Nutrition

for Sport and Exercise, Third Edition

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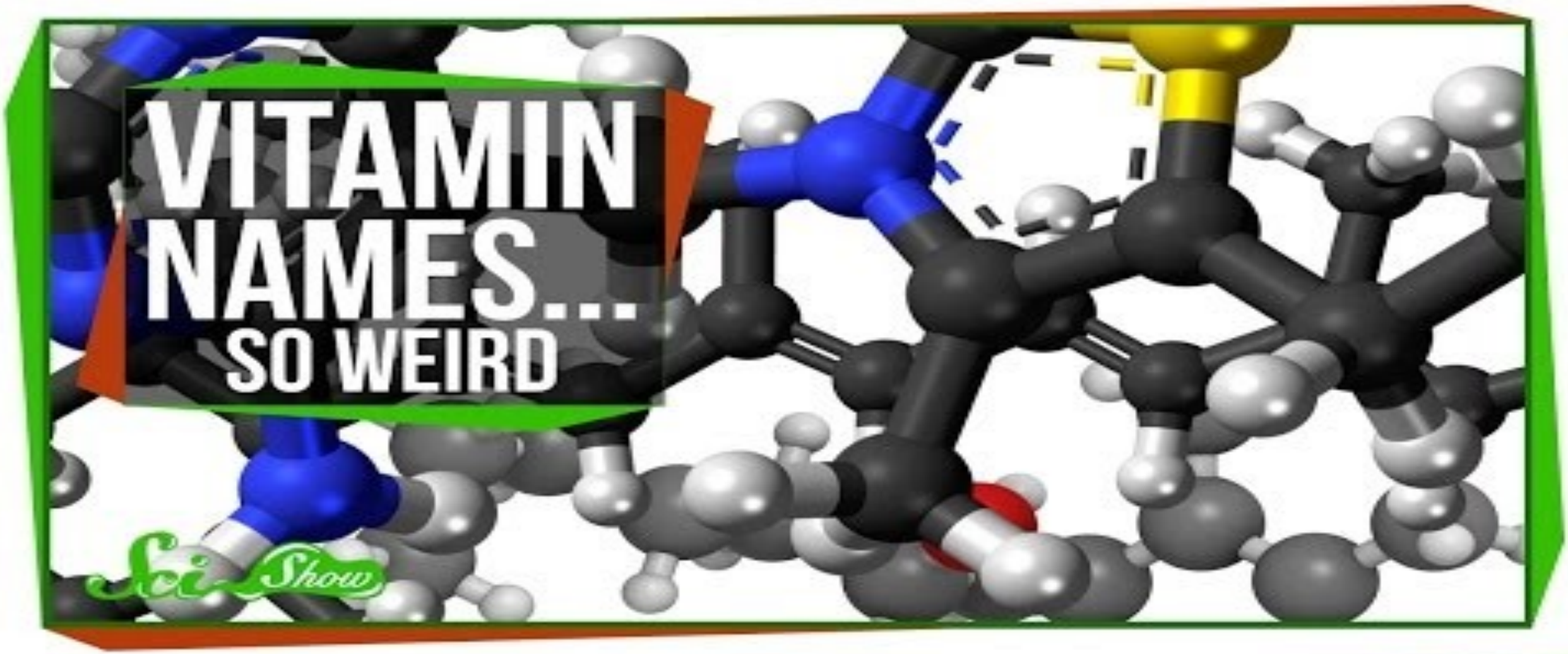
8

Vitamins


VITAMIN
NAMES...
SO WEIRD
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Learning Objectives

- Classify vitamins, describe their general roles, and explain how vitamin inadequacies and excesses can occur and why either might be detrimental to performance and health
- Explain how vitamins function in energy metabolism, blood formation, general growth and development, and as antioxidants, and summarize the results of studies conducted with athletes

Learning Objectives

- Compare and contrast vitamins based on their source—naturally occurring in food, added to foods during processing, and found in supplements—and evaluate the need for vitamin supplements based on food intake

Vitamins

- Vitamins are essential nutrients needed for the proper functioning of the body
- Athletes should develop strategies for consuming enough of all the vitamins without consuming too much
- Endurance and ultraendurance exercise may increase the need for some vitamins and may result in small losses of others via urine or sweat

8.1 Classification of Vitamins

- Solubility
  - Fat-soluble
  - Water-soluble
- Functionality
  - Energy metabolism
  - Antioxidants
  - Red blood cell formation
  - Growth and development

It Is Important to Guard Against Both Vitamin Deficiencies and Toxicities

Mild deficiency

Low intake or
adequate intake but low absorption

⇩

Subclinical deficiency

Initial decline in vitamin-related enzymes
(rarely measured outside the research setting)

⇩

Continued decline in vitamin-related enzymes
(infrequently measured)

⇩

Clinical deficiency

General symptoms
(e.g., fatigue, gastrointestinal distress)

