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Patient education: Vitamin D deficiency (Beyond the Basics)

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INTRODUCTION

Vitamin D plays many important roles in the body, including the development and calcification of the bones.

The use of dairy products fortified with vitamin D has significantly reduced the incidence of vitamin D deficiency. However, vitamin D deficiency is still a common problem in many populations, particularly older adults.

This topic reviews the major causes of vitamin D deficiency, including how it is diagnosed and treated, and safe ways to prevent vitamin D deficiency.

WHAT IS VITAMIN D?

Vitamin D is an oil-soluble vitamin that has several important functions in the body:

- It helps to absorb dietary calcium and phosphorus from the intestines.
- It suppresses the release of parathyroid hormone, a hormone that causes bone breakdown (resorption).

Through these actions, vitamin D helps keep the calcium and phosphate levels in the blood normal, thereby promoting bone health. Vitamin D may have other benefits, such as improving muscle and immune function, but these areas require more research.

Natural sources of vitamin D — Vitamin D is made in the skin under the influence of sunlight. The amount of sunlight needed to synthesize adequate amounts of vitamin D varies with season and time of day, and with the person's age, skin pigmentation, and underlying medical problems. The production of vitamin D in the skin decreases with age. In addition, people who have skin with more pigmentation need more sun exposure to produce adequate amounts of vitamin D.

Foods are another important source of vitamin D. Vitamin D is present in fatty fish, cod liver oil, and (to a lesser extent) in egg yolk. In the United States, commercially fortified cow's milk is the largest dietary source of vitamin D. Milk is fortified with 100 international units (2.5 micrograms) of vitamin D per 8-ounce cup. Vitamin D intake, in international units, can be estimated by multiplying the number of cups of milk consumed per day by 100 (two cups of milk = 200 international units of vitamin D). In the United States and other parts of the world, cereals and a variety of other products are often fortified with vitamin D.

Cod liver oil is a good source of vitamin D but it also contains a large amount of vitamin A. Excessive vitamin A intake can be associated with side effects, including liver damage and bone fractures.

CAUSES OF VITAMIN D DEFICIENCY

The main reasons for low levels of vitamin D are:

- Lack of vitamin D in the diet, often in conjunction with inadequate sun exposure
- Reduced absorption of vitamin D from the intestines
- Reduced processing of vitamin D due to kidney or liver disease

Inadequate intake — Infants, children, and older adults are at risk for low vitamin D levels because of inadequate vitamin D intake. Human breast milk contains low levels of vitamin D, and most infant formulas do not contain adequate vitamin D. Older adults often do not consume enough vitamin D-rich foods, and even when they do, absorption may be limited. People who do not consume dairy products are also at risk for vitamin D deficiency.

Inadequate or ineffective sun exposure — The effectiveness of sun exposure in promoting vitamin D production in the skin varies by latitude and time of day. At the latitude of 42 degrees

north (for example, in Boston, MA), sun exposure triggers vitamin D production only between the months of March and October. As one moves south, the production period increases gradually to a full 12 months per year. Conversely, the production period declines as one moves north. Vitamin D production in the skin is at its maximum at midday, when the sun is directly overhead.

However, exposure to the sun is **not** recommended as a source of vitamin D for anyone, including infants and children, due to the potential long-term risks of skin cancer. (See "Patient education: Sunburn (Beyond the Basics)".)

Adults who have limited sun exposure are at increased risk of vitamin D deficiency, especially if they have more pigmented skin. In addition, older adults make reduced amounts of vitamin D in the skin. The use of sunscreen also limits vitamin D synthesis.

Diseases or surgery that affect fat absorption — Certain diseases affect the body's ability to absorb adequate amounts of vitamin D through the intestinal tract. Examples of these include celiac disease, Crohn's disease, and cystic fibrosis.

Surgery that removes or bypasses portions of the stomach or intestines can also lead to low vitamin D levels. An example of this type of surgery is gastric bypass. (See "Patient education: Weight loss surgery and procedures (Beyond the Basics)".)

Kidney and liver disease — The liver and kidney have important enzymes that change vitamin D from sun-exposed skin or food to the biologically active form of vitamin D. People with chronic kidney and liver disease are at increased risk of low active vitamin D levels because they have decreased levels of these enzymes.

Less common causes of vitamin D deficiency include familial or acquired (non-inherited) diseases that impair the enzymes in the liver or kidney that create the biologically active form of the vitamin. This results in inadequate amounts of active vitamin D.

POTENTIAL COMPLICATIONS OF VITAMIN D DEFICIENCY

The most serious complications of vitamin D deficiency are low blood calcium (hypocalcemia), low blood phosphate (hypophosphatemia), rickets (softening of the bones during childhood), and osteomalacia (softening of the bones in adults). However, these complications have become less common over time because many foods and drinks have added vitamin D.

