

Unit 6

Vitamins

Defining a vitamin

Essential _____ substances

Body _____ synthesize enough to maintain health

Absence from the diet will produce _____ signs and symptoms

May be fat- or water-soluble

Natural versus synthetic

Fat soluble vs. Water soluble

Fat soluble

Absorbed with _____ in diet

_____ by the body

Vitamin A,D,E,K

Water soluble

Absorbed with _____

Readily _____ of the body with _____

Vitamin C and Vitamin B-Complex

Historical Perspective

Foods found to cure illnesses

Liver extract –

Citrus fruits –

All vitamins have probably been discovered – TPN can support life

Vitamin Toxicity

Toxicity of vitamin _____ is most likely

Unlikely to develop toxicity of any vitamin unless individual vitamin supplements are used

Balanced multivitamin and mineral supplement supplies <

Malabsorption of Vitamins

Fat malabsorption leads to deficiencies of fat-soluble vitamins

_____ affects absorption of some B vitamins

_____ affect absorption of some B vitamins

Fat Soluble Vitamins

Digestion and Absorption of Fat-Soluble Vitamins

Absorption of Fat-Soluble Vitamins

40 – 90% of ingested fat-soluble vitamins absorbed (less efficient when consumed in higher quantities)

Distribution of Fat-Soluble Vitamins

Types of Fat-Soluble Vitamins

Vitamin A

Vit A is a ring structure w/ a fatty acid tail

Refers to preformed **retinoids** and **provitamin A carotenoids**

_____ – active forms of Vit A

Retinol, retinal, and retinoic acid

_____ – substance that can be made into a vitamin

_____ – photosynthetic pigment in fruits and vegetables
(yellow → orange → red)

Vitamin A in Foods

Preformed (_____)

Liver, fish oils, fortified milk, eggs, other fortified foods

Contributes ~70% of vitamin A intake for Americans

Provitamin A (_____)

Dark leafy green, yellow-orange vegetables/fruits

Functions of Vitamin A:

Vision

Retinal and Opsin is responsible in forming _____

Retinal turns visual light into nerve signals in retina of eye

Retinoic acid required for structural components of eye

_____ in the retina (Bright lights & Color vision)

_____ in the retina (Dim lights & Black and white vision)

Growth and Differentiation of Cells

Retinoic acid is necessary for _____

Important for embryo development, _____

Retinoic acid influences production, structure, and function of epithelial cells that line the outside (skin) and external passages (mucus forming cells) within the body

Immunity

Deficiency leads to

Supplementation may decrease severity of infections in deficient person

Measuring Vitamin A

International unit (IU)-

Retinol activity equivalent (RAE) –

RDA for Vitamin A for Adults

_____ RAE for men, _____ RAE for women

Average intake meets RDA because much stored in the liver

Deficiency of Vitamin A

Most susceptible populations:

Preschool children with low F&V intake; Urban poor; Older adults; Liver disease (limits storage); _____

Consequences:

_____ (Conjunctival xerosis, Bitot's spots, Xerophthalmia)
Poor growth; Decreased mucus production, Decreased immunity, Bacterial invasion of the eye

Upper Level for Vitamin A

_____ µg retinol

_____ results from long-term supplement use (2 – 4 x RDA)

Toxicity: Fatal dose (_____ g)

Toxicity of Vitamin A

Acute –

symptoms disappear when intake stops GI effects, Headaches, Blurred vision,
Poor muscle coordination

Chronic –

Bone and muscle pain, Loss of appetite, Skin disorders, Headache, Dry skin, Hair loss, Increases liver size, Vomiting

Teratogenic

Tends to produce physical defect on developing fetus as a result of excess vitamin A intake

Spontaneous abortion and Birth defects

Vitamin D

Prohormone –

Synthesis from sun exposure: Sufficient sun exposure makes this a vitamin
How much sunlight do you need?

