

Vitamin D Supplementation in Infants, Children, and Adolescents

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Vitamin D deficiency in children can have adverse health consequences, such as growth failure and rickets. In 2008, the American Academy of Pediatrics increased its recommended daily intake of vitamin D in infants, children, and adolescents to 400 IU. Infants who are breastfed and children and adolescents who consume less than 1 L of vitamin D–fortified milk per day will likely need supplementation to reach 400 IU of vitamin D per day. This recommendation is based on expert opinion and recent clinical trials measuring biomarkers of vitamin D status. It is also based on the precedent of preventing and treating rickets with 400 IU of vitamin D. In addition to dietary sources, exposure to ultraviolet B sunlight provides children and adults with additional vitamin D. Although the American Academy of Pediatrics recommends keeping infants out of direct sunlight, decreased sunlight exposure may increase children's risk of vitamin D deficiency. No randomized controlled trials assessing patient-oriented outcomes have been performed on universal vitamin D supplementation. However, vitamin D may reduce the risk of certain infections and chronic diseases. Physicians should help parents choose the appropriate vitamin D supplement for their child. (*Am Fam Physician*. 2010;81(6):745-748, 750. Copyright © 2010 American Academy of Family Physicians.)

► See related editorial on page 703.

► Patient information: A handout on vitamin D in children, written by the authors of this article, is provided on page 750.

Vitamin D deficiency in children has been linked to adverse effects, such as growth failure and rickets. Although vitamin D is available in several foods and drinks, recent estimates suggest the prevalence of vitamin D deficiency among infants, children, and adolescents is between 12 and 24 percent.^{1,2} Infants who are breastfed appear to be at higher risk of vitamin D deficiency. Family physicians should understand current recommendations for vitamin D supplementation, and be prepared to educate parents about breastfeeding, sun precautions, and nutrition throughout childhood and adolescence.

Vitamin D in Health and Disease

Vitamin D plays several important roles in the metabolism and absorption of other minerals in the body. Vitamin D is essential for facilitating calcium metabolism and bone mineralization; is beneficial for phosphate and magnesium metabolism; and stimulates protein expression in the intestinal wall to promote calcium absorption. Low levels of vitamin D lead to the release of parathyroid hormone, which causes calcium mobilization from the bone. Over time, excessive bone resorption can lead to rickets.

Adequate levels of vitamin D may also help reduce the risk of autoimmune conditions,^{3,4} infection,⁵ and type 2 diabetes.⁶ Evidence from observational studies supports the role of vitamin D supplementation in reducing the risk of type 1 diabetes in infants and children.⁷ Although observational studies suggest that vitamin D may be protective against some cancers,⁸ a randomized controlled trial of calcium and vitamin D supplementation in 36,282 women did not find a protective effect against breast cancer.⁹

Guidelines for Vitamin D Intake

In 2003, the American Academy of Pediatrics (AAP) published a guideline recommending that all children older than two months receive 200 IU of supplemental vitamin D daily.¹⁰ This expert consensus statement was supported by studies of breastfed infants in the United States, Norway, and China and suggested that infants who ingest 100 or 200 IU of supplemental vitamin D daily were less likely to develop rickets.¹¹ Since then, there have been concerns that these dosages may be insufficient. These concerns are supported by studies showing that vitamin D deficiency can occur early in life¹²; that serum 25-hydroxyvitamin D concentrations

SORT: KEY RECOMMENDATIONS FOR PRACTICE

<i>Clinical recommendation</i>	<i>Evidence rating</i>	<i>References</i>	<i>Comments</i>
Infants ingesting less than 1 L (33.8 fl oz) of formula per day, as well as all breastfed or partially breastfed infants, should receive 400 IU of supplemental vitamin D daily.	C	13, 19, 20	Based on disease-oriented evidence and expert opinion
Children and adolescents consuming less than 1 L of vitamin D–fortified milk per day should receive 400 IU of supplemental vitamin D daily.	C	21, 22	Based on disease-oriented evidence and case series
Limiting sunlight exposure may predispose children to vitamin D deficiency.	C	23, 25-27	Based on disease-oriented evidence and expert opinion
The best available biomarker of vitamin D status is serum 25-hydroxyvitamin D levels.	C	28, 29	Based on consensus and disease-oriented evidence
Children at increased risk of vitamin D deficiency may require higher dosages of supplemental vitamin D.	C	32-34	Based on disease-oriented evidence and expert opinion

A = consistent, good-quality patient-oriented evidence; B = inconsistent or limited-quality patient-oriented evidence; C = consensus, disease-oriented evidence, usual practice, expert opinion, or case series. For information about the SORT evidence rating system, go to <http://www.aafp.org/afpsort.xml>.

tend to be lower in breastfed infants¹³; and that 400 IU of vitamin D supplementation in these infants maintains higher concentrations of 25-hydroxyvitamin D.¹⁴ In addition, studies have shown that adolescents consume insufficient levels of dietary vitamin D^{15,16} and that supplementation increases 25-hydroxyvitamin D levels and bone mineral density.¹⁷

Consequently, the AAP issued an updated recommendation in 2008 that all infants, children, and adolescents receive a minimum of 400 IU of vitamin D daily through diet or supplements.¹⁸ Infants who are formula-fed exclusively will most likely have an adequate level of vitamin D. Infants who are breastfed or partially breastfed, as well as children and adolescents who consume less than 1 L (33.8 fl oz) of vitamin D–fortified milk per day, should receive 400 IU of supplemental vitamin D daily.^{13,19-22}

Despite these recommendations, there are no studies showing that universal supplementation improves patient-oriented outcomes, such as the reversal of lethargy, irritability, and growth failure, attributed to vitamin D deficiency. Only indirect evidence supports the contention that 400 IU of supplemental vitamin D daily prevents and treats rickets.¹⁴ Prospective studies focusing on patient-oriented outcomes, rather than biomarkers, are needed before the actual clinical impact of supplemental vitamin D will be understood.

