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Vitamin D: A Rapid Review

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Abstract and Introduction

Abstract

Interest in all aspects of vitamin D seems to be surging due to perhaps the increased number of diverse positive studies suggesting it could prevent a variety of chronic diseases. However, before patients and health care professionals are educated on the preventive aspects of this vitamin that acts more like a hormone, a basic rapid review of vitamin D is needed. There are multiple reasons for the high rate of vitamin D deficiency around the world, including an aging population, obesity, protective skin care measures, skin pigmentation, increased awareness, more utilized diagnostic assays, and perhaps even the lack of natural and fortified food and beverage sources. Various benefits and limitations of vitamin D2 and vitamin D3 supplementation are discussed. The proper use of the vitamin D blood test, also known as "25-OH vitamin D," is important, and changing the normal range of this test may allow for a slightly higher cutoff value based on parathyroid hormone reductions and experience from clinical trials of osteoporosis prevention. The vitamin D doses needed to adequately increase blood levels are provided. Finally, increasing the recommended daily allowance of this vitamin to 800 to 1,000 IU per day may be beneficial for most age groups.

Introduction

Sales and interest in vitamin D is surging because there may be a strong relationship between lower rates of a variety of chronic diseases and higher levels of vitamin D (Khazai, Judd, & Tangpricha, 2008). Minimally, the impact of vitamin D on calcium absorption and improving bone mineral density are impressive enough to garner attention. Dietary supplementation of vitamin D is not difficult and should be discussed with most patients. However, an objective review is still necessary for the clinician to separate fact from fiction regarding this specific vitamin, which has always acted more like a hormone than a vitamin (Coen, 2008).

Why Most People Are Vitamin D Deficient

It has become difficult to identify a population of individuals that has sufficient blood levels of vitamin D. Why are so many people vitamin D deficient? A review of the various factors that can cause vitamin D deficiency are found in (Wolpowitz & Gilchrest, 2006).

Table 1.

Table 1.
The Primary Factor(s) that Can Potentially Determine an Individual's Vitamin D Blood Level from A to Z

Factor That Influences Vitamin D Levels	Comment
Aging (Older individuals lose their ability to adequately produce vitamin D, regardless of sun exposure time)	Older individuals make less vitamin D for many reasons; 7-dehydrocholesterol in the skin decreases over time so it is more difficult to make vitamin D3 (for example, individuals above the age of 65 have a fourfold reduction in the capacity of the skin to produce vitamin D3), liver and kidney function is not as efficient, and the gut's ability to just absorb vitamin D from food or supplements is reduced.
Belly Fat (Obesity or greater amounts of visceral fat)	Obese individuals tend to have lower vitamin D concentrations because this vitamin gets absorbed by fat-tissue and is not easily released in the blood stream; another reason is that the volume of the blood is so large that it dilutes this nutritional test.
Cholesterol-Lowering Medications (Statins)	Preliminary research suggests that lowering cholesterol may increase vitamin D levels.
Dietary Vitamin D Intake (Natural or non-fortified sources)	The more vitamin D one gets from dietary sources, the higher the blood level. Fish and other seafood are the best naturally producing dietary sources, followed by mushrooms and egg yolks, which are both considerably lower sources.
Dietary Vitamin D Intake (Fortified vitamin D sources)	In the U.S. and Canada, milk, soy milk, bread products, cereals, protein bars, and beverages are fortified with vitamin D. In Europe, margarine is one of the more common fortified sources of vitamin D. However, independent surveys have found that many of these products do not contain the amount of vitamin D on the label (usually less).
Frequency of Vitamin D Intake (Daily versus weekly versus monthly)	Recent research has demonstrated that taking a daily pill has a higher probability of keeping a normal blood level of vitamin D compared to a once-weekly or once-monthly dosage equivalent formulation.
Skin Pigmentation	Darker-skinned individuals have more melanin (increased skin pigmentation), which blocks the impact of UVB radiation and reduces the production of vitamin D. African-American individuals have a higher risk of vitamin D deficiency.
Sunlight Exposure Due to Outside Activities	The more one's occupation or activities involves being outdoors, especially in the spring and summer, the greater the chance that you will have higher vitamin D levels.
Sunscreen/Sun-Protective Clothing and Other Measures	The higher the SPF of sunscreen, the more it blocks the ability of UVB light from the sun to increase vitamin D level. This is also the case with sun-protective clothing. Individuals that are completely covered by clothing for a variety of purposes (including religious) have lower vitamin D levels.
Supplemental Vitamin D (Supplement availability and type or form of vitamin D)	Multivitamins generally contain 400 IU (10 mcg) per capsule, and vitamin D individual tablets can now be purchased and are cost effective. However, many of these pills and liquids contain vitamin D2 and not vitamin D3.
Ultraviolet-B (UV-B) Light Radiation (Wavelength = 290 to 315 nm; exposure based on where one lives)	UVB radiation from the sun is the primary source of vitamin D for most people. Thus, geographic location (where you live) has an impact on how much sun and vitamin D is produced (more sun or closer to the equator = more vitamin D). In latitudes of approximately 40 degrees north and south of the equator, vitamin D production in skin rarely occurs in the winter (for example, Boston, MA, is 42 degrees north and Edmonton, Canada, is 53 degrees north).

