

Vitamins:

By

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Outline

- ❑ Introduction.
- ❑ Classification of Vitamins.
- ❑ Difference between fat-soluble and water-soluble vitamins.
- ❑ Fat-soluble vitamins.
- ❑ Water-soluble vitamins.



What are Vitamins

Vitamins are organic compounds that body needs in small amounts to function properly, grow, and stay healthy.

They are essential nutrients that usually must come from food, because the body either cannot make them at all or cannot make enough on its own.

They are not a source of calories (energy).

- The word "vitamin" comes from the Latin word "vita", means "life".
- VITAMINS are "Micronutrients" or trace nutrients which are necessary for everyday healthy functioning of the body.
- They are found in very small amounts in many different foods.
- Everybody must eat a certain amount of vitamins to stay healthy.

VITAMIN DEFICIENCIES

These may have the following causes:

- inadequate intake:– individuals with an inadequate dietary intake or unusual diet.
- inadequate absorption, for example malabsorption states.
- excess loss, for example via gastrointestinal or renal tract.
- enhanced utilization, for example sepsis or trauma.

VITAMIN EXCESS

Some vitamins (notably A and D) are toxic if taken in excess, and overdosage has recently become more common, possibly because of the increased availability of these compounds in over-the-counter preparations



Provitamins:

These are precursors of active form of vitamins they are present in food, when ingested in the body, by the help of enzymatic reaction they could be converted into vitamins.

- As such, provitamins have no function similar vitamin form
- e.g. beta-carotenes present in fruits and vegetables are provitamin of A.
- preformed vitamins:
- Vitamins in food in their active form do not need to be converted.



