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In 1921, scientists discovered that sunlight helped strengthen bones and prevented Rickets in childhood and Osteomalacia in adulthood.¹ Moreover, sunlight supported our bodies in creating vitamin D. Scientists also found that fish liver oil contains vitamin D. The United State (U.S.) has been supplementing vitamin D in milk and various foods since 1930, which has reduced the incidence of Rickets and Osteomalacia.²

Sources of vitamin D

1. Mushroom, spinach, broccoli and other green vegetables contain vitamin D2 which is created by ultraviolet rays (UV) from sunlight. Vitamin D2 will then transform into vitamin D3 in our bodies, but this is not sufficient for our body’s needs.

2. Vitamin D3 can be created by ultraviolet B (UVB) from sunlight in skin within one day. Skin can produce vitamin D3 up to 20,000 international units (IU) after getting sufficient sunlight over a period of time.

3. Vitamin D3 can be found in sea fish such as salmon, mackerel, sardine etc. although these sources alone do not have sufficient levels of vitamin D3. For example; 5 ounces (oz) of salmon, 7 oz of halibut, 30 oz of cod, 7 oz of tuna may contain as much as vitamin D3 400 IU. Although fish liver oil has a lot of vitamin D, it has excessive vitamin A. An egg yolk has only 25 IU vitamin D but contains cholesterol of up to 275 milligrams (mg). Daily intake of cholesterol should not exceed 300 mg. 3.5 oz of cow liver contains 46 IU vitamin D3.

4. Vitamin D3 can be obtained from fortified milk cereal, bread and vitamin supplements. A cup of milk has approximately 100 IU vitamin D.

Vitamin D added to yoghurt, orange, juice, cereal and some kinds of bread is a low dose of vitamin D.³ A regular multivitamin pill has 400 IU vitamin D3. For most people who do not have vitamin D deficiency one pill per day will suffice.

Note: Vitamin D originating from sunlight is kept in the body for a month but vitamin D sourced from food and supplements will remain in the body for two weeks.

The transformation of vitamin D in the body

There are two types of vitamin D. The first type, vitamin D3 comes from plants. Vitamin D3 is derived from skin synthesis, sea food, beef and pork, and nutritional supplements. Vitamin D2 will change into vitamin D3 in the body to merge with existing vitamin D3 levels and then passes through the liver and is processed to become inactive vitamin D3, 25-hydroxyvitamin D or 25(OH)D. Most inactive vitamin D3 will pass through the kidneys
in order to change into active vitamin D3 1,25-dihydroxyvitamin D \([1,25(OH)2D]\). Before the body is able to use active vitamin D3, it passes through the blood vessels to go to four important organs namely intestine, kidney, bones, and the parathyroid gland. These four organs are responsible for controlling the levels of calcium and phosphorus in our blood. Both inactive vitamin D3, \(25(OH)D\) and active vitamin D3, \(1,25(OH)2D\) will circulate in blood vessels and they play a role in controlling the function of organs. Inactive vitamin D3, \(25(OH)D\) which the liver produces can be transformed into active vitamin D3, \(1,25(OH)2D\) in many organs.4

**The quality of Vitamin D**

Many cells in our body use vitamin D in order to control the cell system to work properly and effectively as follows:

1. Increase the strength of bones, to control the absorption of calcium in the intestine, to maintain normal levels of calcium in the blood, to help prevent vertebral compression fractures and hunchback as we age, bones are harder to break in the elderly, and to prevent decayed teeth.
2. Increase muscle strength, to allow us to sit down and get up from a chair easily without stumbling and falling.
3. Increase the flexibility of our blood vessels, to help improve the expansion and shrinking of blood vessels, to control blood pressure.
4. Control the growth of blood vessels and to prevent them from increasing too much.
5. Improve the work of the cardiac muscle.
6. To help our lungs to work better, to help asthmatics to breathe properly.
7. Help control diabetes by producing insulin to decrease blood sugar levels.
8. Help to improve immunity to protect against infections.
10. Control the dividing of cells, both in terms of size and amount of cells produced, and to help prevent large intestine cancer up to 28%.
11. Control the cell life cycle.
12. Help to control the parathyroid hormone to remain normal. In cases of a deficiency in vitamin D, parathyroid hormone levels will be high, which aggravates mental instability, insomnia and paresthesia muscle cramps and palpitations. Vitamin D helps to increase calcium levels, which has an impact on parathyroid hormone reduction. Symptoms will then disappear. But when vitamin D levels are normal and there is a high level of calcium in the blood, there are other issues that will be discussed below.