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demonstrates how easy it is to become deficient in this vitamin. For example, just getting older can reduce vitamin D levels because the mechanisms needed to synthesize its structure from cholesterol become less efficient through time, as is the case with most intrinsic synthesizing methods in the human body. It is obvious that human beings age externally (such as with wrinkles, gray hair). However, it is less obvious that humans also age internally, and inadequate vitamin D synthesis is just one example of this internal aging issue. Low levels of vitamin D are also found in individuals with larger amounts of belly fat or visceral obesity (Aasheim, Hofso, Hjelmesaeth, Birkeland, & Bohmer, 2008). Numerous theories abound as to why this is the case, such as hemodilution from greater blood volumes or the finding that adipose tissue is a greater storage site for vitamin D. Higher cholesterol levels may be associated with lower vitamin D blood levels, and conversely, cholesterol-lowering medications, such as statins, may increase vitamin D synthesis (Perez-Castrillon et al., 2008).

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Dietary Vitamin D Intake (Fortified vitamin D sources)	In the U.S. and Canada, milk, soy milk, bread products, cereals, protein bars, and beverages are fortified with vitamin D. In Europe, margarine is one of the more common fortified sources of vitamin D. However, independent surveys have found that many of these products do not contain the amount of vitamin D on the label (usually less).
Frequency of Vitamin D Intake (Daily versus weekly versus monthly)	Recent research has demonstrated that taking a daily pill has a higher probability of keeping a normal blood level of vitamin D compared to a once-weekly or once-monthly dosage equivalent formulation.
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Supplemental Vitamin D (Supplement availability and type or form of vitamin D)	Multivitamins generally contain 400 IU (10 mcg) per capsule, and vitamin D individual tablets can now be purchased and are cost effective. However, many of these pills and liquids contain vitamin D2 and not vitamin D3.
Ultraviolet-B (UV-B) Light Radiation (Wavelength = 290 to 315 nm; exposure based on where one lives)	UVB radiation from the sun is the primary source of vitamin D for most people. Thus, geographic location (where you live) has an impact on how much sun and vitamin D is produced (more sun or closer to the equator = more vitamin D). In latitudes of approximately 40 degrees north and south of the equator, vitamin D production in skin rarely occurs in the winter (for example, Boston, MA, is 42 degrees north and Edmonton, Canada, is 53 degrees north).

