface; this deficiency can affect anyone, including healthcare professionals. One physician reports that his father, a widower with diabetes, a fractured hip, and depression, had a 25(OH)D level that was only 6 ng/mL. Another anecdote recounts the story of a morbidly obese woman with diabetes in great pain during her stay at a rehabilitation hospital. When tested, her 25(OH)D level was <4 ng/mL. In this day of advanced medicine, are we forgetting to check for basic nutrient deficiencies that may help preserve the quality of life? As more and more light is shined on vitamin D, it is hoped that these types of stories will become the exception, rather than the rule.

Practice Pearls

- The correct test for evaluating vitamin D (also known as calcidiol) status is 25(OH)D.
- It is only necessary to test (1,25[OH]₂D), or calcitriol, if the patient has advanced kidney disease, a high calcium level, or certain diseases that induce a vitamin D hyper-

sensitivity.

- Research now shows that activated vitamin D (calcitriol) is made in most tissues and cells, not only the kidneys, as was previously believed.
- Vitamin D fortification is required only in liquid milk. Other dairy products do not provide vitamin D unless specified on the label.
- Sensible sun exposure for the face, arms, and legs to the sun should include approximately 15 to 20 minutes before applying sunscreen at least three times/week. It is estimated that a Caucasian could make 10,000 IU vitamin D during that time.
- Vitamin D percentage on food labels can be converted to IU by using the current AI of 400 IU. For example, if the label states the food provides 25% of the requirement for vitamin D, the product contains 100 IU/serving (400 x 25%).
- Always make sure you request and review the actual test results because different labs use different amounts to define normal limits. ■

Coming next month — transcultural issues in nutrition

References

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Additional Resources

Dr. John Cannell: www.VitaminDcouncil.com
 Dr. Michael Holick: www.uvadventure.org and www.vitaminDhealth.org
 National Academy of Sciences. Unraveling the Enigma of Vitamin D: www.beyonddiscovery.org/content/view/article.asp?a=414