"Subclinical" vitamin D deficiency or vitamin D insufficiency is common and is defined as a vitamin D level that is lower than normal but causes no visible signs or symptoms. However,

vitamin D insufficiency is often associated with reduced gastrointestinal calcium absorption, decreased bone density (osteopenia or osteoporosis), and, in some cases, a mild decrease in the blood calcium level, elevated parathyroid hormone (which accelerates bone resorption), and an increased risk of falls and possibly fractures, all of which can seriously affect a person's quality of life.

Thus, identifying and treating vitamin D insufficiency or deficiency is important to maintain bone strength. Treatment may even improve the health of other body systems, such as the immune, muscular, and cardiovascular systems, although more research is needed in these areas.

DIAGNOSIS OF VITAMIN D DEFICIENCY

A low vitamin D level can be diagnosed with a blood test called 25-hydroxyvitamin D or 25(OH)D (OH = hydroxy, D = vitamin D). Although definitions of vitamin D deficiency vary to some extent, most groups use the following values recommended by the National Academy of Medicine for adults:

- Vitamin D **sufficiency** is defined as a 25(OH)D concentration ≥20 ng/mL (50 nmol/L)
- Vitamin D **insufficiency** is defined as a 25(OH)D concentration of 12 to <20 ng/mL (30 to 50 nmol/L)
- Vitamin D **deficiency** is defined as a 25(OH)D level <12 ng/mL (30 nmol/L)
- A "risk" of vitamin D toxicity is defined as a 25(OH)D level >100 ng/mL (>250 nmol/mL) in adults ingesting substantial amounts of calcium

Most experts agree that levels lower than 20 ng/mL (50 nmol/L) are suboptimal for bone health.

Who needs testing for vitamin D? — Testing for vitamin D deficiency or insufficiency is not recommended for everyone but may be advised for people who are home bound or in a long-term care facility (eg, nursing home) if the person has a medical condition that increases the risk of vitamin D deficiency or insufficiency; for anyone with osteoporosis or a past history of a low-trauma fracture (eg, fracture after fall from standing); or if a person has a low blood calcium or phosphate level. (See "Patient education: Bone density testing (Beyond the Basics)" and "Patient education: Osteoporosis prevention and treatment (Beyond the Basics)".)

TREATMENT OF VITAMIN D DEFICIENCY

Vitamin D supplements — Many types of vitamin D preparations are available for the treatment of vitamin D deficiency or insufficiency. The two commonly available forms of vitamin D supplements are ergocalciferol (vitamin D2) and cholecalciferol (vitamin D3). We suggest vitamin D3 when possible, rather than vitamin D2, because vitamin D3 may raise vitamin D levels more effectively.

Dosing — The recommended dose of vitamin D depends upon the nature and severity of the vitamin D deficiency.

In people who do not have problems absorbing vitamin D:

- In people whose 25-hydroxyvitamin D (25[OH]D) is <12 ng/mL (30 nmol/L), treatment typically includes 25,000 to 50,000 international units (625 to 1250 micrograms) of vitamin D2 or D3 by mouth once per week for six to eight weeks, and then 800 to 1000 international units (20 to 25 micrograms), or more, of vitamin D3 daily thereafter.

- In people whose 25(OH)D is 12 to <20 ng/mL (30 to <50 nmol/L), treatment usually includes 800 to 1000 international units (20 to 25 micrograms) of vitamin D3 by mouth daily. However, some people may need higher doses. The "ideal" dose of vitamin D is determined by testing the individual's 25(OH)D level and increasing the vitamin D dose if the level is not within normal limits. Once a normal level is achieved, continued therapy with 800 international units (20 micrograms) of vitamin D per day is usually recommended.

- In people whose 25(OH)D is 20 to 30 ng/mL (50 to 75 nmol/L), treatment with 600 to 800 international units (15 to 20 micrograms) of vitamin D3 by mouth daily is usually sufficient to maintain levels in the target range.

- In infants and children whose 25(OH)D is <20 ng/mL (50 nmol/L), treatment usually includes 1000 to 2000 international units (25 to 50 micrograms) of vitamin D2 by mouth per day (depending on the child's age) for two to three months. Children with rickets (softening of the bones, which can be seen on an X-ray) may need higher doses of vitamin D and should have medical follow-up to ensure that the rickets resolves.

In people who have diseases or conditions that prevent them from absorbing vitamin D normally, the recommended dose of vitamin D is determined on an individual basis.

Do I need other vitamins or minerals? — During treatment for vitamin D deficiency, it is important to consume at least 1000 mg of calcium per day for males and premenopausal females and 1200 mg per day for postmenopausal females.

Calcium can be found in food sources (table 1) or dietary supplements (table 2). (See "Patient education: Calcium and vitamin D for bone health (Beyond the Basics)".)

Monitoring — In adults being treated for vitamin D deficiency, a blood test is recommended to monitor blood levels of 25(OH)D three months after beginning treatment. The dose of vitamin D may need to be adjusted based on these results and subsequent blood levels of 25(OH)D obtained to assure that normal levels result from the adjusted dose.