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The lack of reliable dietary sources that contain consistently higher levels of vitamin D has been an issue. It is of interest that the highest concentration of vitamin D is found in some heart-healthy fish, so patients can get "two for the price of one" by consuming fish high in omega-3 and vitamin D, such as salmon. Fortification of some foods and beverages have not solved the vitamin D deficiency problem, and recent studies suggest that the regular intake of vitamin D may increase blood levels greater than weekly or monthly oral intakes of equivalent doses (Chel, Wijnhoven, Smit, Ooms, & Lips, 2008). Sunscreen has the ability to block ultraviolet B (UVB) light, and this form of light stimulates vitamin D synthesis in skin tissue. Thus, wearing sunscreen, and sun-protective clothing, or avoiding sunlight all have the ability to result in lower blood levels of vitamin D. However, no clinician should recommend trading one condition for another, and it is a concern that some clinicians advise regular sun exposure several times a week. Why increase a person's risk for melanoma just to improve vitamin D levels, when supplementation is generally simplistic and cost effective? Melanoma kills, and death rates have not decreased over the last decade; the responsible recommendation lies in proper sun protection and potential vitamin D supplementation. Another thought in some medical circles is that individuals residing in areas with greater sun exposure experience higher blood levels of vitamin D. Theoretically, this makes sense; however, it has not been substantiated through recent research demonstrating low blood levels of vitamin D in individuals residing in Florida and

southern Arizona (Jacobs et al., 2008; Levis et al., 2005). Perhaps regular sun avoidance, aging, and obesity are independently or synergistically involved in lowering vitamin D levels in some of these geographic areas.

Dietary Sources of Vitamin D

The only foods that naturally contain vitamin D are seafood, mushrooms, and egg yolks. A partial list of foods and their natural vitamin D content is found in (Chen et al., 2007; National Institutes of Health Office of Dietary Supplements, 2008).

Table 2.

Table 2.
A Partial List of Foods that Naturally Contain Vitamin D

Food	Serving Size	Vitamin D (IU)
Oysters	3 oz	545
Salmon (wild)	3 oz	1,000
Cod-liver oil	1 teaspoon	450
Catfish	3 oz	425
Bluefish	3 oz	415
Mackerel	3 oz	395
Trout (farmed)	3 oz	375
Salmon (farmed)	3 oz	275
Sardines (canned in oil)	3 oz	230
Halibut	3 oz	170
Tuna (bluefin)	3 oz	170
Tuna (canned in water)	3 oz	135
Shrimp	3 oz	120
Milk*	1 cup	100
Cod	3 oz	80
Mushrooms (Shitake)	2 oz	55
Mushrooms (Chanterelle)	2 oz	50
Sole/flounder	3 oz	50
Bass (freshwater)	3 oz	35
Swordfish	3 oz	35
Clams	3 oz	30
Egg (whole)	1	25

Note: IU = International Units.

* Milk is listed here as a reference and not a natural source. Whole, low-fat, or non-fat/skim milk is supposed to be fortified with 100 IU of vitamin D per cup, but past studies have not yet definitely proven the reliability of the fortification process. Studies have suggested that many dairy products are under fortified with vitamin D despite claims in the label.

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Several items from are worth noting. Wild salmon contains as much as 3 times the amount of vitamin D compared to farmed salmon (Chen et al., 2007). Patients inquire regularly about the differences and similarities between farmed and wild fish. Both are equally high in omega-3 fatty acids, which are heart-healthy, and both tend to have a low level of mercury and other contaminants (Mozaffarian & Rimm, 2006). A preliminary difference lies in the inherent vitamin D content of these fish, and generally speaking, both types of fish are healthy to consume.

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Catfish	3 oz	425
Bluefish	3 oz	415
Mackerel	3 oz	395
Trout (farmed)	3 oz	375
Salmon (farmed)	3 oz	275
Sardines (canned in oil)	3 oz	230
Halibut	3 oz	170
Tuna (bluefin)	3 oz	170
Tuna (canned in water)	3 oz	135
Shrimp	3 oz	120
Milk*	1 cup	100
Cod	3 oz	80
Mushrooms (Shitake)	2 oz	55
Mushrooms (Chanterelle)	2 oz	50
Sole/flounder	3 oz	50
Bass (freshwater)	3 oz	35
Swordfish	3 oz	35
Clams	3 oz	30
Egg (whole)	1	25

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Vitamin D2 and/or Vitamin D3

There are two types of vitamin D supplements available for over-the-counter purchase (vitamin D2 and vitamin D3). Vitamin D3 is the type that most

experts believe should be utilized in clinical practice (Wolpowitz & Gilchrest, 2006). Vitamin D2 is also known as "ergocalciferol," and vitamin D3 is also known as "cholecalciferol." This is important for patients who have purchased a dietary supplement that does not indicate the specific type of vitamin D in the product by number but have listed the scientific name. Most experts now believe that the only form that should be purchased is vitamin D3. Vitamin D2 is also very acceptable, but in the author's opinion, most individuals should switch to D3. There is a plethora of logical reasons for advocating the use of vitamin D3 over vitamin D2 dietary supplements (Wolpowitz, & Gilchrest, 2006), including:

- UVB light from the sun strikes the skin, and humans synthesize vitamin D3, so it is the most "natural" form. Human beings do not make vitamin D2, and most healthy fish contain vitamin D3.
- Vitamin D3 is the same price as vitamin D2.
- Vitamin D3 may be less toxic than D2 because higher concentrations of D2 circulate in the blood when consumed (compared to vitamin D3). It does not bind as well to the receptors in the human tissues compared to vitamin D3.
- Vitamin D3 is the more potent form of vitamin D, which is a potential benefit. For example, obesity tends to lower blood levels of vitamin D, so a more potent form is needed.
- Vitamin D3 is more stable on the shelf compared to D2, and is more likely to remain active for a longer period of time and when exposed to different conditions (temperature, humidity, and storage). This is perhaps why the amount of vitamin D2 in certain fortified food products have been significantly lower than that advertised on the label in numerous instances.
- Vitamin D3 has been the most utilized form of vitamin D in clinical trials, and there have only been a few clinical trials of vitamin D2 to prevent bone fractures in adults.
- Vitamin D3 is more effective at raising and maintaining the vitamin D blood test (again, D2 binds less tightly to the vitamin D receptors in the body; therefore, D2 does not circulate as long in the body, which means it has a shorter half-life).

Vitamin D2 is a fungus/yeast-derived product, and it was first produced in the early 1920s by exposing foods to ultraviolet light (Wolpowitz & Gilchrest, 2006). This process was patented and licensed to pharmaceutical companies. Currently, many major prescription forms of vitamin D are actually vitamin D2 and not vitamin D3. Vitamin D2 is synthetically made from radiating a compound (ergosterol) from the mold ergot. Vitamin D3 is made commercially and synthetically in a similar way that it is produced intrinsically in human and animal skin when exposed to UVB light. Wool sources of 7-dehydrocholesterol are used (from cholesterol), and irradiatied to form active vitamin D3. Vegetarians or especially vegans may be opposed to the use of vitamin D3 supplementation because it is derived from an animal source, and these individuals should be guided to the vitamin D2 form. Multivitamins have either vitamin D2 or D3, but many companies are now utilizing mostly vitamin D3. Cod liver oil has vitamin D3 in it.

Rickets, a defect in bone growth in infancy and childhood, was first identified in 1650 (Welch, Bergstrom, & Tsang, 2000). It was not until 1922 that medical research demonstrated that something in cod liver oil prevented and cured rickets. Additionally, vitamin D2 added to milk in the United States and Europe in the 1930s essentially eliminated rickets (disease of weak bones in children) or osteomalacia (same disease of weak bones but in adults). Currently, fortification with vitamin D2 or D3 has continued to keep rickets scarce in North America. The minimum amount of vitamin D needed to prevent rickets is 100 IU (2.5 mcg) per day in infants with little to no sun exposure.

The Vitamin D Blood Test (25-OH Vitamin D): Who, How, When, and Where

Clinically speaking, things began to change in the 1970s when the blood test for vitamin D (known as the "25-OH vitamin D" test) became more accurate and widely utilized (Wolpowitz & Gilchrest, 2006; Zerwekh, 2008). This test reflected the total amount of vitamin D in the body that was coming from all sources (diet, dietary supplements, and the sun), which makes this test extremely important in the field of nutrition. Low concentrations of 25-OH vitamin D causes secondary hyperparathyroidism (high levels of parathyroid hormone or PTH). This means a person loses more calcium from his/her bones when PTH is abnormally high (PTH>65 pg/ml) and has an even greater risk for bone loss. Vitamin D3 seemed more effective than D2 at raising this important blood test. Furthermore, preliminary work showed that enzymes in the liver and the final vitamin D receptors (VDR) in important tissues bind vitamin D3 more effectively. As humans age, these metabolic differences make a very large difference in terms of effectiveness. Almost all successful anti-fracture

clinical trials have used vitamin D3 at a dosage of at least 800 IU/day (20 mcg per day).