Fig 1. **Classification of vitamins**

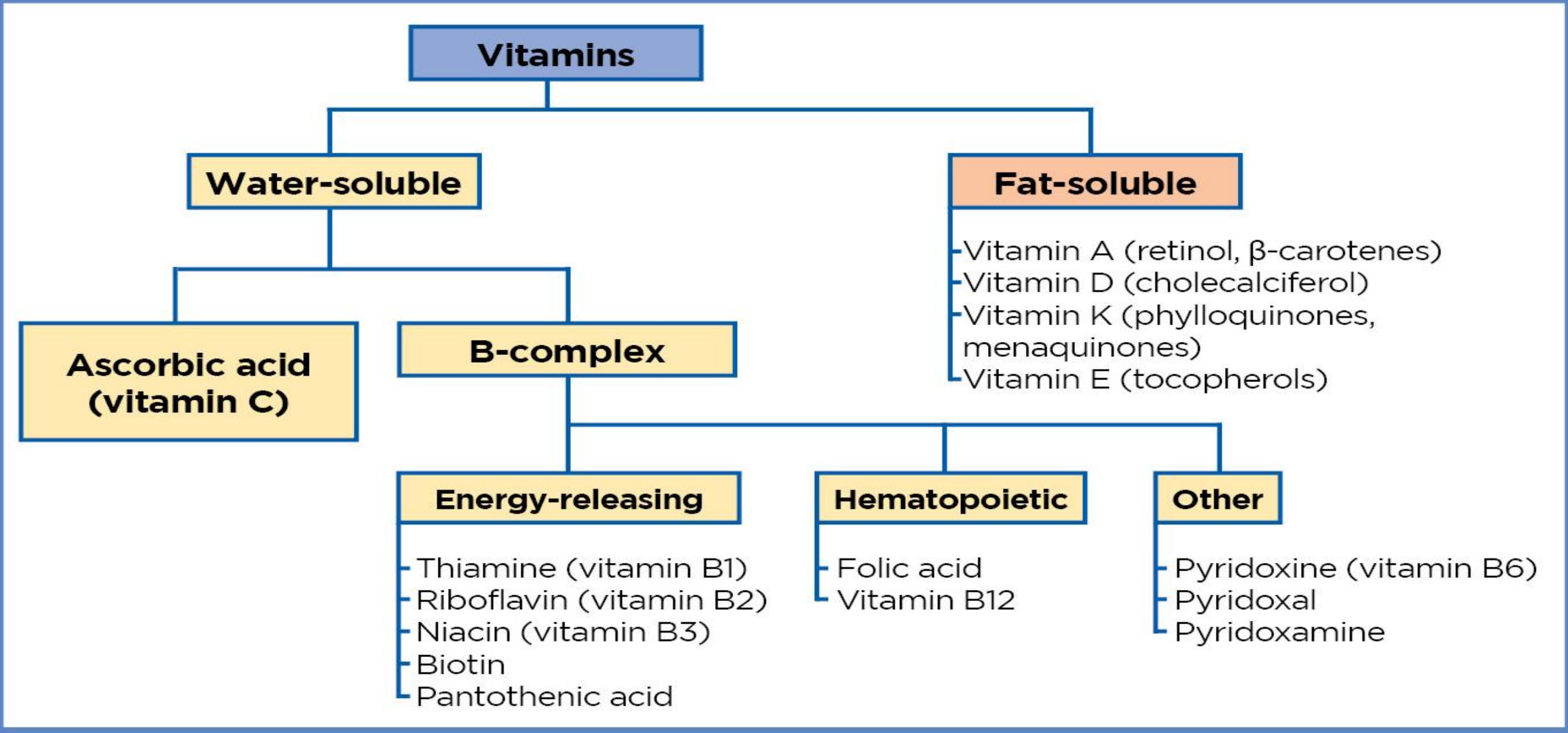


Table 8.1 Comparison of fat and and water soluble vitamins

S. No.	Characteristics	Fat soluble vitamins	Water soluble vitamins
1	Solubility	Fat soluble	Water soluble
2	Absorption	Bile salts are required	Simple intestinal absorption
3	Transportation	Transported by carrier protein	Travels freely in the body without requiring carrier protein (except Vitamin B ₁₂)
4	Storage	Stored in liver and fatty tissues	Not stored (except vitamin B ₁₂)
5	Excretion	Usually the surplus vitamins are stored	Surplus vitamins are detected in kidney and removed in urine
6	Accumulation	Usually hypervitaminosis occurs	Usually hypervitaminosis doesn't occur (except in high dosage and slow release of some B vitamins)
7	Deficiency compensation	Required in periodic doses (weeks or months)	Required in frequent doses (1 - 3 days)



FAT SOLUBLE VITAMINS

A

Fat Soluble



Vision,
Reproduction,
Bone Health,
Immune System,
Skin

D

Fat Soluble



Strengthens Bones,
Calcium Absorption,
Immune System

E

Fat Soluble



Immune System,
Flushes Toxins

K

Fat Soluble



Blood Clotting,
Bone Health



Vitamin A

Vitamin A is a crucial component of various fat-soluble compounds, including retinol, retinyl palmitate, and β -carotene.

These compounds are essential for vision, cellular differentiation, epithelial integrity, immune function, and gene regulation.

Vitamin A is obtained from dietary sources as preformed vitamin A found in animal products and provitamin A carotenoids in plant-based foods.

Both of these forms must be converted into retinal and retinoic acid for biological activity.

Active Form

Vitamin A consists of three biologically active molecules which are collectively known as retinoids.

1. Retinol 2. Retinal 3. Retinoic acid (toxic form cannot reduced in the body)

β -Carotene: Plant foods contain β -carotene,

Retinoids are converted to retinol in the intestines and transported with dietary fat in form of chylomicrons to the liver, where it is stored.

A special transport protein, retinol binding protein (RBP), transports vitamin A from the liver to other tissues.

Absorption: Vitamin A is primarily absorbed in the gastrointestinal tract, where β -carotene is converted into retinol. This process depends on bile salts, pancreatic lipase, and dietary fat to facilitate proper absorption.

Distribution: After absorption, vitamin A is transported by chylomicrons through the lymphatic system into the bloodstream, where it is delivered to the liver and other tissues for storage and use. The liver stores approximately 70% of the body's total vitamin A reserves, while smaller amounts are stored in other organs and fat cells.

Metabolism: The liver primarily stores vitamin A as retinol palmitate within Kupffer cells. Under normal conditions, these liver stores can supply the body's vitamin A needs for up to 2 years.

Elimination: Vitamin A is primarily excreted through bile into the intestines, with elimination occurring via feces. Small amounts of vitamin A and its metabolites are also excreted in urine.