⇩

Specific symptoms of the vitamin deficiency disease

Table 8.1 Fat- and Water-Soluble Vitamins

Fat soluble	Water soluble
Vitamin A	Vitamin B_1 (Thiamin)
Vitamin D	Vitamin B_2 (Riboflavin)
Vitamin E	Vitamin B_3 (Niacin)
Vitamin K	Pantothenic acid
	Biotin
	Folate (Folic acid, folacin)
	Vitamin B_6
	Vitamin B_{12}
	Vitamin C

Table 8.2 Summary of Fat- and Water-Soluble Vitamin Characteristics

	Vitamin A
Names	In animal sources: retinol, retinal, and retinoic acid (also known as preformed vitamin A) In plant sources: carotenoids (precursors to vitamin A), including beta-carotene
Major physiological functions	Overall health of cells and membranes resulting in proper vision, reproduction, bone and tooth development, immune system function; carotenoids are antioxidants
Solubility	Fat soluble
Deficiency disease	Hypovitaminosis A
Symptoms of deficiency	Night blindness, permanent blindness, more frequent and severe infections, lack of growth, inability to reproduce
Toxicity disease	Hypervitaminosis A (from preformed vitamin A)
Symptoms of toxicity	Blurred vision, lack of growth, birth defects, hemorrhaging, liver failure; can be fatal
Health promotion and disease prevention	Adequate daily intake is necessary for good health; lack of evidence that vitamin A or beta-carotene supplements prevent disease; some evidence that mortality is increased with these supplements
Food sources	Animal (preformed vitamin A): liver, fish oil, milk and milk products (fortified); plant (provitamin A): dark-green leafy vegetables (for example, spinach); orange fruits and vegetables (for example, carrots, cantaloupe, tomatoes)
Other	Beta-carotene supplements are not recommended and may promote tumor growth in smokers and those exposed to asbestos; the yellowing of the skin that occurs is thought to be harmless but is indicative of a high level of carotenoid intake.

Source: Gropper and Smith (2012).

	Vitamin D
Names	Calciferol, cholecalciferol
Major physiological functions	Regulates bone mineralization, cardiac and skeletal muscle, and growth of normal and cancerous cells
Solubility	Fat soluble
Deficiency disease	Rickets (children), osteomalacia (adults)
Symptoms of deficiency	Bowing of the legs, demineralization of bones, joint pain, muscle spasms
Toxicity disease	Hypervitaminosis D
Symptoms of toxicity	Calcification of tissues, including blood vessels; kidney stones; general gastrointestinal and nervous system symptoms
Health promotion and disease prevention	Adequate intake daily is necessary for good health; vitamin D and calcium supplements together reduce the loss of bone mass and help prevent bone fractures; vitamin D supplements help prevent falls in older people
Food sources	Fish oil; some fish such as salmon, mackerel, tuna, and shrimp; milk (fortified); margarine (fortified)
Other	Ultraviolet light (sunshine) can activate a vitamin D precursor in the skin; adequate vitamin D helps to maintain performance in athletes and physically active people

Source: Gropper and Smith (2012).

	Vitamin E
Names	Tocopherol (for example, alpha-tocopherol, beta-tocopherol)
Major physiological functions	Antioxidant; proper red blood cell formation
Solubility	Fat soluble
Deficiency disease	Deficiencies are rare
Symptoms of deficiency	Anemia, muscle weakness
Toxicity disease	None; toxicities are rare
Symptoms of toxicity	General symptoms such as fatigue or nausea
Health promotion and disease prevention	Adequate intake daily is necessary for good health; some evidence that mortality is increased with vitamin E supplementation by people with heart disease or diabetes
Food sources	Oil; soybeans; almonds and other nuts; sunflower seeds; wheat germ
Other	Powerful antioxidant

Source: Gropper and Smith (2012).

Table 8.2 Summary of Fat- and Water-Soluble Vitamin Characteristics (Continued)

	Vitamin K
Names	Phylloquinone
Major physiological functions	Normal blood clotting; role in bone mineralization
Solubility	Fat soluble
Deficiency disease	Vitamin K deficiency
Symptoms of deficiency	Hemorrhaging; poor bone mineralization
Toxicity disease	None
Symptoms of toxicity	Not known
Food sources	Green leafy vegetables
Other	Synthesized by bacteria in the intestine; vitamin K supplements are prescription-only, since excessive vitamin K could interfere with medications that prevent clotting of the blood

Source: Gropper and Smith (2012).

