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Minerals and Nutrition (Ca, Fe, Zn):
Learning Objectives

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1. Identify at least two important functions of the following three minerals: calcium, iron, and zinc.

2. Explain the methods used to assess status for the above three minerals.

3. Describe three modifiers of need or stores for each of the three minerals.

4. Name the adverse effects of excessive intakes of each of these three minerals.

5. Know which minerals are being consumed in the United States in inadequate amounts.

Minerals and Nutrition (Ca, Fe, Zn):
Answers to Learning Objectives

1. **Identify at least two important functions of the following three minerals.**
   Calcium:
   a. As a dissolved ion in body fluids, calcium, along with other ions, regulates the activity of many enzymes, maintains acid-base balance, osmotic pressure, facilitates membrane transfer of essential compounds, and maintains nerve transmission and the regulation of heart beat. A low calcium intake may contribute to the development of hypertension as well as colon cancer.
   b. Calcium is the most abundant mineral in the skeleton, necessary for building and maintaining bones and teeth.

   Iron:
   a. The functions of iron result from its physical and chemical properties, mainly its ability to participate in oxidation and reduction reactions. Iron has a role in the respiratory transport of oxygen and carbon dioxide and is an active part of enzymes involved in the process of cellular respiration. Specifically, iron is part of the "heme" protein, hemoglobin, present in red blood cells. Hemoglobin combines with oxygen in the lungs and with carbon dioxide in the tissues. Myoglobin, also an iron-containing heme protein, serves as an oxygen reservoir in the muscles.
   b. Adequate iron is essential for normal functioning of the immune system. Both iron overload and iron deficiency result in changes in immune function.
   c. Iron is also critical for normal brain function. Differences have been found between the scholastic performance, sensorimotor competence, attention, learning, and memory of anemic children and control subjects.

   Zinc:
   a. Zinc is part of enzymes that participate in numerous reactions involving the metabolism of carbohydrates, lipids, proteins, and nucleic acids.
   b. Zinc is abundant in the nucleus, where it stabilizes RNA and DNA structure and is required for the activity of RNA polymerases important in cell division.
   c. Zinc is a component of the crystalline structure of bone and bone enzymes that participate in osteoblastic activity.
   d. Zinc is important for the immune system: both a deficiency and an overload can impair immune function.

2. **Explain the methods used to assess status for the three minerals.**
   Serum levels are often not sensitive measures of nutritional status as they can remain constant while stores are being depleted. For example:
   a. **Calcium** levels in the serum remain relatively constant. When calcium levels fall below about 10 mg/100 ml of blood serum, parathormone, secreted by the parathyroid gland, promotes the transfer of exchangeable calcium from the bone into the blood. When

serum calcium is above normal, the hormone calcitonin lowers it by inhibiting further bone resorption. Calcium status, however, can be estimated by bone density tests.

b. **Iron** status is best assessed with specific function tests. A very early (stage I) positive iron balance may best be determined by measuring saturation of iron-binding capacity. Conversely, measurement of serum ferritin (storage form of iron) may best reveal early (stage I and stage II) negative iron balance. Hemoglobin or hematocrit measurements indicate anemia.
c. **Zinc** levels in the plasma fluctuate in response to low dietary intake, as well as to physiologic factors, such as injury or inflammation. For example, plasma zinc levels drop by 50% in the acute-phase response to injury.

3. Describe three modifiers of need or stores for each of the three minerals.

a. **Calcium**: A chronic low calcium intake will lead to a loss of calcium from the bone. Low vitamin D intake or synthesis on the skin will lead to a decreased absorption of calcium from the diet and to a subsequent loss of calcium from the bone. Calcium is best absorbed in an acid medium. With aging there is less stomach acid produced, and, consequently, less calcium absorption. Chronic use of antacids can also interfere with calcium absorption. Excessive protein and fiber decrease calcium absorption as well.
b. **Iron**: A chronic ingestion of high levels of iron or frequent blood transfusions can lead to abnormal accumulation of iron in the liver. Iron deficiency can be caused by injury, hemorrhage, or illness (GI diseases that impact iron absorption). Many dietary factors affect the absorption of iron. Heme-iron is the form of iron found in meat, fish, and poultry. This iron is the most readily absorbed. Nonheme iron, the form found in grains and cereals, is less available for absorption. Like calcium, the degree of stomach acidity enhances the availability of iron in food. Ascorbic acid (vitamin C) forms a chelate with iron that remains soluble at the higher pH of the small intestine. The nonheme iron in grains and cereals is more easily absorbed when eaten along with a source of vitamin C. Excessive fiber in the diet, as well as phytates in certain foods (unleavened bread) and tannins in tea can also interfere with iron absorption.
c. **Zinc**: Alcoholism alters zinc metabolism and may result in a zinc deficiency. Acquired zinc deficiency may result from malabsorption, starvation, or increased loss via urinary, pancreatic, or other exocrine secretions. Both a high level of fiber and phytate (from unleavened bread) can bind with zinc in the intestine and prevent absorption.

Pregnancy, lactation, aging, and certain illness increase the need for all three of the above minerals.

4. Name the adverse effects of excessive intakes of each of these three minerals.

a. **Calcium**: Excessive intakes of calcium along with vitamin D (usually as a result of taking supplements), is a potential source of hypercalcemia. This may result in calcification in bone and soft tissues. High intakes of calcium can interfere with iron absorption. Therefore, when a person needs to consume both as supplements, the iron supplement should be taken at a different time. The Tolerable Upper Intake level of calcium for males and females over the age of one is 2.5 grams/day.

b. **Iron**: Iron overload usually results from a hereditary condition known as hemochromatosis. It can also result from transfusion overload, usually in individuals with sickle cell disease who require frequent transfusions. Excessive iron in the diet or in supplements is very rare, iron deficiency is much more common. The Tolerable Upper Intake level of iron for males and females under the age of 14 is 40 mg/day. From age 14-70, the level is 45 mg/day.
c. **Zinc**: Excess oral ingestion of zinc to the point of toxicity is rare. However, continued supplementation with zinc in excess of the RDA will interfere with copper absorption. The Tolerable Upper Intake level of zinc for males and females is 23 mg/day for ages 9-13 years, 34 mg/day for ages 14-18 years, and 40 mg/day for ages 19-70 years.

5. Know which minerals are being consumed in the United States in inadequate amounts for males and females.

According to the NHANES Survey (National Health and Nutrition Exam Survey) from 2001-02, dietary intakes of calcium, iron, magnesium, potassium, and phosphorus were low in women.