Vitamin D and Sunlight

In addition to dietary sources, children and adults obtain vitamin D through exposure to ultraviolet B sunlight. As little as 10 to 15 minutes of direct sunlight can generate 10,000 to 20,000 IU of vitamin D. Many factors influence vitamin D synthesis, such as skin pigmentation, latitude, and amount of skin exposed, making it difficult to assess how much vitamin D will be converted from sunlight exposure. Infants and children who have darker pigmentation require five to 10 times the length

of sunlight exposure to reach the same levels of 25-hydroxyvitamin D when compared with children who have lighter pigmentation.²³ However, the AAP recommends that infants younger than six months be kept out of direct sunlight.²⁴ Although the goal of limiting sunlight exposure is to minimize the risk of skin cancer, it may also predispose children to vitamin D deficiency.²⁵⁻²⁷ Because the safe level of sunlight exposure needed for vitamin D conversion is unknown, increasing vitamin D supplementation is a reasonable alternative.

Complications of Vitamin D Deficiency

Risk factors for vitamin D deficiency are summarized in *Table 1*. Physicians should confirm suspicion of vitamin D deficiency by measuring levels of 25-hydroxyvitamin D, which is the best available biomarker for checking vitamin D status.^{28,29} Vitamin D deficiency in adults is defined as 25-hydroxyvitamin D levels of less than 20 ng per mL (50 nmol per L), although this varies among studies.³⁰ There is no set level of 25-hydroxyvitamin D to confirm vitamin D deficiency in infants, children, and adolescents. Although no set level has been established for children and adolescents, recent studies have used less than 15 to 20 ng per mL (37.44 to 50 nmol per L) as a cutoff for vitamin D deficiency in these age groups.

Table 1. Risk Factors for Vitamin D Deficiency in Children

Anticonvulsant medication therapy
Chronic diseases associated with fat malabsorption
Darker skin pigmentation
Exclusive breastfeeding without vitamin D supplementation
Insufficient sunlight exposure
Low maternal vitamin D levels (risk factor for infants)

Patients with severe cases of rickets may present with growth failure, hypocalcemic seizures, decreased bone mass, and characteristic bone changes or fractures (*Figure 1*). Nonspecific symptoms, such as irritability, lethargy, and developmental delay, may be less obvious. In a case-control study of children hospitalized for acute illnesses, investigators found an increased rate of admissions for lower respiratory tract infections among those with rickets.³¹

Supplementation Options

Vitamin D₃, known as cholecalciferol, is the preferred form of vitamin D for supplementation. Children with certain conditions, such as fat malabsorption, and those who require long-term use of seizure medications may need higher dosages of vitamin D because of increased risk of deficiency.³²⁻³⁴ Monitoring 25-hydroxyvitamin D levels every three months, and parathyroid hormone levels and bone-mineral status every six months, is recommended for these children.

Vitamin D deficiency during pregnancy may increase the risk of abnormal fetal growth and bone development, but further studies are needed before high-dose supplementation in pregnant women can be universally recommended.³⁵

No evidence suggests that daily supplementation of 400 IU of vitamin D is toxic. Physicians should provide patients with detailed administration instructions to avoid accidental overdose. Vitamin D₃ drops, which are preferable for infants, are available in formulations of 400, 1,000, and 2,000 IU per drop. Varying amounts of vitamin D₃ are available within formulations of the same brand. Chewable and gummy vitamins for older children contain 200 or 400 IU of vitamin D, but may vary by formulation from the same manufacturer. Physicians may prefer to recommend one brand and formulation for each age group to ensure that patients reach a daily dosage of 400 IU (*Tables 2 and 3*).

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Figure 1. Ankle radiograph of a 17-month-old girl with healing rickets. Note the lateral bowing of the fibulas and the right tibia, as well as the bandlike lucency in the metaphysis.

Table 2. Vitamin D Liquid Supplements for Infants and Children Younger than Two Years

Brand	Vitamin D per serving (IU)	Serving size
Carlson Baby D Drops	400	1 drop
Enfamil Poly-Vi-Sol Multivitamin Supplement Drops	400	1 mL
Enfamil Tri-Vi-Sol Vitamins A, C & D with Iron	400	1 mL
Sunlight Vitamins Just D infant vitamin drops	400	1 mL
Twinlab Infant Care Multivitamin Drops with DHA	400	1 mL

DHA = docosahexaenoic acid.

Table 3. Multivitamins Containing Vitamin D for Children and Adolescents

Brand	Vitamin D per serving (IU)	Serving size
Centrum Kids Complete Multivitamins, chewable tablets	400	One tablet for children four years and older (1/2 tablet for children two and three years of age)
Disney Gummies Children's Multivitamin	200	Two gummies for children two years and older
Flintstones Children's Complete Multivitamin, chewable tablets	400	One tablet for children four years and older (1/2 tablet for children two and three years of age)
Flintstones Gummies with Calcium & Vitamin D, multivitamin	400	Two gummies for children four years and older (one gummy for children two and three years of age)
Li'l Critters Gummy Vites Kids Multivitamin	240	Two gummies for children two years and older
Sundown Spider-man Complete Children's Gummies	200	Two gummies for children two years and older

Vitamin D Supplementation

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