	Vitamin B_1
Names	Thiamin
Major physiological functions	Release of energy from carbohydrates, proteins, and fats via thiamin-containing enzymes; normal nervous system function
Solubility	Water soluble
Deficiency disease	Beriberi
Symptoms of deficiency	Muscle wasting, weight loss, cardiovascular problems
Toxicity disease	None
Symptoms of toxicity	None known
Health promotion and disease prevention	Adequate daily intake is necessary for good health; at the present time there is not enough research to adequately determine if B_1 supplementation has a beneficial effect on Alzheimer's, Parkinson's, or related diseases
Food sources	Whole grain breads and cereals; bread and cereals made from processed grains or flour (fortified); dried beans, pork
Other	Deficiencies seen in the United States are usually due to alcohol abuse or gastric bypass surgery

Source: Gropper and Smith (2012).

Table 8.2 Summary of Fat- and Water-Soluble Vitamin Characteristics (Continued)

	Vitamin B_3
Names	Niacin, nicotinic acid, nicotinamide
Major physiological functions	Release of energy from carbohydrates, proteins, and fats via niacin-containing enzymes
Solubility	Water soluble
Deficiency disease	Pellagra
Symptoms of deficiency	Diarrhea, mental changes, skin rash
Toxicity disease	Not named; usually referred to as niacin toxicity
Symptoms of toxicity	Flushing, itching, rash, sweating
Health promotion and disease prevention	Adequate daily intake is necessary for good health; high doses of niacin may be prescribed by a physician to help raise high-density lipoprotein cholesterol ("good cholesterol") to prevent cardiovascular events such as heart attack
Food sources	Meat, fish, poultry, and eggs; milk; nuts; whole grain breads and cereals; bread and cereals made from processed grains or flour (fortified)
Other	Tryptophan, an amino acid found in foods, is a precursor to niacin. Niacin rush (flushing, itching, rash) may be a result of a high intake of supplemental vitamin B_3 in a short period of time

Source: Gropper and Smith (2012).

Table 8.2 Summary of Fat- and Water-Soluble Vitamin Characteristics (Continued)

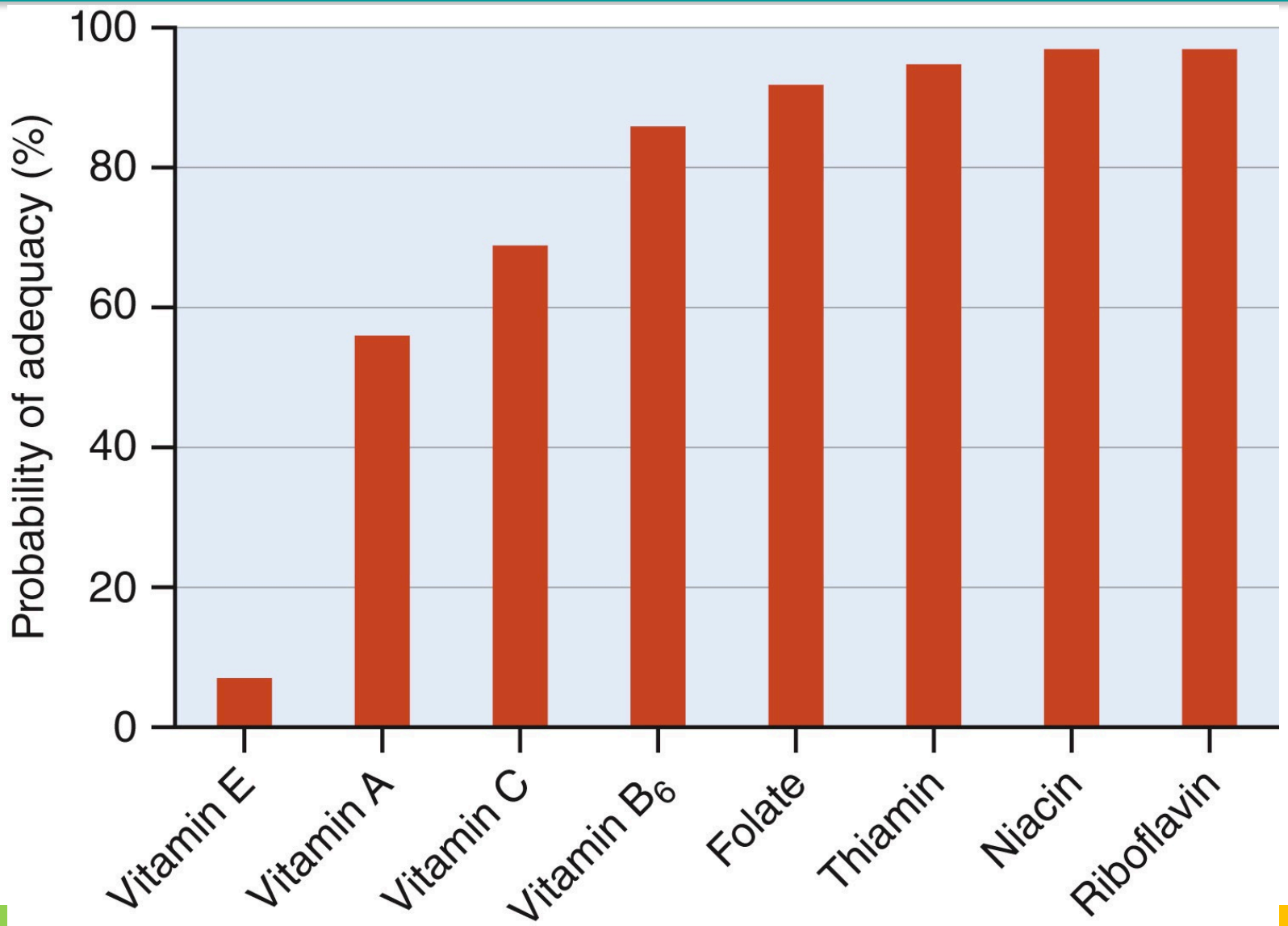
	Vitamin B_{12}
Food sources	Animal foods only; specially formulated yeast or other fortified foods
Other	Intrinsic factor (IF), which is produced in the stomach, is needed for vitamin B_{12} absorption in the intestine. Lack of IF may require vitamin B_{12} injections; injections do not boost energy in athletes.
	Folate
Names	Folate (when found naturally in food) or folic acid (when added to fortified foods or in supplements)
Major physiological functions	Synthesis of new cells; red blood cell formation
Solubility	Water soluble
Deficiency disease	Not named
Symptoms of deficiency	Megaloblastic (large cell) anemia; depression; in pregnancy, increased risk for neural tube defects
Toxicity disease	None
Symptoms of toxicity	None known
Health promotion and disease prevention	Adequate daily intake is necessary for good health and to reduce the prevalence of neural tube defects in utero; lack of evidence that supplementation of folic acid alone or in combination with vitamins B_6 and B_{12} helps to prevent cardiovascular events such as heart attack or stroke
Food sources	Leafy green vegetables; whole grain breads and cereals; dried beans; bread and cereals made from processed grains or flour (fortified); orange juice
Other	Folate supplementation can mask the symptoms of vitamin B_{12} deficiency and can delay diagnosis.

