

# Vitamin Deficiencies: An Overview

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## Abstract

Vitamins are substances that act as coenzymes (enablers) and regulators of metabolic processes. There are 13 known vitamins (vitamins A, B1, B2, niacin, pantothenic acid, B6, folic acid, B12, biotin, C, D, E, and K). Most have to be added to the body via food or vitamin supplements. Vitamins A, D, E, and K are fat-soluble while the others are water-soluble. Deficiencies in one or more of the vitamins lead to so-called "vitamin deficiency syndromes." This article briefly reviews the symptoms and diseases found in such vitamin deficiencies.

## 1. VITAMIN A (RETINOL, CAROTENE) DEFICIENCY

Vitamin A (retinol) is a fat soluble vitamin and found in fish liver oils, liver, egg yolks, butter, and cream. Another substance,  $\beta$ -carotene found in vegetables such as carrots, can also be converted to retinol. Vitamin A deficiency is a public health problem in over 100 countries, especially in Africa and South-East Asia. It is the leading cause in the world of preventable blindness in children and raises the risk of disease and death from severe infections.

### NYCTANOPIA, NYCTALOPIA, NIGHT BLINDNESS:

Night blindness may be an early sign of vitamin A deficiency. Individuals suffering from night blindness not only see poorly at night, but also require some time for their eyes to adjust from bright light. In addition, contrast vision may also be affected.

### XEROPHTHALMIA:

Dry eyes, also known as Xerophthalmia, result from inadequate production of tears. The disease begins with night blindness and conjunctival xerosis (dryness of the eye membranes) and progresses to corneal xerosis (dryness of the cornea), and to keratomalacia (softening of the cornea).

### OTHER GENERAL SIGNS OF VITAMIN A DEFICIENCY:

Other signs include growth retardation in children, follicular hyperkeratosis of the skin, keratinization of lung, GI tract, and urinary tract epithelia, as well as increased susceptibility to infections.

## 2. VITAMIN B1 (THIAMINE) DEFICIENCY

Thiamin is a water-soluble and heat-labile vitamin and found in grain, roast pork, ham, nuts, catfish, and pasta. It acts as a coenzyme in the carbohydrate metabolism and possibly in nerve conduction (essential for the synthesis of acetylcholine). Inadequate intake of thiamine occurs particularly in people subsisting on highly polished rice.

### BERIBERI (DRY BERIBERI, WET BERIBERI, WERNICKE-KORSAKOFF SYNDROME:

The first clinical descriptions of beriberi came from Dutch physicians in the 1940's and 1950's. They treated a patient from the East Indies suffering from what the natives called beriberi or "the disease of lameness." There are two major manifestations of thiamine deficiency: cardiovascular disease (wet beriberi) and nervous system disease ("dry beriberi" and Wernicke-Korsakoff syndrome). Beriberi now occurs primarily in alcoholic patients with malnutrition.

Dry beriberi: Symptoms of dry beriberi include pain, tingling, or loss of sensation in hands and feet (peripheral neuropathy), muscle wasting with loss of function or paralysis of the lower extremities, and potentially brain damage and death.

Wet beriberi or wet brain or Wernicke-Korsakoff syndrome: Wet beriberi is characterized by edema (swelling), increased heart rate, lung congestion, and enlarged heart related to congestive heart failure. The Wernicke-Korsakoff syndrome is an alcohol-related brain damage affecting language and thinking.

### 3. VITAMIN B2 (RIBOFLAVIN) DEFICIENCY

Vitamin B2 is a water-soluble vitamin and found in milk and other animal products. It acts as coenzyme in many reactions involved with carbohydrate metabolism. It is also needed to process amino acids and fats, activate vitamin B6 and folic acid, and help convert carbohydrates to energy (adenosine triphosphate ATP). Under some conditions, vitamin B2 can also act as an antioxidant. Vitamin B2 deficiency is quite uncommon. Those most vulnerable to deficiency of vitamin B2 include alcoholics, elderly persons, persons who suffer adverse reactions to dairy products (i.e. lactose intolerance), and women who use oral contraceptives.

#### GENERAL SIGNS OF VITAMIN B2 DEFICIENCY:

Vitamin B2 deficiency results in oral, ocular, cutaneous, and genital lesions. The signs include visual problems such as itching and irritation of the eyes, lacrimation, cataracts, and excessive sensitivity of the eyes to light (photosensitivity). In addition, reddening of the lips with cracking at the corners (cheilosis and angular stomatitis), tongue inflammation (glossitis), skin inflammation and itching (dermatitis), swelling (edema), dizziness, hair loss, insomnia, trembling, and delayed mental response may also occur.