Physiological Role

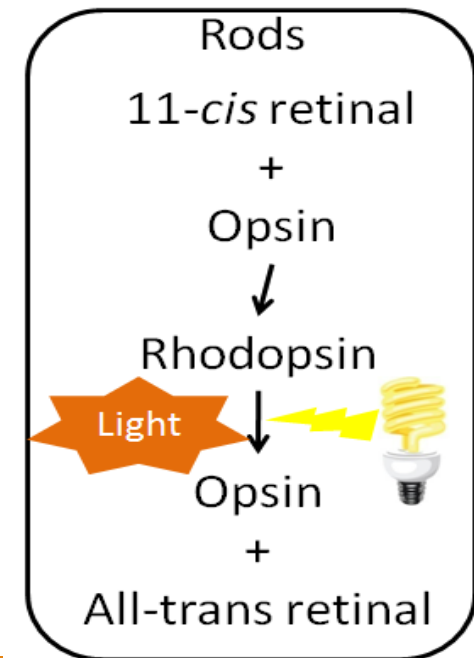
1. Retinal and retinol are involved in vision (visual cycle or Rhodopsin cycle.)
2. Growth: Vitamin A deficiency results in a decreased growth rate in children. Bone development is also slowed.
3. Reproduction: Retinol and retinal are essential for normal reproduction, supporting spermatogenesis in the male and preventing fetal resorption in the female.
4. Maintenance of epithelial cells: Vitamin A is essential for normal differentiation of epithelial tissues and mucus secretion

Role of vitamin A in vision

Retina of the eye contains two types of cells.

1. Rod cells (Vision in dim light)

2. Cone cells (Vision in bright light).— Rod cells have a photosensitive pigment called rhodopsin, is a conjugated protein made up of opsin and 11-cis retinal— Rhodopsin once exposed to light it converted to all trans retinal then it will pass in cyclic changes in our body to regenerates 11-cis retinal and rhodopsin again by help of vitamin A



Effect of Vitamin A Deficiency

1- • Night blindness is one of the earliest symptoms of vitamin A deficiency. This is characterized by loss of vision in night

- Severe vitamin A deficiency causes dryness of cornea and conjunctiva, a clinical condition termed as xerophthalmia (dry eyes).

- White opaque spots develop on either side of cornea in vitamin A deficiency are known as Bitot's spot.

- If this situation prolongs it will lead keratinization and ulceration of cornea

then end with (blindness)

- Other Symptoms of Vitamin A Deficiency Acne and psoriasis

- Squamous metaplasia of the bronchial epithelium has also been reported with risk of chest infections.



Vitamin D (Cholecalciferol)

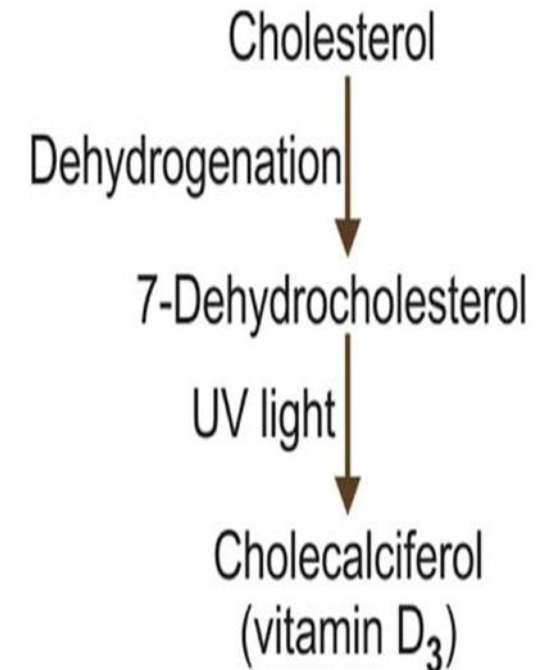
Vitamin D is also known as calciferol because of its role in calcium metabolism and antirachitic factor because it prevents rickets.

- The D vitamins are a group of sterols that have a hormone-like function.

The active molecule, 1,25-dihydroxycholecalciferol (1,25 diOH-D3), binds to intracellular receptor proteins to stimulate the synthesis of calcium binding protein.

mechanism of action of 1,25diOH-D3 is typical of steroid hormones

The most prominent actions of 1,25-diOH-D3 are to regulate the plasma levels of calcium and phosphorus.