Source: Gropper and Smith (2012).

	Vitamin C
Names	Ascorbic acid
Major physiological functions	Collagen synthesis; antioxidant; immune function; aids absorption of iron
Solubility	Water soluble
Deficiency disease	Scurvy
Symptoms of deficiency	Poor wound healing; bleeding gums, small blood vessel hemorrhages
Toxicity disease	Not named
Symptoms of toxicity	Diarrhea, fatigue, kidney stones in some people
Health promotion and disease prevention	Adequate daily intake is necessary for good health; vitamin C supplementation does not prevent colds in the general population but does reduce the duration and severity of the cold; some evidence that supplementation may prevent colds in those who engage in rigorous exercise, especially in cold temperatures
Food sources	Oranges, grapefruit, and other citrus fruits; strawberries, cabbage, broccoli, peppers, tomatoes
Other	Antioxidant that works independently of and in conjuction with vitamin E

Source: Gropper and Smith (2012).

Poor Food Choices Often Lead to Low Vitamin Intake



Developing and Reversing Vitamin Toxicities

- Takes months or years to develop
  - Mild deficiency
  - Subclinical deficiency
  - Clinical deficiency
- Non-specific medical signs and symptoms
- Toxicities in the U.S. are rare
- Treatment is to stop consumption of the supplement

A Recommended Daily Intake Has Been Established For Each Vitamin

- Dietary Reference Intakes (DRI)
  - How much is enough?
- Tolerable Upper Intake Level (UL)
  - How much is too much?

Moderate to Rigorous Exercise May Increase the Need for Some Vitamins

- Factors that could increase need
  - Decreased absorption from GI tract
  - Increased loss in sweat or urine
  - Increased utilization due to the stress of exercise
  - Increased need associated with large gains and maintenance
- Effect of exercise is small
- Athletes can improve their vitamin status by increasing their intake of fruits, vegetables, and whole grains

8.2 The Role of Vitamins in the Body

- Some of the B-complex vitamins are associated with energy metabolism
  - Thiamin (B_1), riboflavin (B_2), niacin (B_3), vitamin B_6, pantothenic acid, and biotin are often referred to as the B-complex vitamins
  - Primarily involved in the production of ATP
  - The vitamin is part of an enzyme

Some Vitamins Have Antioxidant Properties

- Free radicals or reactive oxygen species (ROS) are byproducts of oxidative phosphorylation processes
  - ROS damage cell membranes and DNA
  - Antioxidants help maintain the balance between rate of ROS production and ROS clearance

Some Vitamins Have Antioxidant Properties

- Role of exercise in ROS
  - Exercise is a physiological stress than can result in an imbalance between ROS production and clearance
  - Directly related to increased exercise intensity and duration
  - Endurance training results in an increase in antioxidant protection

