The Micronutrients & Water

HNF 610: Nutrition & Fitness
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Micronutrients

- Micronutrients include vitamins and minerals.
- They do not provide energy.
- They are needed in small quantities.
- Deficiencies and excesses of the micronutrients can affect health.
Vitamins

- Vitamins are organic substances.
- Plants manufacture vitamins during photosynthesis.
- Vitamins have no particular chemical structure in common.
- Provitamins are inactive precursors to vitamins.
Classifications of Vitamins

- Fat-soluble
  - Vitamins A, D, E, and K

- Water-soluble
  - Vitamin C
  - B-complex
    - Thiamine (B$_1$), riboflavin (B$_2$), pyridoxine (B$_6$), niacin (nicotinic acid), pantothenic acid, biotin, folic acid, and cobalamin (B$_{12}$)
Fat-Soluble Vitamins

- Dissolve and stored in the body’s fatty tissues
- Dietary lipids are a source of fat-soluble vitamins.
- Should not be consumed in excess without medical supervision
- Are not excreted easily from the body
Water-Soluble Vitamins

- Act largely as coenzymes
- Disperse readily in the body fluids
- Excess intake is voided in the urine.
- Marginal deficiencies could develop within about 4 weeks of inadequate intake.
  - A broad array of vitamins are readily available in the foods consumed in a well-balanced diet, so little chance occurs for long-term vitamin deficiency.
Roles of Vitamins

- Serve as essential links and regulators in numerous metabolic reactions that release energy from food
- Regulate metabolism
- Control process of tissue synthesis
- Protect the cells’ plasma membrane
Eye function: A
Teeth: A, D, C
Blood clotting: K
Blood cells: E
Hormone formation:
Steroids: A, pantothenic acid, norepinephrine, thyroxine, B₆
Neuromuscular function:
A, B₆, B₁₂, thiamine, niacin, pantothenic acid
Cell membranes: E
Bones: A, D, C
Blood formation: B₆, B₁₂, C, folate
Energy release: thiamine, riboflavin, niacin, biotin, B₆, pantothenic acid
Reproduction: A, riboflavin
Skin: A, C, B₆, niacin, riboflavin, pantothenic acid
Dietary Reference Intakes

- Dietary Reference Intake (DRI) provide a comprehensive approach to nutritional recommendations for individuals.
- DRI is an umbrella term that encompasses several standards—Recommended Daily Allowance, Estimated Average Requirement, Adequate Intake, and the Tolerable Upper Intake Level.
Values for Nutrients in the DRIs

- **Recommended Dietary Allowance (RDA):** The average daily nutrient intake level sufficient to meet the requirement of nearly 97-98% of healthy individuals in a particular life stage and gender group.

- **Estimated Average Requirement (EAR):** Average level of daily nutrient intake to meet the requirement of one-half of the healthy individuals in a particular life stage and gender group.
Values for Nutrients in the DRIs

- Adequate Intake (AI): Provides an assumed adequate nutritional goal when no RDA exists.
- Tolerable Upper Intake Level (UL): The highest average daily intake level likely to pose no risk of adverse health effects to almost all individuals in a specified gender and life stage group.
Antioxidant Role of Vitamins

- A free radical is a highly chemically reactive atom or molecule that contains at least one unpaired electron in its outer valence shell.
- An accumulation of free radicals increases the potential for cellular damage (oxidative stress).
- This increases the likelihood of cellular deterioration associated with aging, cancer, diabetes, coronary artery disease, exercise-related damage, and a general decline in CNS and immune functions.
Antioxidant Role of Vitamins

- Vitamins A, C, E, and beta-carotene serve important protective functions as antioxidants.
- Appropriate levels of these vitamins can reduce the potential for free radical damage (oxidative stress) and may protect against heart disease and cancer.
Disease Protection

- Isothiocyanates: natural detoxifier
- Lutein and zeaxanthin: protect eye health
- Lycopene: decreases the risk for heart disease and cancer
- Vitamin E: neutralizes harmful compounds
Homocysteine

- All individuals produce homocysteine.
- It normally converts to other nondamaging amino acids.
- Three B vitamins, folate, $B_6$, and $B_{12}$, facilitate the conversion.
- If the conversion slows due to vitamin deficiency, homocysteine levels increase and promote cholesterol’s damaging effects on the arterial lumen.
**A. Mechanism**

1. Protein-rich foods contain the amino acid methionine that converts to homocysteine

2. Excess levels of homocysteine damage the lining of arteries

3. Cholesterol builds up inside the scarred arteries, which can lead to fatal blockages

**B. Proposed Defense**

- **Vitamin B₁₂**: Found in meat, fish, and dairy products
- **Vitamin B₆**: Found in green leafy vegetables, poultry, nuts, whole-grain cereals, and fish
- **Folic acid**: Found in green leafy vegetables, fruits, orange juice, wheat germ, dried beans, and peas

When taken in daily supplements, 10 µg of B₁₂, 3 mg of B₆, and 400 µg of folic acid are recommended.
Minerals

- Consist of 22 mostly metallic elements
- Minerals essential to life
  - 7 major minerals (required in amounts >100 mg daily)
  - 14 minor or trace minerals (required in amounts <100 mg daily)
- A balanced diet generally provides adequate mineral intake, except in some geographic locations lacking specific minerals.
Roles of Minerals