Food Sources of Vitamin D

Fatty fish (salmon, herring), Fortified milk, Some fortified cereal

Functions of Vitamin D

Regulate blood calcium level

With parathyroid hormone, releases calcium from bone

Cell differentiation

Linked to reduction of breast, ovarian, colon, and prostate cancer development

Vitamin D Needs

Due to variation in sunlight exposure, no RDA set, but AI established as:

5 µg/d (200 IU/d) for adults under age 51

10-15 µg/d (400 - 600 IU/d) for older adults

Light skinned individuals can produce enough vitamin D to meet the AI from casual

sun exposure

Infants are born with vitamin D, but AAP recommends supplementing breastfed infants with 5 µg (200 IU)/d until weaned to fortified infant formula

Vitamin D Deficiency

Rickets –

Osteomalacia –

Vitamin D resistance –

Upper Level for Vitamin D

UL = 50 µg/d (2000 IU/d)

Regular intake of 5-10x the AI can be toxic

Over-absorption of calcium (hypercalcemia), increase calcium excretion

Calcium deposits in kidneys, heart, and blood vessels, narrowing of pulmonary arteries and aorta, facial changes, mental retardation

Vitamin E

Tocopherols and tocotrienols

Vitamin E in Foods

Plant oils, Wheat germ, Asparagus, Peanuts, Margarine, Nuts and seeds

Actual amount is dependent on harvesting, processing, storage and cooking

Functions of Vitamin E

Antioxidant:

Free Radicals

Antioxidant

Peroxy-radical from

Protects PUFAs within the cell membrane and plasma lipoproteins

Redox agent –

Vitamin E Needs

RDA = 15 mg/d for women and men (22 IU of natural source or 33 IU of synthetic form)

Vitamin E Deficiency

Rare

Consequences of deficiency: Hemolytic anemia, Nervous system damage

Susceptible populations: Premature infants, People with fat malabsorption, Smokers (destroys vit E)

Upper Level for Vitamin E

Upper Level is _____ IU (natural sources) or _____ IU (synthetic forms)

Inhibit vitamin ____ metabolism and anticoagulants

Possible impact on _____ health

Vitamin K (“Koagulation”)

Phylloquinone (K1) from plant sources

Menaquinones (K2) from fish oils, meats, and intestinal bacteria

Dietary Sources of Vitamin K

Liver, Green leafy vegetables, Broccoli, Peas, Green beans, Resistant to cooking losses,

Limited vitamin K stored in the body

Functions of Vitamin K

_____ : Formation of **osteocalcin**, Low intake is increases risk for hip fractures

Vitamin K Needs

AI = ____ $\mu\text{g}/\text{d}$ for women, ____ $\mu\text{g}/\text{d}$ for men

Vitamin K Deficiency

_____ : Destroy intestinal bacteria, Inhibit vitamin K synthesis and absorption, Potential for excessive bleeding

Excess vitamins__ and __ interferes with vitamin ____

Newborns are injected with vitamin K (breast milk is a poor source)

Vitamin K – Toxicity

Water-Soluble Vitamins

General characteristics

Dissolve in water and Readily excreted

In the diet

Consumed in _____ form, cleaved during digestion, absorbed as free vitamins

50 – 90% B vitamins in diet are absorbed

Once absorbed,

Vitamin C

Ascorbic acid (reduced form), dehydroascorbic acid (oxidized form)

Synthesized by most animals (_____)

Vitamin C in Foods

Citrus fruits, Potatoes, Green peppers, Cauliflower, Broccoli, Strawberries, Romaine lettuce, Spinach

Sensitive to heat so it's easily lost through cooking & sensitive to iron, copper, oxygen

Functions of Vitamin C

_____ : Works much like Vit E only in
fluids instead of fats

Biosynthesis: Hormones, Neurotransmitters, Bile acids

_____ functions: WBC have highest concentration of Vit C

Vitamin C Needs

RDA is ___ mg/d for male adults & ___ mg/d for female adults

Needs increased under certain conditions

+35 mg/d for smokers, Oral contraceptives, Tissue injury

Deficiency of Vitamin C

Deficient for _____ days

Consequences of deficiency

Fatigue, Pinpoint hemorrhages, bleeding gums and joints, Impaired wound healing,

Bone pain, fractures and Diarrhea

Upper Level for Vitamin C

Fairly nontoxic (at <__ gm)