Vitamins With Antioxidant Properties

- May be able to repair some damage
- At high concentrations, vitamins can act as pro-oxidants
- Studies of antioxidant supplementation in endurance athletes have been mixed
- Prudent to consume fruits, vegetables, nuts, and whole grains, which are rich in antioxidants

Vitamin E

- Primary antioxidant in cell membranes
- Can prevent cell damage by direct interaction with ROS
- Supplementation popular with athletes
  - Current evidence suggests supplements do not enhance training
  - Doses > 200 mg/day may increase oxidative damage; dose may be listed on label as IU

Vitamin E

- Excellent sources of vitamin E include oils, seeds, nuts, whole grains, and vegetables

Vitamin C

- Functions independently in extracellular tissue and in conjunction with E
- Supplementation popular, especially to self-treat colds
  - Does not prevent colds but may reduce the duration
  - Current evidence for enhanced need by athletes and benefit of supplementation is mixed
  - Excessive intake may increase oxidative damage

Vitamin C

- Vitamin C containing fruits and vegetables include strawberries, citrus fruits, and peppers

Vitamin A

- Term includes both pre-formed and precursors
  - Pre-formed
    - Retinol
  - Precursors
    - Carotenoids: beta-carotene, lycopene, lutein, many other compounds
- Weak antioxidant compared to vitamins C and E

Vitamin A

- Supplementation
  - Popular in the past
  - Supplements may actually increase risk for premature mortality
  - Supplements not recommended
  - Excessive intake may increase oxidative damage

Vitamin A

- Dark green, orange, and red colored fruits and vegetables are excellent sources of vitamin A.

Folate

- Supplementation
  - No evidence to suggest improved athletic performance
  - Breads, cereals, beans, oranges, and bananas provide folic acid

Christina Micek

Sources of Vitamins

- Concentrated source; amount in supplement may be more than could be consumed from food
- Bioavailability may be high
- Advantages
  - Excellent source of one or more vitamins
  - Prevents or reverses deficiencies
  - “Insurance” policy
- Disadvantages
  - Excessive amounts; may not be needed or beneficial

The Dose and Potency of a Vitamin Supplement can Vary

SUPPLEMENT FACTS	
Serving size: 1 tablet	
Servings per container: 60	
Amount per serving	% Daily Value
Thiamin 50 mg	3,333%
Riboflavin 50 mg	2,941%
Niacin 50 mg	250%
Vitamin B_6 50 mg	2,500%
Vitamin B_{12} 50 mcg	833%
Folate 400 mcg	100%
Vitamin C 500 mg	833%
Vitamin A 10,000 IU	200%
Vitamin E 400 mg	1,333%

Summary

- Vitamins are essential nutrients needed for the proper functioning of the body
- Adequate amounts of all the vitamins are needed to support training, recovery, performance, and health
- Athletes in training are unlikely to need more than the DRI
- Vitamins perform specific biochemical functions and often interact with each other

Summary

- Vitamins do not provide energy (kcal), but some vitamins regulate energy reactions
- The body's antioxidant system depends on balance
- A "food first, supplements second" policy can serve athletes well
- Athletes should read vitamin supplement labels carefully and recognize that some supplements may contain high doses that could be potentially harmful

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9

Minerals

Learning Objectives

- Classify minerals and describe their general roles
- Explain how mineral inadequacies and excesses can occur and why each might be detrimental to performance and health
- Describe the factors that increase, maintain, and decrease bone mineral density, including a discussion of the minerals associated with bone formation and their effects on performance and health

Learning Objectives

- Describe the role of iron in red blood cell formation and the impact of low iron intake on performance and health
- Describe the roles of minerals in the immune system
- Compare and contrast minerals based on their source—naturally occurring in food, added to foods during processing, and found in supplements—including safety and effectiveness

Minerals

- Minerals differ from vitamins in several ways
  - The chemistry, absorption, metabolism, and excretion are generally very different when compared to vitamins

9.1 Classification of Minerals

- Amount found in body
  - Macrominerals
  - Microminerals
- Functionality
  - Proper bone formation
  - Electrolytes
  - Enzyme-related functions

Table 9.1 Minerals

Macrominerals	Microminerals (trace minerals)
Calcium	Iron
Phosphorus	Zinc
Magnesium	Copper
Sodium	Fluorine (fluoride)
Potassium	Iodine
Chloride	Chromium
Sulfur	Selenium
	Manganese
	Molybdenum
	Cobalt
	Silicon
	Boron
	Nickel
	Vanadium

Macrominerals are found in relatively large amounts in the body, whereas micro-minerals are found in trace amounts.