Ideally, the vitamin D blood test should be offered from the fall season through winter when vitamin D blood levels are at their lowest. Spring and summer months can give patients and clinicians a false sense of vitamin D security. Patients should have a 25-OH vitamin D test yearly from September through March, around the same time they get their fasting lipid level. Fasting is not necessary to obtain a vitamin D level; however, getting blood tests at the same time makes sense, reducing the burden of time on the patient. Some health insurances cover vitamin D testing and some do not, and prices vary from $10 to $50, so local laboratory costs should be checked before telling the patient that a vitamin D test is needed.

An example of the greater need for utilizing the vitamin D blood test are men on androgen or hormone deprivation treatment for prostate cancer or those on this or a similar medication for other medical conditions (such as women being treated for breast cancer). It is now common knowledge that these life-saving medications that reduce estrogen and testosterone can also increase the risk of bone loss. In the author's opinion, less than 1% of men and women are offered a vitamin D test when given this injection, and this is disappointing. Some of these men and women will be prescribed a bisphosphonate or another drug without hesitation if needed. However, some of these men and women were not given the chance to maintain their bone mineral density through lifestyle changes (such as weight lifting) and supplement intake of calcium and vitamin D before being offered the prescription medication. In other words, health care professionals should offer a cholesterol-lowering drug if diet and exercise do not work (for example, cardiovascular prevention), but patients should be educated about lifestyle changes as well. Therefore, when diet, exercise, and blood tests do not work to maintain bone mineral density, the bisphosphonates and other osteoporosis prevention medications are a wonderful option, and are more effective with diet and exercise.

Personal Belief Regarding Vitamin D Testing

I am often asked when vitamin D blood testing should begin and who really qualifies for vitamin D blood testing. My answer is simple. Who does not qualify for vitamin D testing annually or once every few years? To my knowledge, no group in the world consistently carries a higher than normal vitamin D blood level. This is true for African Americans, Asians, Caucasians, Hispanics, babies, pregnant women, adolescents, older adults, and middle-aged individuals. This has confirmed my belief that few people do not qualify for regular testing.

The "Ideal" Vitamin D Blood Level

Over the past few decades, the "normal" blood level of vitamin D (25-OH vitamin D) was based on the amount needed to keep PTH from becoming abnormally high. Again, PTH at high levels can cause calcium loss from the bone, so this would make sense that vitamin D could maintain or improve bone health at these levels. However, PTH can change due to renal function, exercise level, the time of day, or even diet. There has been no consensus on the optimal level of vitamin D intake to reduce PTH, and this is why many laboratories report the normal range of vitamin D to be so wide (20 to 40 ng/ml, or in some cases, 50 to 100 nmol). However, this is tantamount to saying a normal total cholesterol level is between 100 to 500.

What is the best blood level of vitamin D? Several prominent experts reviewed a large number of past studies to arrive at an answer to this question (Bischoff-Ferrari, Giovannucci, Willett, Dietrich, & Dawson-Hughes, 2006). Their findings were satisfactory in this author's opinion. A variety of health changes not specific to bone health were evaluated, and the researchers sought to determine what level of vitamin D could maintain muscle strength, prevent falls, improve dental health, and prevent cancer (especially colorectal cancer). Weaker evidence for vitamin D includes preventing multiple sclerosis, other cancers, arthritis, hypertension, and tuberculosis, as well as solving insulin problems (diabetes mellitus). These researchers also reviewed a variety of other areas apart from keeping PTH normal and looked at studies that included a variety of ethnic groups. These experts found a consistent answer, which is that most clinical studies in a variety of health areas point toward a blood level of vitamin D that is between 90 to 100 nmol/L, or 35 to 40 ng/ml, for preventive health.