**The cause of Vitamin D deficiency**5,4

Vitamin D deficiency is found in people who get too little sunlight. For example, people who live above or below latitude 35 (except Eskimos who do not lack of vitamin D because they regularly consume fatty fish). Generally in winter, people will experience a lack of vitamin D if they do not have enough sunlight. Sun block and lotion with sun protect factor (SPF) 30 that protect against UVB rays up to 99%, leads to an inability of the skin to produce vitamin D. People with black skin lack vitamin D because the black melanin pigment protects against UVB. People who wear clothes that cover the whole body do not get enough exposure to UVB. UVB cannot penetrate the skin of people who are older than 50 years, so they lack vitamin D as well. Moreover, vitamin D deficiency is found in people who are vegetarian, are pregnant without enough exposure to sunlight and lack food and vitamin D supplements. Infants who only drink their mother’s milk lack vitamin D because mother’s milk has low levels of vitamin D. People who have a problem with their liver and kidney will lack vitamin D because the liver cannot produce active vitamin D3, \(25(OH)D\) and the kidney cannot produce active vitamin D3, \(1,25(OH)2D\). Vitamin D that we ingest that the intestine cannot digest is found to cause malabsorption syndrome, an effect of gastric surgery and a disorder of vitamin D metabolism. People who use steroid anticonvulsive drugs and statins can also be vitamin D deficient.

**The control of calcium levels and the change of phosphate levels in the blood when there is a lack of Vitamin D**

The organs that control calcium levels and the change of phosphate levels are the intestine, parathyroid gland, bones and kidneys. When inactive vitamin D levels, \(25(OH)D\) in the blood is low, active vitamin D, \(1,25(OH)2D\) will be low as well. This process decreases the ability of the intestine to absorb calcium and phosphate from food. As a result, calcium and phosphate levels in the blood are low. Calcium is essential for neuromuscular function and cardiac function. The body cannot let calcium levels drop, so the parathyroid glands release more parathyroid hormone, which results in the reduction of calcium and phosphate levels in bones. Calcium and phosphate from bones are taken into the blood and circulated in order to maintain normal calcium levels in the blood and to ensure the heart and nervous system work normally. This process, however, has an impact on osteopenia, osteomalacia and osteoporosis. This is one of the important factors which contribute to bone fractures. When the blood flows to the kidneys, calcium and phosphate is distilled via urine but the kidney retains calcium in the blood vessels while the phosphate is flushed out by urine. Consequently, the blood has normal levels of calcium but very low levels of phosphate. This symptom is found in people who lack vitamin D.5,6

**How to detect vitamin D levels in our blood**

If we detect inactive vitamin D3 (25 (OH) D) with a testing serum, inactive D3 can exist for 15 days (half-life 15 days) and active vitamin D3 (1,25(OH)2D) can exist for 15 hours (half life 15 hours). So, we do not use this.
method to determine the level of vitamin D3. The readings are as follows:

- Vitamin D3 lower than 20 < 20 ng/ml: High loss
- Vitamin D3 lower than 30 < 30 ng/ml: Loss
- Vitamin D3 level 30 ≥ 30 ng/ml: Normal
- Vitamin D3 higher level > 150 ng/ml: Toxic level

Note: nanogram per one milliliter (ng/ml)

The result of taking a lot of vitamin D3 can lead to headaches, vomiting, nausea and mental disorders. These are the symptoms of abnormally high calcium levels in the blood.

**X-ray to detect Bone Mineral Density (BMD)**

Testing for BMD used to be part of a diagnosis paired with blood tests for inactive vitamin D, 25(OH)D. If a low BMD shows osteopenia, we will find that vitamin D3 in the blood is low (loss). If BMD shows osteomalacia or osteoporosis, we will find that inactive vitamin D3 in the blood is very low (high loss).

**Flushing out vitamin D**

By the process of hydroxylation action inactive vitamin D3, 25(OH)D and active vitamin D3, 1,25 (OH)2D will disintegrate and go through the liver in order to travel via the bile duct and then the intestine to leave the body via excrement. When the liver does not function, there is no change of vitamin D in the liver and the vitamin D3 will then be disintegrated via urine directly by the kidneys.7

**Dose of vitamin D per day**

Relevant Daily Allowances

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<th>Age</th>
<th>Male</th>
<th>Female</th>
<th>Pregnancy</th>
<th>Breast Feeder</th>
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<td>400 IU</td>
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**References**


**Important note**

Normally, we use vitamin D3 to prevent many diseases. The dose recommended is given above in the table. If we increase our intake of vitamin D3 to more than 1,000 IU daily to cure many diseases including vitamin D deficiency diseases, we should consult a doctor. This is because vitamin D can be toxic if we consume more than 40,000 IU per day.

Importantly, we should also check calcium and phosphate levels in the serum annually. Toxic levels of vitamin D (> more than 150 mg/ml) will be found when calcium and phosphate levels are higher than normal. This may cause metastatic calcification, kidney destruction and mental disorders.

High levels of calcium in the blood can come from other diseases, for example, a tumor of the parathyroid gland, cancer, chronic infections such as Tuberculosis (TB), Fungus, Sarcoidosis and Wegener’s Granulomatosis, etc.

According to The American Blood Pressure Control Medical Association, daily levels of calcium in food and medication must not exceed 1,230 mg. According to The Diabetes Association, calcium consumption is limited to 1,000-1,500 mg per day.

People who have low vitamin D3 levels should take calcium and vitamin D3 in order to prevent bone hungry syndrome which causes many symptoms of low calcium in the blood because the bone leaches calcium from the blood rapidly. This process results in carpopedal spasm, convulsion and other symptoms of hyperparathyroidism.