Classification of Minerals

- Proper bone formation
  - Calcium, phosphorus, magnesium, fluoride
- Electrolytes
  - Sodium, potassium, chloride, calcium, magnesium, phosphorous
- Enzyme-related functions
  - Iron, zinc, selenium, copper

	Calcium
Chemical symbol	Ca^{2+} (divalent cation)
Major physiological functions	Mineralization of bones and teeth, muscle contraction, nerve conduction, secretion of hormones and enzymes
Symptoms of deficiency	A dietary calcium deficiency is not associated with any signs or symptoms as bone mineral density declines; spine, wrist, or hip fractures are often the first symptoms; low calcium intake can contribute to hypertension (high blood pressure); low blood calcium concentration, a sign of deficiency, is associated with disease states such as renal (kidney) failure
Symptoms of toxicity	Elevated blood calcium levels, impaired renal function, decreased absorption of other minerals; toxicity typically caused by a disease state but could be caused by excessive intake of either calcium or vitamin D
Health promotion and disease prevention	Adequate intake daily is necessary for good health and is associated with a decreased risk for osteoporosis, high blood pressure, cardiovascular disease, and type 2 diabetes
Food sources	Milk and milk products; green leafy vegetables; fish with bones such as salmon or sardines; calcium-fortified products such as soy milk or orange juice

Sources: Institute of Medicine (1997, 2000, 2001, 2004, 2010), Gropper and Smith (2012), and Office of Dietary Supplements website.

	Iodine (Iodide)
Chemical symbol	I^-
Major physiological functions	Synthesis of thyroid hormones
Symptoms of deficiency	Mental retardation, impaired growth and development, goiter (enlargement of the thyroid gland), inadequate thyroid hormone production
Symptoms of toxicity	Thyroid-related medical problems
Health promotion and disease prevention	Adequate intake daily is necessary for good health
Food sources	Iodized salt; saltwater fish; mushrooms; eggs

	Iron
Chemical symbol	Fe^{2+} (divalent cation; ferrous) or Fe^{3+} (trivalent cation; ferric)
Major physiological functions	Component of hemoglobin, which is necessary for oxygen and carbon dioxide transport; component of enzymes necessary for cellular use of oxygen; immune system functions
Symptoms of deficiency	Fatigue, loss of appetite, reduced resistance to infection
Symptoms of toxicity	Gastrointestinal distress; in those who overabsorb iron, excess iron storage in liver and subsequent liver dysfunction (hemochromatosis)
Health promotion and disease prevention	Adequate intake daily is necessary for good health; always keep iron supplements away from children to prevent accidental overdose; never self-prescribe iron supplements because of risk for iron overload
Food sources	Well-absorbed (heme) sources: clams, oysters, liver, meat, fish, poultry; lesser-absorbed (nonheme) sources: dried beans and legumes, green leafy vegetables, dried fruit, iron-fortified grains
Other	Fe^{2+} = ferrous (storage) form; Fe^{3+} = ferric (transport) form
	Magnesium
Chemical symbol	Mg^{2+} (divalent cation)
Major physiological functions	Bone formation, component of more than 300 enzymes
Symptoms of deficiency	Muscle weakness, confusion, loss of appetite
Symptoms of toxicity	Diarrhea
Food sources	Green leafy vegetables; nuts and seeds; dried beans and legumes

Sources: Institute of Medicine (1997, 2000, 2001, 2004, 2010), Gropper and Smith (2012), and Office of Dietary Supplements website.

	Potassium
Chemical symbol	K^+ (cation)
Major physiological functions	Intracellular cation, proper cellular function
Symptoms of deficiency	Severe deficiency: hypokalemia (low blood potassium) resulting in cardiac arrhythmias and muscle weakness Moderate deficiency: contributes to hypertension and calcium loss from bone
Symptoms of toxicity	Most people readily excrete potassium in urine so toxicity is associated with impaired potassium excretion, which results in hyperkalemia (high blood potassium) and risk for cardiac arrhythmias
Health promotion and disease prevention	Adequate intake daily is necessary for good health; low intake is associated with high blood pressure, glucose intolerance, and an increased risk for kidney stones
Food sources	Vegetables, especially green leafy vegetables; dried beans and peas; orange juice; bananas; melons; potatoes; milk and yogurt; nuts

Sources: Institute of Medicine (1997, 2000, 2001, 2004, 2010), Gropper and Smith (2012), and Office of Dietary Supplements website.

	Sodium
Chemical symbol	Na^+ (cation)
Major physiological functions	Extracellular cation, helps to maintain fluid balance
Symptoms of deficiency	Not likely, since sodium is widely found in foods and the body has a remarkable capacity to conserve sodium by limiting loss in urine and sweat
Symptoms of toxicity	Elevated blood pressure (depends on genetic predisposition to sodium sensitivity)
Health promotion and disease prevention	High intake of sodium is associated with high blood pressure, especially in those who are salt sensitive; as blood pressure increases, risk for stroke and cardiovascular disease also increases
Food sources	Table salt (NaCl); addition of sodium to processed foods

Sources: Institute of Medicine (1997, 2000, 2001, 2004, 2010), Gropper and Smith (2012), and Office of Dietary Supplements website.