Why not surpass the number of 35 to 40 ng/ml as some experts have suggested? Unfortunately, higher does not mean better. Medical research is replete with examples of where a little higher helped, but more was not necessarily better. Supraphysiologic levels beyond what is now recommended in this manuscript is not yet supported in medical literature. It is interesting that some studies (for example, in the area of prostate cancer) have not yet found considerable benefits to achieving such higher vitamin D levels (Mucci & Spiegelman, 2008). In fact, it has been suggested that long-term significant increases in vitamin D could be detrimental. Thus, some experts suggest that there is no harm of carrying high vitamin D levels (70 ng/ml or more for example), but this recommendation is based on acute and not chronic observations. Not long ago, this same philosophy was applied to selenium or vitamin E, and ample evidence now exists to suggest that toxicity can occur when these nutrients are given chronically in mega-doses to achieve higher-thannormal blood levels of these nutrients.

Dosage of Vitamin D Needed To Achieve 35 to 40 ng/ml (90-100 nmol/L)

Historically, 400 IU (10 ug) of vitamin D was recommended for better health because it closely approximated the amount of vitamin D in a teaspoonful of cod liver oil. However, 800 to 1,000 IU is the dose that may have a better chance of giving a patient a normal vitamin D level. In some countries, vitamin D is listed in micrograms, and the relationship is as follows:

- 2.5 mcg (micrograms) = 100 IU.
- 5 mcg = 200 IU.
- 10 mcg = 400 IU.
- 15 mcg = 600 IU.
- 20 mcg = 800 IU.

It is much easier to access the patient's need after a vitamin D blood test. Few individuals would allow their clinician to simply guess an individual's cholesterol level before placing him/her on some type of medication. Clinicians have access to an accurate lipid test that provides guidance. The same is true for vitamin D levels. Clinicians should not suggest high intakes of vitamin D (5,000 IU for example) before recommending the 25-OH vitamin D test.

Health care professionals need to keep in mind that in general, 100 IU (2.5 mcg) of vitamin D per day can raise the vitamin D blood test only 1 ng/ml or just 2.5 nmol/L after 2 to 3 months. How much vitamin D is needed per day to obtain a normal vitamin D blood level? The following examples include:

- 100 IU (2.5 mcg) per day increases vitamin D blood levels 1 ng/ml (2.5 nmol/L).
- 200 IU (5 mcg) per day increases vitamin D blood levels 2 ng/ml (5 nmol/L).
- 400 IU (10 mcg) per day increases vitamin D blood levels 4 ng/ml (10 nmol/L).
- 500 IU (12.5 mcg) per day increases vitamin D blood levels 5 ng/ml (12.5 nmol/L).
- 800 IU (20 mcg) per day increases vitamin D blood levels 8 ng/ml (20 nmol/L).
- 1000 IU (25 mcg) per day increases vitamin D blood levels 10 ng/ml (25 nmol/L).
- 2000 IU (50 mcg) per day increases vitamin D blood levels 20 ng/ml (50 nmol/L).

If the vitamin D blood test was 30 ng/ml (75 nmol/L) and a 40 ng/ml (100 nmol/L) level was desired, 1,000 IU (25 mcg) of vitamin D per day over several months should be taken to achieve a normal blood level or 40 ng/ml (100 nmol/L). Upon reaching the goal, most individuals need to supplement with 800 to 1,000 IU per day to maintain this level. Only working closely with a clinician over time can provide the most accurate answer. However, issues of insurance and health care access suggest that 800 to 1,000 IU is ample for many individuals who are not able to have their blood tested.

Calcium and Vitamin D Recommended Daily Allowances

Calcium and vitamin D work synergistically to provide optimal potential clinical benefits, and this is now well known from clinical research (Khazai et al., 2008). Regardless of the adult age, the average intake of calcium is about 600 mg to 800 mg per day at best. These recommended dosages from various government organizations and from the author's personal experience are found in (Prentice, 2002).

Table 3.