Chronic high doses may lead to (UL = __ g/d)

Stomach inflammation, Diarrhea, Kidney stones

Vitamin B1: _____

Contains sulfur and nitrogen group and is destroyed by alkaline and heat

Coenzyme: Thiamin pyrophosphate (TPP)

Thiamin in Foods

White bread, pork, hot dogs, luncheon meat, cold cereal, Enriched grains/ whole grains

Functions of Thiamin

Thiamin pyrophosphate (TPP) is a coenzyme in the metabolism of _____,
branched-chain amino acids, and pentoses

Decarboxylase & Transketolase

Thiamin Needs

RDA ___ mg/d for women and ___ mg/d for men

No UL; surplus is rapidly lost in urine

Thiamin-Deficiency Disease

Beriberi:

Peripheral neuropathy: Impaired sensory, motor and reflex

Occurs within 7 days on a thiamin deficient diet

Mainly in alcoholics: Alcohol ↓ thiamin absorption and ↑ excretion, Poor quality diet

Consequences of deficiency: Involuntary eye movement, Double vision, Ataxia:

staggering, poor muscle coordination, Mental confusion, “drunken stupor”

Vitamin B2: _____

Coenzymes: Flavin mononucleotide (FMN) and Flavin adenine dinucleotide (FAD)

Riboflavin in Foods

Milk/products, Enriched grains, Liver, Oyster, Brewer’s yeast

Functions of Riboflavin

Coenzymes in oxidation-reduction reactions(_____)

FMN shuttles hydrogen ions and electrons to into the electron transport chain

Riboflavin Needs

RDA 1.1 mg/d for women and 1.3 mg/d for men

No UL, toxicity not documented, readily excreted

Riboflavin-Deficiency Diseases

Occurs within 2 months, usually in combination with other deficiencies

Glossitis- tongue; Cheilosis- corner mouth; Seborrheic dermatitis- skin; Stomatitis- mouth

Vitamin B3: _____

Nicotinic acid (niacin) and nicotinamide (niacinamide)

Coenzyme: Nicotinamide adenine dinucleotide (**NAD**)

Nicotinamide adenine dinucleotide phosphate (**NADP**)

Niacin in foods

Mushrooms; Enriched grains; Beef, chicken, turkey, fish

Heat stable; little cooking loss; 60 mg tryptophan can be converted into 1 mg niacin

Functions of Niacin

Coenzyme (NADH and NADPH) in oxidation-reduction reactions

Catabolic reactions use _____

Glycolysis, Citric acid cycle, Alcohol dehydrogenase

Anabolic reactions use _____

Fatty acid synthesis

Niacin Needs

RDA: 14 NE/day for women and 16 NE/day for men

Niacin-Deficiency Diseases

_____: Occurs in 50-60 days and is prevented with an adequate protein diet

Consequences of deficiency include Diarrhea, Dementia, Dermatitis

Upper Level for Niacin

Toxicity effects: Flushing of skin, Itching, Nausea, Liver damage

UL = 35 mg/d of *supplemental* niacin

Vitamin B4: _____

Consumed as Coenzyme ____

Vitamin B4: Pantothenic Acid in Foods

“From every side”; Meat; Milk; Mushrooms; Liver; Peanuts

Functions of Pantothenic Acid

Part of Coenzyme-A

Pantothenic Acid Needs

Adequate Intake = 5 mg/d; Average intake usually exceeds AI

No UL

Pantothenic Acid-Deficiency Diseases

Rare; Lethargy, fatigue, headache, sleep disturbance, nausea, abdominal distress;

Alcoholics at risk

Usually in combination with other deficiencies

Vitamin B5: _____

Exists in free and protein-bound (biocytin) forms; biocytin must be cleaved from protein by biotinidase before being absorbed