	Zinc
Chemical symbol	Zn^{2+} (divalent cation)
Major physiological functions	Component of hundreds of enzymes; needed for proper cellular function and proper immune system function
Symptoms of deficiency	Impaired growth, poor immunity
Symptoms of toxicity	Immunosuppression; decrease in high-density lipoproteins (HDL); impaired copper metabolism
Health promotion and disease prevention	Adequate daily intake is necessary for good health; mild zinc deficiency is associated with immune system dysfunction
Food sources	Animal foods (for example, meat and milk); whole grains

Sources: Institute of Medicine (1997, 2000, 2001, 2004, 2010), Gropper and Smith (2012), and Office of Dietary Supplements website.

Moderate to Rigorous Exercise Increases the Loss of Some Minerals

- Mineral loss in sweat and urine may be greater in athletes
- Moderate losses of minerals via sweat or urine can be offset by adequate mineral intake from food
- Athletes who have substantial losses may need to increase their dietary intake or supplement the diet with the lost mineral(s)

Poor Food Choices Often Lead to Low Mineral Intake

- Homeostasis
- Generally maintained by adjusting absorption and excretion
  - If storage is high, absorption decreases
  - If storage is low, absorption increases
- Hormonal and other mechanisms are also influential

9.2 Mineral Deficiencies and Toxicities

- In general, absorption is low or moderate for most minerals, in part because excretion is normally low
- Prevalence of subclinical mineral deficiencies
  - Deficiencies develop over time
  - No signs or symptoms initially
  - Signs or symptoms are non-specific when they first occur
  - Specific symptoms associated with severe deficiencies

Mineral Deficiencies and Toxicities

- Iron-deficiency anemia
  - In U.S., 3% of females
  - Prevalence in female athletes is not known
  - Prevalence in male athletes very low
- Osteoporosis
  - In U.S., 8 million women and 2 million men
  - The athlete's best defense against mineral deficiencies is an adequate intake of minerals daily through the consumption of nutrient-dense foods in sufficient quantities to meet caloric needs

Bones Have Both Structural and Metabolic Functions

- Skeletal support, movement, and protection of vital organs
- Maintaining mineral homeostasis and acid–base balance
- Bone remodeling

Bones Have Both Structural and Metabolic Functions

- Bone turnover is constant
- Osteoclasts resorb bone
  - Stimulated by physical activity and microfractures
  - Stimulated by hormones — Parathyroid hormone (PTH) and calcitriol
- Osteoclast/osteoblast balance
  - In children and adolescents, deposition is favored
  - In young adults, balance generally exists
  - In middle aged to older adults, resorption is favored

Calcium May Be Taken from Bone to Maintain Calcium Homeostasis

- Bone turnover is not balanced
- Slow calcium exchange
  - PTH stimulates dissolution of bone
  - Increases osteoclastic activity; decreases osteoblastic activity
  - Calcium (and phosphate) released from bone
  - Over time, integrity of bone is decreased

Bone Loss is Associated with Aging

- In women, 0.5 – 1.0% yearly until age 50
- With estrogen deficiency, 1 – 2% yearly
- In older men, ~ 1% yearly

The Roles of Calcium and Exercise in Aging

- Diet-related
  - Calcium supplementation after age 35 has limited effectiveness
  - In women under 50 and most men, adequate calcium and vitamin D intakes slow the loss of bone calcium
  - In the first 10 years after menopause, calcium supplementation has a small, positive effect
  - In women after age 70, calcium supplementation is beneficial

The Roles of Calcium and Exercise in Aging

- Exercise-related
  - High-intensity weight-bearing activities
  - Resistance training
  - Other types of exercise are beneficial but do not slow bone loss

There Are Numerous Strategies for Increasing Dietary Calcium Consumption

- Calcium sources
  - Milk and milk products
  - Reduced lactose or lactose-treated milk products
  - Some green leafy vegetables
  - Calcium-fortified foods
  - Calcium supplements

Milk and Milk Products are Excellent Sources of Calcium

Daniel Hurst Photography/Getty Images

Other Sources of Calcium

- Those with lactose intolerance may use alternatives that allow them to include calcium-dense dairy foods in their diets
- Dark green vegetables are good nondairy sources of calcium

Iron Efficiency Anemia Negatively Affects Performance

- Iron-deficiency anemia impairs performance
  - VO_{2max} (aerobic capacity) declines
  - Endurance capacity declines
- Effect of iron deficiency without anemia on performance is unclear

Athletes May Develop Iron Deficiency and Iron Deficiency Anemia

- Unlikely in most males
- Infrequently seen in adolescent males or male endurance athletes
- Some medications induce bleeding and loss of iron
- Greatest risk is for menstruating females
- Athletes with low caloric intake are at greater risk