Table 3.
Approximate Government Recommendations for Calcium and Vitamin D Based on Age (Author's Commentary in Parentheses)

Age	Calcium (mg)	Vitamin D (IU) (I wish we tested all age groups for vitamin D blood levels on a regular basis.)
0 to 6 months	200	200 (I wish we even tested infants at this age for vitamin D levels.)
7 to 12 months	250	200 IU or 5 mcg (I wish it were at least 400 IU or 10 mcg.)
1 to 3 years	500	200 IU or 5 mcg (I wish it were at least 400 IU or 10 mcg.)
4 to 8 years	800	200 IU or 5 mcg (I wish it were at least 400 IU or 10 mcg.)
9 to 18 years	1,200	200 IU (I wish it were at least 800 to 1,000 IU or 20 to 25 mcg.)
19 to 50 years	1,000	200 (I wish it were at least 800 to 1,000 IU or 20 to 25 mcg.)
50 to 70 years	1,200	400 (I wish it were at least 800 to 1,000 IU or 20 to 25 mcg)
Over 70 years	1,200	600 (I wish it were at least 800 to 1,000 IU or 20 to 25 mcg.)
Pregnancy	1,200	400 (I wish it were at least 800 to 1,000 or 20 to 25 mcg.)
Lactation	1,200	400 (I wish it were at least 800 to 1,000 IU or 20 to 25 mcg.)

Source: Prentice, 2002.

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By 10 years of age (double figures) nutritional intake should include approximately 1,000 mg of calcium a day total (from diet and supplements) and close to 1,000 IU of vitamin D (from diet and supplements after blood testing) for the rest of one's life, regardless of gender.

The daily requirement of vitamin D in is disputed by this author. The minimum requirement should be from 400 to 800 IU in all ages, and especially, from age of a few years old to over 70 years, it should be at least 800 IU. However, as stated previously, the exact determination of minimum vitamin D intake should come from a blood test given in the fall or winter. Also, patients should be told that vitamin D is a fat-soluble vitamin that takes months to deplete; it also does not have to be in a calcium supplement as some companies advertise. It is difficult today, however, to find a calcium supplement without vitamin D in it.

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19 to 50 years	1,000	200 (I wish it were at least 800 to 1,000 IU or 20 to 25 mcg.)
50 to 70 years	1,200	400 (I wish it were at least 800 to 1,000 IU or 20 to 25 mcg)
Over 70 years	1,200	600 (I wish it were at least 800 to 1,000 IU or 20 to 25 mcg.)
Pregnancy	1,200	400 (I wish it were at least 800 to 1,000 or 20 to 25 mcg.)
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Side Effects and Toxicity

Some studies have given healthy individuals 100,000 IU tablets or more once every 4 to 6 months without acute toxicity (Wolpowitz & Gilchrest, 2006). A 21-year-old man or women exposed to summer UVB light generates 10,000 IU (the equivalent of 250 mcg, 25 multivitamin pills of vitamin D, or 100 glasses of milk) of vitamin D in 15 to 20 minutes. However, longer exposure does not produce more vitamin D. Humans were basically built to produce and carry higher levels of vitamin D when exposed to the sun. Previous research suggests that the first sign of real side effects or toxicity of vitamin D occurs at a blood level of greater than 88 ng/ml (220 nmol/L) where abnormally high blood levels of calcium result from too much absorption of calcium from food and that can lead to problems (Bischoff-Ferrari et al., 2006; Wolpowitz & Gilchrest, 2006). Regardless, as mentioned earlier, apart from the acute toxicity of hypercalcemia or hypercalciuria, the long-term implications of blood levels of 70 to 90 ng/ml are not known, and in this author's opinion, should not be entertained without more long-term safety data.

Conclusion

It is difficult to remember if I ever received a lecture on vitamin D during my university or medical training years. Perhaps I did, but I was not listening. Today, after reviewing the medical literature, vitamin D has my attention as well as the attention of most specialties. There seems to be a multitude of lessons that can be learned from the vitamin D deficiency rates around the world. For example, it seems that the more access to health care, the better the diet, and the lower the rate of obesity, the higher the potential blood level of vitamin D. However, part of the vitamin D deficiency issue also lies in health care professional advice being followed and the aggressive promotion of sun avoidance for better skin health.

Clinicians need to remember their message's implications whenever disease-specific education is applied to any patient. The next time advice is given to use sunscreen and other sun-protective measures, there should also be ample time given to the various proven methods of raising vitamin D levels, including fish consumption and vitamin D supplementation, not just to improve bone health, but to improve overall health and well being.

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