### 4. VITAMIN B3 (NIACIN) DEFICIENCY

Niacin (nicotinic acid or nicotinamide) is essential in the form of the coenzymes nicotinamide adenine dinucleotide (NAD) and NAD phosphate (NADP) and found in dairy products, poultry, fish, lean meats, nuts, and eggs. NAD and NADP serve in many biological reactions such as intracellular respiration as well as in fatty acid and steroid synthesis. This disease can be common for persons who obtain most of their food from maize.

#### PELLAGRA:

Pellagra, the classic niacin deficiency disease, is characterized by cutaneous, mucous membrane, central nervous system (CNS), and gastro-intestinal (GI) symptoms. The complete syndrome of advanced deficiency includes symmetric photosensitive rash in sun exposed areas, scarlet stomatitis, glossitis, diarrhea, and mental aberrations.

### 5. VITAMIN B5 (PANTOTHENIC ACID) DEFICIENCY

Pantothenic acid is an essential component of coenzyme A, which functions as a cofactor for many enzymatic reactions needed in the metabolism of carbohydrates, fats, corticosteroids, and sex hormones. It is found in meats, lobsters, poultry, soybeans, green vegetables, yogurt,

avocado, mushroom, and sweet potato. Pantothenic acid deficiency is rare in humans. It is also integral to the proper functioning of the adrenal glands and nervous system as well as for normal growth and development throughout the human body.

#### GENERAL SIGNS OF VITAMIN B5 DEFICIENCY:

Symptoms of deficiency may include fatigue, nausea, abdominal pain, headache, and numbness or tingling in the limbs and extremities (paresthesias). It may also cause cramping of the muscles and a lack of coordination.

### 6. VITAMIN B6 (PYRIDOXINE) DEFICIENCY

Vitamin B6 acts as coenzyme in many reactions, including the metabolism of fatty acids and amino acids. It is therefore important in blood, central nervous system (CNS), and skin metabolism. It is found in fortified cereals, beans, meat, poultry, fish, and some fruits and vegetables.

#### GENERAL SIGNS OF VITAMIN B6 DEFICIENCY:

Vitamin B6 deficiency results in seborrheic dermatosis, glossitis, cheilosis, peripheral neuropathy, and lymphopenia. Vitamin B6 deficiency can cause convulsions in infants and anemia in adults.

### 7. VITAMIN B9 (FOLIC ACID) DEFICIENCY

Folic acid is found in green leafy vegetables, citrus fruits, and animal products. Folic acid deficiency is one of the most common vitamin deficiencies in the United States (5% of US population and 20% pregnant women). Folic acid is important for the synthesis of DNA, RNA, and proteins and also used in the metabolism of homocysteine (deficiency leads to its accumulation in the body).

#### GENERAL SIGNS OF FOLIC ACID DEFICIENCY:

Anaemia, red tongue, cancer, spontaneous abortion and other pregnancy abnormalities, congenital malformation (i.e., neural tube defect called spina bifida), as well as coronary artery disease and stroke due to homocysteine accumulation.

### 8. VITAMIN B12 (COBALAMIN) DEFICIENCY

Vitamin B12 plays an important role in DNA synthesis and neurologic function. It is found in meat, eggs and dairy products. Increased popularity of gastric acidblocking agents can lead to decreased vitamin B12 levels.

#### GENERAL SIGNS OF VITAMIN B12 DEFICIENCY:

Tiredness due to anemia leading to fatigue and weakness, loss of appetite, intermittent diarrhea and constipation,

weight loss, menstrual symptoms, psychological symptoms, and nervous system problems, such as numbness and tingling in the feet and hands.

### **9. BIOTIN DEFICIENCY**

Biotin functions as a coenzyme for carbon dioxide transfer and hence is essential to fat and carbohydrate metabolism. It is found in liver, cauliflower, salmon, carrots, bananas, soy flour, cereals, and yeast. Raw egg white contains a biotin antagonist, the glycoprotein avidin, which has a remarkable affinity for biotin. Once a biotin-avidin complex forms, the bond is essentially irreversible. Heating the egg whites denatures avidin and destroys its affinity for biotin.

### **EGG-WHITE INJURY SYNDROME:**

Prolonged consumption of raw egg whites may result in severe dermatitis, loss of hair, and lack of muscular coordination. Other symptoms include depression and muscle pains.