- Provide structure in the formation of bones and teeth
- Help to maintain normal heart rhythm, muscle contractility, neural conductivity, and acid-base balance
- Regulate metabolism by becoming constituents of enzymes and hormones that modulate cellular activity
Mineral Bioavailability

- Factors that affect the bioavailability of minerals in food
  - Type of food
  - Mineral–mineral interaction
  - Vitamin–mineral interaction
  - Fiber–mineral interaction
Calcium and Osteoporosis

- Osteoporosis is the loss of bone, with a bone density more than 2.5 standard deviations below normal for age and gender.
- Osteopenia is a midway condition where bones weaken with increased fracture risk.
- Adequate calcium intake and regular weight-bearing exercise or resistance training help prevent bone loss at any age.
Osteoporosis

- A significant association between muscular strength and bone density exists.
- Strength testing of postmenopausal women may be used as a tool to screen for osteoporosis.
Osteoporosis Risk Factors

- Advanced age
- White or Asian female
- Slight build or tendency to be underweight
- Anorexia nervosa or bulimia nervosa
- Sedentary lifestyle
- Postmenopause, including early or surgically induced menopause
- Low testosterone levels in men
- High protein intake
- Excess sodium intake
- Cigarette smoking
- Excessive alcohol use
- Abnormal absence of menstrual periods
- Calcium-deficient diet in years before and after menopause
- Family history of osteoporosis
- High caffeine intake (possible)
- Vitamin D deficiency
6 Principles for Promoting Bone Health

- Specificity
- Overload
- Initial values
- Diminishing returns
- More not necessarily better
- Reversibility
The Female Triad

- The Triad usually begins with disordered eating and leads to amenorrhea and then osteoporosis.
- Women who train intensely and cut calories below energy requirements may adversely affect menstruation.
  - Oligomenorrhea – irregular cycles
  - Amenorrhea – cessation of menstruation
The Female Triad

- These women often show advanced bone loss at an early age.
- Restoration of normal menstruation does not totally restore bone mass.
Treatment of Athletic Amenorrhea

- Nonpharmacologic approaches
  - Reduce training level by 10-20%
  - Gradually increase total energy intake
  - Increase body weight by 2-3%
  - Maintain daily calcium intake at 1500 mg
Phosphorus

- Combines with calcium to form hydroxyapatite and calcium phosphate
- An essential component of AMP, PCr, and ATP
- Combines with lipids to form phospholipids, part of the cell membrane
- Phosphate enzymes regulate cellular metabolism
- Participates in buffering acid end products of energy metabolism
Magnesium

- Helps to regulate metabolism
- Vital role in glucose metabolism
- Participates as a cofactor in the breakdown of glucose, fatty acids, and amino acids during energy metabolism
- Affects the synthesis of lipids and proteins
- Allows the neurologic system to function properly
Iron and Exercise-Related Functions

- Most of the iron in the body is combined with hemoglobin in the red blood cells.
- Iron is a structural component of myoglobin and the cytochromes.
- Some iron does not combine in functionally active compounds and exists as hemosiderin and ferritin stored in the liver, spleen, and bone marrow.
Iron-Deficiency Anemia

- About 40% of American women of childbearing age suffer from dietary iron insufficiency that could lead to iron-deficiency anemia.
- Causes sluggishness, loss of appetite, and a decreased ability to sustain even mild activity.
- This condition negatively affects aerobic exercise performance and the ability to perform heavy training.
Iron Sources

- Nonheme iron
  - Primarily found in plant products
  - 2-10% absorption by the intestines

- Heme iron
  - Primarily found in animal products
  - 10-35% absorption by the intestines
Vegetarian Diets and Anemia

- Nonheme iron has a low bioavailability.
- Women on vegetarian-type diets increase their risk for developing iron insufficiency.
- Both vitamin C and moderate physical activity increase intestinal absorption of nonheme iron.
Sports Anemia

- Reduced hemoglobin levels approaching clinical anemia
- Due to intense training
- Hemoglobin becomes diluted due to an increase in plasma volume.
Electrolytes

- Electrically charged particles dissolved in body fluids
  - Sodium
  - Potassium
  - Chlorine

- Establish the proper electrical gradient across cell membranes

- Modulate fluid exchange within the body's fluid compartments

- Regulate the acid and base qualities of body fluids
Sodium Intake and Health

- Sodium-induced hypertension occurs in about one-third of individuals with hypertension.
- The Dietary Approaches to Stop Hypertension (DASH) diet lowers blood pressure in some individuals to the same extent as pharmacologic therapy.
- A low-sodium diet and excessive perspiration can result in hyponatremia (low blood levels of sodium).
Water

- Water constitutes 40-70% of the total body mass.
  - Muscle contains 65-75% water by weight.
  - Water represents only about 50% of the weight of body fat.
  - Of the total body water, roughly 62% exists in the intracellular compartment, and 38% is present in the extracellular compartment in the plasma, lymph, and other fluids outside the cell.
Roles of Water

- Provides structure and form to the body
- Regulates temperature
- Provides a medium for substances to interact chemically
- Transports oxygen and nutrients
Water Intake and Output

- **The average daily water intake comes from**
  - Liquid – about 1.2 L
  - Food – about 1.0 L
  - Metabolic water – about 0.3 L

- **Daily water loss occurs from**
  - Urine – about 1-1.5 L
  - Insensible perspiration – about 0.50-0.70 L
  - Water vapor in expired air – about 0.25-0.30 L
  - Feces – about 0.10 L