Sources

- D 2 in plants
- D 3 in animal sources as fish, egg and liver and its synthesized in human begins in the intestinal mucosa and is converted to vitamin D3 by UV light in the skin. This process is referred to as photobiogenesis.

Nutritional Requirement

The daily requirements of vitamin D is 200–400 IU

Metabolism and activation of vitamin D:

Cholecalciferol is an inactive form of vitamin D. It needs further metabolism to produce the active form of the vitamin.

1,25 dihydroxycholecalciferol also known as calcitriol is the active form of vitamin D.

The steps involved in activation are:

1. The first step is the conversion of cholecalciferol to 25hydroxycholecalciferol.

The 25-hydroxylation occurs in liver and is catalyzed by 25-hydroxylase

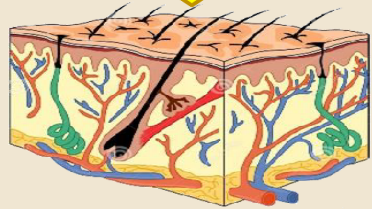
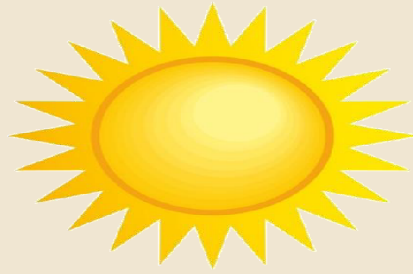
2. The 25-hydroxycholecalciferol formed transported to the kidney,

where it is further hydroxylated by, $1,\alpha$ -hydroxylase enzyme in the 1 position to 1,25 dihydroxycholecalciferol.

Adequacy of Calcitriol $1,25-(OH)_2D_3$ is essential for normal mineralization of bone and neuromuscular activity.

- When calcium and phosphours levels in the body are within the normal limts, the predominant dihydroylated form of vit. D synthesized is the less active metablite. $24,25-(OH)_2D_3$

The Body Needs All Forms of Vitamin D



Vitamin D3 made in the skin is used by skin cells that cannot rely on vitamin D from the blood

↓ DNA Damage
Cell Death

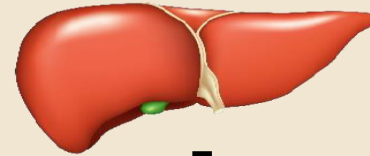
↑ DNA Repair



VITAMIN D3
(Cholecalciferol)



- Taken directly into cells for local conversion and use
 - Most potent form for endothelial stability
 - Anti-inflammatory
 - Form needed by breastfeeding mothers to transfer to baby through breastmilk
- Must receive daily/semi-daily due to very short half-life of roughly 24 hours



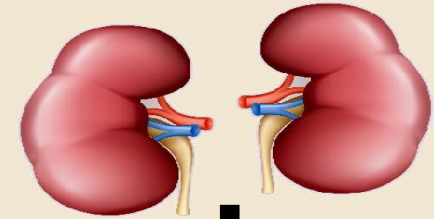
25-hydroxylase



25(OH)D
(Calcifediol)



- Form measured in blood as indicator of vitamin D status
- Taken directly into cells and converted to 1,25(OH)₂D for local use
 - Used as a signaling molecule in most cells and tissues, including immune, brain, blood vessels, heart, lungs, and many more



1 α hydroxylase



1,25(OH)₂D
(Calcitriol)



Hormonal Vitamin D – regulated by parathyroid hormone (PTH) for blood calcium control



Calcium absorption in the gut
Bone turnover
Calcium in the blood



Functions

It maintains the normal plasma level of calcium and phosphorus by acting on intestine, kidneys and bones.

Action of Vitamin D on intestine It increases the absorption of calcium and phosphate.

from the intestine by enhancing the synthesis of calcium binding proteins calbindins.

This protein increases the calcium uptake by the intestine.

Action of Vitamin D on kidney It stimulates the reabsorption of calcium and phosphorus from the kidney and decreases their excretion

Action of Vitamin D on bone It is believed that calcitriol has both anabolic and catabolic role on bone.