### **10. VITAMIN C (ASCORBIC ACID) DEFICIENCY**

Vitamin C (ascorbic acid) is essential for collagen formation and helps maintain the integrity of connective tissue, bony tissue, and dentin. It is essential for wound healing and facilitates recovery from burns. Vitamin C also protects folic acid reductase, which converts folic acid to folinic acid, and may help release free folic acid from its conjugates in food. Vitamin C facilitates the absorption of iron. It is found in citrus fruits such as oranges, limes, and grapefruit, and vegetables including tomatoes, green pepper, potatoes.

### **SCURVY, ASCORBIC ACID DEFICIENCY, BARLOW'S DISEASE:**

Acute or chronic disease characterized by hemorrhagic manifestations and abnormal bone and dentin formation. Signs include tiredness, bleeding gums (infection, gangrene, and loosening of teeth in later stages) and slow healing wounds, bone changes such as bowing of long bones and sunken sternum, bleeding into muscles or joints, and brain bleeding. Later stage changes include jaundice, edema, fever, weakness, irritability, weight loss, and vague myalgias and arthralgias.

### **11. VITAMIN D (CHOLECALCIFEROL) DEFICIENCY**

Synthesis in the skin is normally the major source of Vitamin D. It is also found in fish liver oils and egg yolks. Vitamin D is a prohormone with several active metabolites that act as hormones. In the skin, previtamin D3 is

synthesized photochemically. In the liver, vitamin D3 is converted to 25(OH)D3, the major circulating form. It passes through the liver circulation and is reabsorbed from the gut. In the kidneys, it is then further metabolized into the metabolically active vitamin D hormone. The main function of vitamin D is to increase calcium absorption from the guts and promote normal bone formation and mineralization. Inadequate exposure to sunlight and low dietary intake are usually necessary for development of clinical vitamin D deficiency.

### **RICKETS:**

Includes the following: unhealthy teeth, soft bones or osteomalacia (causes weakening of bones), pectus excavatum (sunken chest), pectus carnitum (barrel chest), bowed legs, enlarged forehead, fractures, scoliosis, muscle weakness, and infants walk or crawl late.

### **OTHER SIGNS OF VITAMIN D DEFICIENCY:**

Some forms of cancer, including breast cancer and colon cancer, osteoporosis, joint pain, muscle twitching, young infants are restless and sleep poorly, rachitic tetany caused by hypocalcemia.

### **12. VITAMIN E (TOCOPHEROL) DEFICIENCY**

Vitamin E appears to act through several mechanisms including acting as an antioxidant, through immunomodulation, and through an antiplatelet effect. It is found in vegetable oils, nuts, green leafy vegetables, fruits, and fortified cereals.

### **GENERAL SIGNS OF VITAMIN E DEFICIENCY:**

The deficiency may cause fertility problems, weak muscles with hyporeflexia and ataxia, as well as abnormalities of liver, bone marrow, and brain function. Classic abnormalities of the eyes include a limitation in upward gaze, and strabismus to long-tract defects, including profound muscle weakness and visual-field constriction. Other symptoms include hemolysis of red blood cells, defective embryogenesis, and a disorder of capillary permeability. Skeletal muscle dystrophy may also occur. Patients with severe deficiency may develop complete blindness, cardiac arrhythmia, and dementia.

### **13. VITAMIN K DEFICIENCY**

Vitamin K is an essential lipid-soluble vitamin that plays a vital role in the production of coagulation proteins. Some of the vitamin K is synthesized by bacteria in the intestinal tract and can supply part of the requirement. It is found in nature in

two forms: K1, also called phylloquinone, is found in plants and vitamin K2, also called menaquinone, can be synthesized by many bacteria. Vitamin K3, menadione, is a synthetic form of this vitamin which is man-made. Vitamin K controls the formation of several coagulation factors such as factors II (prothrombin), VII (proconvertin), IX (Christmas factor, plasma thromboplastin component), and X (Stuart factor). Other coagulation factors dependent on vitamin K are protein C, protein S, and protein Z. In

addition, some bone matrix proteins necessary for normal bone metabolism are also vitamin K-dependent.

### **COAGULOPATHY, BLEEDING DISORDER:**

Bleeding is the major manifestation of a vitamin K deficiency. Easy bruisability and mucosal bleeding (especially nose bleeding, GI hemorrhage, menorrhagia, and hematuria) occur when the vitamin is missing or decreased.

### **References**

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