Side effects — Side effects of vitamin D are uncommon unless the 25(OH)D level becomes very elevated (>100 ng/mL or 250 mmol/L) and the person is taking high-dose calcium supplements. However, it is important to follow dosing instructions closely and to avoid taking multiple products that contain vitamin D (eg, multivitamin and vitamin D).

If 25(OH)D levels do become very elevated, complications such as high blood calcium levels or kidney stones can develop.

PREVENTION OF VITAMIN D DEFICIENCY

The amount of vitamin D you need per day to maintain a normal level of 25-hydroxyvitamin D (25[OH]D) depends on the pigmentation in your skin, sun exposure, diet, and underlying medical conditions.

In general, adults are advised to take a supplement containing 800 international units (20 micrograms) of vitamin D per day to maintain a normal vitamin D level. Older people who are confined indoors may have vitamin D deficiency even at this intake level. (See 'Vitamin D supplements' above.)

All infants and children are advised to take a vitamin D supplement containing 400 international units (10 micrograms) of vitamin D, starting within days of birth. For infants and children, vitamin D is included in most nonprescription infant multivitamin drops. In some countries, infant drops are available that contain only vitamin D. (See "Patient education: Breastfeeding guide (Beyond the Basics)" and "Patient education: Starting solid foods during infancy (Beyond the Basics)".)

Exposure to the sun or tanning beds is **not** recommended as a source of vitamin D. This can lead to skin damage and increase the risk of skin cancer.

WHERE TO GET MORE INFORMATION

Your health care provider is the best source of information for questions and concerns related to your medical problem.

This article will be updated as needed on our website (www.uptodate.com/patients). Related topics for patients, as well as selected articles written for health care professionals, are also available. Some of the most relevant are listed below.

Patient level information — UpToDate offers two types of patient education materials.

The Basics — The Basics patient education pieces answer the four or five key questions a patient might have about a given condition. These articles are best for patients who want a general overview and who prefer short, easy-to-read materials.

Patient education: Vitamin D deficiency (The Basics)
Patient education: Osteoporosis (The Basics)
Patient education: Calcium and vitamin D for bone health (The Basics)
Patient education: Vitamin supplements (The Basics)
Patient education: Vitamin D for babies and children (The Basics)

Beyond the Basics — Beyond the Basics patient education pieces are longer, more sophisticated, and more detailed. These articles are best for patients who want in-depth information and are comfortable with some medical jargon.

Patient education: Sunburn (Beyond the Basics)
Patient education: Weight loss surgery and procedures (Beyond the Basics)
Patient education: Bone density testing (Beyond the Basics)
Patient education: Osteoporosis prevention and treatment (Beyond the Basics)
Patient education: Calcium and vitamin D for bone health (Beyond the Basics)
Patient education: Breastfeeding guide (Beyond the Basics)
Patient education: Starting solid foods during infancy (Beyond the Basics)

Professional level information — Professional level articles are designed to keep doctors and other health professionals up-to-date on the latest medical findings. These articles are thorough, long, and complex, and they contain multiple references to the research on which they are based. Professional level articles are best for people who are comfortable with a lot of medical terminology and who want to read the same materials their doctors are reading.

Hypophosphatemia: Causes of hypophosphatemia
Causes of vitamin D deficiency and resistance
Epidemiology and etiology of osteomalacia

Clinical manifestations, diagnosis, and treatment of osteomalacia in adults
Endocrine dysfunction in the nephrotic syndrome
Etiology of hypocalcemia in adults
Geriatric nutrition: Nutritional issues in older adults
Overview of vitamin D
Overview of chronic kidney disease-mineral and bone disorder (CKD-MBD)
Vitamin D deficiency in adults: Definition, clinical manifestations, and treatment
Vitamin D insufficiency and deficiency in children and adolescents
Etiology and treatment of calcipenic rickets in children

The following organizations also provide reliable health information.

- National Institutes of Health Office of Dietary Supplements

  (http://ods.od.nih.gov/factsheets/vitamind.asp)

- National Osteoporosis Foundation

  (www.nof.org/prevention/preventing-fractures/prevention-and-healthy-living/)

[1]

REFERENCES

1. Giustina A, Adler RA, Binkley N, et al. Controversies in Vitamin D: Summary Statement From an International Conference. J Clin Endocrinol Metab 2019; 104:234.

This generalized information is a limited summary of diagnosis, treatment, and/or medication information. It is not meant to be comprehensive and should be used as a tool to help the user understand and/or assess potential diagnostic and treatment options. It does NOT include all information about conditions, treatments, medications, side effects, or risks that may apply to a specific patient. It is not intended to be medical advice or a substitute for the medical advice, diagnosis, or treatment of a health care provider based on the health care provider's examination and assessment of a patient's specific and unique circumstances. Patients must speak with a health care provider for complete information about their health, medical questions, and treatment options, including any risks or benefits regarding use of medications. This information does not endorse any treatments or medications as safe, effective, or approved for treating a specific patient. UpToDate, Inc. and its affiliates disclaim any warranty or liability relating to this information or the use thereof. The use of this information is governed by the Terms of Use, available at

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