Sources of Biotin:

Cauliflower, yolk, liver, peanuts, cheese; Intestinal synthesis of biotin; Biotin content only available for a small number of foods; We excrete more than we consume

Functions of Biotin

Cofactor in carboxylase reactions (addition of CO₂)

Citric acid cycle, Fatty acid synthesis, and Fatty acid elongation

Allows for breakdown of amino acids

Biotin Needs

AI = 30 µg/d for adults (This may overestimate the amount needed for adults) and No UL

Biotin-Deficiency Diseases

Susceptible populations: Those with high intake of raw egg whites and Alcoholics

Consequences of deficiency

Skin rash; Hair loss; Convulsion; Neurological disorders

Vitamin B-6: _____

Three compounds: Pyridoxal, Pyridoxine, Pyridoxamine

Main coenzyme form: pyridoxal phosphate (**PLP**)

Vitamin B-6 in Foods

Meat, fish, poultry; Whole grains (not part of enrichment program); Banana, Spinach, Avocado, Potato

Heat and alkaline sensitive

Functions of Vitamin B-6

Heme synthesis; Participates in 100+ enzymatic reactions (Decarboxylation of amino acid and Transamination reaction); Carbohydrate metabolism; Lipid metabolism;

Neurotransmitter synthesis

Vitamin B-6 Needs

RDA = 1.3 - 1.7 mg/d for adults and average intake is more than the RDA

Vitamin B-6 Deficiency Diseases

Rare and Consequences of deficiencies include Microcytic hypochromic anemia; Seborrheic dermatitis; Convulsion, depression, confusion; Reduced immune response; Peripheral nerve damage

Pharmacologic Use of Vitamin B-6

Upper Level for Vitamin B-6

100 mg/d and is Based on development of nerve damage with toxicity

Folate (Folic acid, Folacin)

Consists of pteridine group, para-aminobenzoic acid (PABA), and glutamic acid
Coenzyme form: tetrahydrofolic acid (**THFA**)

Folate in Foods

Liver; Fortified breakfast cereals; Grains, legumes; Foliage vegetables

Functions of Folate

DNA synthesis: Synthesis of adenine and guanine and Anticancer drug methotrexate
Homocysteine metabolism; Neurotransmitter formation ; Amino acid metabolism
RDA = 400 µg/d for adults

Folate-Deficiency Diseases

Consequences of deficiency
Megaloblastic anemia: Similar signs and symptoms of vitamin B-12 deficiency
Neural tube defects

Upper Level for Folate

UL for synthetic folate = 1 mg/d
Toxicity symptoms: Epilepsy, Skin disorder, Respiratory disorder
FDA limits nonprescription supplements to 400 µg per tablet for non-pregnant adults

Vitamin B-12: _____

Forms of Vitamin B-12

Cyanocobalamin (free vitamin B-12); Methylcobalamin (coenzyme); 5-deoxyadenosylcobalamin (coenzyme)

Contains cobalt

Vitamin B-12 in Foods

Synthesized by bacteria, fungi and algae
Animal products: Organ meat, Seafood, Eggs, Hot dogs, Milk

Functions of Vitamin B-12

Coenzymes that move 1-C groups
Citric acid cycle, Oxidation of fatty acids, Folate metabolism
Nervous system functions – maintenance of myelin sheath

Vitamin B-12 Needs

RDA = 2.4 µg/d for adults and elderly adults while average intake exceeds RDA and no UL

Vitamin B-12-Deficiency Diseases

Looks like folate deficiency
Causes: Usually due to decreased absorption ability

Consequences

Pernicious anemia

Nerve degeneration, weakness; Tingling/numbness in the extremities (parasthesia);
Paralysis and death

Susceptible populations

Older adults; Infants of vegan mothers; Vegans (after many years); People with malabsorptive diseases

Treatment

Monthly injections
Nasal gel
Weekly ingestion of megadoses