- Vitamin D promotes the mineralization of bones by deposition of calcium and phosphorus.
- Vitamin D along with PTH stimulates the mobilization of calcium and phosphorus from bone causes elevation of plasma calcium and phosphorus levels.

Deficiency

Deficiency of vitamin D causes **rickets** in growing **children** and **osteomalacia** in **adults**.

Insufficient exposure to daylight and/or

deficiencies in vitamin D consumption occur predominantly in infants and the elderly

Toxicity of vitamin D

Like all fat-soluble vitamins, vitamin D can be stored in the body and is only slowly metabolized.

High doses (100,000 IU for weeks or months) can cause loss of appetite, nausea, thirst, and stupor.

Enhanced calcium absorption and bone resorption results in hypercalcemia, which can lead to deposition of calcium in many organs, particularly the arteries and kidneys.



Vitamin E (-Tocopherol)

Vitamin E is a fat-soluble antioxidant essential for various bodily functions, including protecting cells from oxidative stress and supporting immune function.

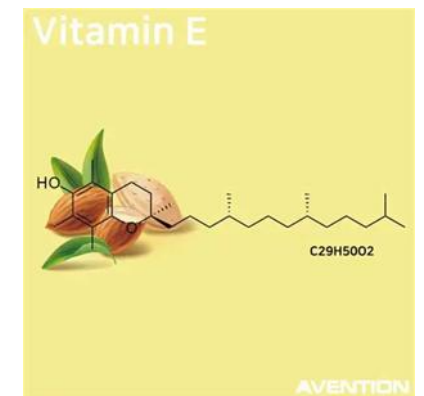
Vitamin E refers to a group of eight compounds, including four tocopherols and four tocotrienols.

The most studied and biologically active form is **alpha-tocopherol**.

It plays a crucial role in protecting cells from damage caused by free radicals, which are harmful molecules that can contribute to chronic diseases such as cancer and heart disease.

The major dietary sources of vitamin E are fats and oils.

The richest sources are germ oil, corn oil, fish oil, eggs and lettuce.



Absorption, Transport and Storage

Vitamin E is absorbed from intestine together with dietary lipid.

It is incorporated in chylomicrons.

It is delivered to the liver via chylomicron.

The liver can export vitamin E into very low density lipoprotein (VLDL) to target cells where antioxidant activity is required.

The major site of

vitamin E storage is in the adipose tissue.

Functions

- Vitamin E acts as a natural **antioxidant** by **scavenging free radicals** and **molecular oxygen generated** by metabolic process and environmental pollutants
- Protection of erythrocyte membrane from oxidant is the major role of vitamin E in humans.

It protects the RBCs from hemolysis.

- Vitamin E also helps **to prevent oxidation of LDL.**

Oxidized LDL may be more atherogenic than native LDL and thus vitamin E may **protect against atherosclerotic coronary heart disease.**

The major symptom of **vitamin E deficiency** in human is **hemolytic anemia** and increased risk of **atherosclerosis**



Vitamin K

Vitamin K is a fat-soluble vitamin that plays a crucial role in various bodily functions, particularly in blood coagulation and bone metabolism.

It exists in two main forms:

Vitamin K1 (Phylloquinone): Found mainly in green leafy vegetables like kale, spinach, and broccoli.

Vitamin K2 (Menaquinone): Found in animal products and fermented foods, and can also be produced by bacteria in the human gut.



Functions of Vitamin K

Blood Clotting: Vitamin K is vital for synthesizing proteins required for blood coagulation. Without sufficient vitamin K, the body cannot produce these proteins, leading to uncontrolled bleeding.

Bone Health: It helps in the formation of osteocalcin, a protein that binds calcium in bones, thus contributing to bone strength and reducing the risk of fractures.

Calcium Regulation: Vitamin K aids in preventing calcium buildup in blood vessels, which can lead to cardiovascular issues.



Deficiency and Health Implications

Vitamin K deficiency is rare but can occur, particularly in individuals with malabsorption disorders or those on long-term antibiotics that disrupt gut bacteria.

Symptoms may include easy bruising, bleeding gums, and increased bleeding after injury.

Newborns are particularly at risk and are often given vitamin K injections shortly after birth to prevent hemorrhagic disease.