9.5 The Role of Minerals in the Immune System

- Zinc
  - Widely found in cellular enzymes
  - Involved in various immune functions
  - DRI is 8 mg/day for females; 11 mg/day for males
  - Most endurance athletes do not meet the DRI
  - Supplemental zinc can interfere with iron and copper absorption

9.6 The Adequate Intake of All Minerals

- Obtaining minerals from food
  - A varied, nutrient dense diet can provide adequate amount of minerals
  - High sugar/high fat diets often do not meet daily mineral requirements

Summary

- More than 20 minerals are needed for the proper functioning of the body
- Extreme intakes – too little or too much – are detrimental to health
- Athletes in training are unlikely to need more than the DRI
- Adequate mineral intake is associated with adequate caloric intake and a variety of nutrient dense foods

Summary

- Adequate calcium intake is critical across the lifecycle to maintain calcium homeostasis, calcium balance, and bone mineral density
- Iron-deficiency anemia impairs endurance performance
- A “food first, supplements second” policy can serve athletes well

Water-soluble:

Vitamin	Alternate Name	Function in Body	Food Sources
Thiamin	Vitamin B_1	Aids in carbohydrate metabolism and nervous function	Whole grain cereals, beans, pork, enriched cereals
Riboflavin	Vitamin B_2	Aids in energy metabolism, protein metabolism, skin and eye health	Dairy, dark green leafy vegetables, whole grain cereals, enriched grains
Vitamin B_6	Pyridoxine	Aids in carbohydrate, fat and protein metabolism, protein synthesis	Meats, whole grain cereals, enriched cereals, eggs
Folic Acid	Folate	Aids in formation of DNA and red blood cells	Green leafy vegetables, beans, whole grain cereals, oranges, bananas
Vitamin B_{12}	Cobalamin	Aids in energy metabolism, protein synthesis	Animal foods, fortified cereals
Niacin	Nicotinic Acid	Aids in energy metabolism	Milk, eggs, turkey, chicken, whole grains, meat, fish
Pantothenic Acid	Pantothenate	Aids in energy metabolism	All foods except processed and refined
Biotin	None	Aids in glucose and fat synthesis	Egg yolks, legumes, dark green leafy vegetables
Vitamin C	Ascorbic Acid	Aids in iron absorption, collagen synthesis	Fruits and vegetables

Fat-soluble:

Vitamin	Alternate Name	Function in Body	Food Sources
Vitamin A	Retinol	Aids in maintaining healthy cells, eyes and immune system	Liver, cheese, dark green and brightly pigmented fruits and vegetables
Vitamin D	Cholecalciferol	Aids in absorption of calcium and phosphorus	Fish liver oil, eggs, canned fish, fortified milk, margarine
Vitamin K	Phylloquinone	Aids in formation of blood clots and assists with bone strengthening	Dark green leafy vegetables, vegetable oils
Vitamin E	Tocopherol	Aids in antioxidant protection of cells	Poly- and monounsaturated vegetable oils, margarine, fortified cereals, eggs

Macro minerals:

Mineral	Function in Body	Food Sources
Calcium	Growth and maintenance of bones and teeth, important for heart and skeletal muscle function, nerve impulse transmission, blood clotting, and release of some hormones	Dairy products, dark green leafy vegetables, calcium fortified foods/beverages
Phosphorus	Aids in bone strength and structure, acid-base balance, B-vitamin function	High protein foods, whole grains, carbonated drinks
Magnesium	Aids in protein synthesis, glucose metabolism, bone structure, muscle contraction	Milk and milk products, meat, nuts, whole grains, dark green leafy vegetables, fruit
Sodium	Aids in water balance, acid-base balance, muscle contraction	Processed and canned foods, cheese, soy sauce, (almost everything)
Chloride	Aids in water balance	Table salt
Potassium	Aids in water balance, glucose delivery to cells	Citrus fruits, potatoes, vegetables, milk, meat, fish, bananas

Micro minerals:

Mineral	Function in Body	Food Sources
Iron	Aids in oxygen delivery, essential for aerobic metabolism	Meat, fish, poultry, shellfish, eggs, whole grains, vegetables, nuts
Iodine	Aids in metabolism control by forming thyroid hormone	Iodized salt and seafood
Selenium	Antioxidant	Meat, fish, seafood, whole grains, nuts
Copper	Aids in iron transportation	Meat, fish, poultry, shellfish, eggs, nuts, whole grains, bananas
Manganese	Aids in energy metabolism, fat synthesis, bone structure	Whole grains, legumes, green leafy vegetables, bananas
Zinc	Aids in energy metabolism, protein synthesis, immune function	Meat, fish, poultry, shellfish, eggs, whole grains, vegetables, nuts
Chromium	Aids in glucose control	Brewer's yeast, mushrooms, whole grains, nuts, legumes, cheese