Trace Elements

PGT Biochemistry

Zinc

- Zinc is an essential trace element, necessary for plants, animals, and microorganisms.
- Zinc is found in nearly 100 specific enzymes.

Zinc

- Serves as part of transcription factors.
- In proteins, Zn ions are often found in combination with the amino acid such as aspartic acid, glutamic acid, cysteine and histidine.

Zinc

- 2–4 grams of zinc distributed throughout the human body.
- Most zinc is in the brain, muscle, bones, kidney, and liver.
- Highest concentrations in the prostate, parts of the eye and Semen

Zinc

- Has roles in the metabolism of RNA and DNA, signal transduction, and gene expression.
- It also regulates apoptosis.

Zinc

- In the brain, zinc is stored in specific synaptic vesicles.
- In learning.

Zinc

- Zinc-containing enzymes
  - Carbonic anhydrase
  - Carboxypeptidase's

Zinc

- In blood plasma, zinc is bound to and transported by albumin (60%, low-affinity) and transferrin (10%).
- Since transferrin also transports iron, excessive iron reduces zinc absorption, and vice-versa.
- A similar reaction occurs with copper.

Zinc

- The concentration of zinc in blood plasma stays relatively constant regardless of zinc intake.

- Cells in the salivary gland, prostate, immune system and intestine use zinc signaling as one way to communicate with other cells.

Zinc

- However, inadequate or excessive zinc intake can be harmful;
- Excess zinc particularly impairs copper absorption because metallothionein absorbs both metals.

Dietary Sources

Zinc deficiency

- Zinc deficiency is usually due to:
  - Insufficient dietary intake,
  - Malabsorption
  - Chronic liver disease
  - Chronic renal disease
  - Sickle cell disease
  - Diabetes
  - Malignancy

Zinc deficiency

- Groups at risk for zinc deficiency include the elderly, vegetarians, and those with renal insufficiency.

Magnesium

- Over 300 enzymes require the presence of magnesium ions for their catalytic action.

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Dietary Sources

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Magnesium

- Adult human bodies contain about 24 grams of magnesium:
  - with 60% in the skeleton
  - 39% intracellular (20% in skeletal muscle)
  - 1% extracellular.

Magnesium

- Magnesium is absorbed in the gastrointestinal tract, with more absorbed when body stores is lower.
- In humans, magnesium appears to facilitate calcium absorption.
- Low and high protein intake inhibit magnesium absorption.

Magnesium

- Spices, nuts, cereals, coffee and vegetables are rich sources of magnesium.
- Green leafy vegetables such as spinach are also rich in magnesium.

Manganese

- Manganese is an essential trace nutrient in all forms of life.
- The classes of enzymes that have manganese cofactors are very broad and include oxidoreductases, transferases, hydrolases, lyases, isomerases and ligases.

Manganese

- The reverse transcriptases of many retroviruses contain manganese.
- The best known manganese-containing polypeptides may be arginase, the diphtheria toxin, and Mn-containing superoxide dismutase (Mn-SOD).

Manganese

- The human body contains about 10 mg of manganese,
  - which is stored mainly in the liver and kidneys.
- In the human brain the manganese is bound to manganese metalloproteins most notably glutamine synthetase in astrocytes.

Selenium

- The substance loosely called selenium sulfide (approximate formula SeS2) is the active ingredient in some anti-dandruff shampoos.

- Selenium is used widely in vitamin preparations and other dietary supplements, in small doses
- (Typically 50 to 200 micrograms per day for adult humans).

Iodine

- Iodine's is a constituent of the thyroid hormones: thyroxine (T4) and triiodothyronine (T3).
- Iodine has a nutritional relationship with selenium.
- A group of selenium-dependent enzymes called deiodinases converts T4(Inactive hormone) to T3 (active hormone) by removing an iodine atom from the outer tyrosine ring.

Iodine

- Iodine accounts for 65% of the molecular weight of T4 and 59% of the T3.
- 15–20 mg of iodine is concentrated in thyroid tissue and hormones, but 70% of the body's iodine is distributed in other tissues

Iodine

- The daily Dietary Reference Intake recommended is:
  - Between 110 and 130 μg for infants
  - 90 - 130 μg for children
  - 150 μg for adults
  - 220 μg for pregnant women
  - 290 μg. for lactating mothers

Iodine

- Natural sources of iodine include seafood, as well as plants grown on iodine-rich soil.
- Iodized salt is fortified with iodine.

Iodine deficiency

- In areas where there is little iodine in the diet, such as hilly areas.

Iodine deficiency

- Iodine deficiency is the leading cause of preventable mental retardation.

- Other possible health effects being investigated as being related to deficiency include:
  - Breast cancer.
  - Stomach cancer

Dietary Sources

Dietary Sources

- Rich sources of copper include beef or lamb liver, nuts, green olive.

Copper

- The human body normally contains copper at a level of about 1.4 to 2.1 mg for each kg of body weight.
- Copper is distributed widely in the body and occurs in liver, muscle and bone.
- Copper is transported in the bloodstream on a plasma protein called ceruloplasmin.

Copper

- When copper is first absorbed in the gut it is transported to the liver bound to albumin.
- Copper metabolism and excretion is controlled delivery of copper to the liver by ceruloplasmin, where it is excreted in bile.

Copper

- RDA for copper in normal healthy adults is 0.9 mg/day.
- Copper deficiency can often produce anemia-like symptoms.
- Conversely, an accumulation of copper in body tissues are believed to cause the symptoms of Wilson's disease in humans.

Iron

- Iron is an absolute requirement for most forms of life.
- Iron can also be potentially toxic.
- It can catalyze the conversion of hydrogen peroxide into free radicals.

- The most important group of iron-binding proteins contain the heme molecules, all of which contain iron at their centers.
- The iron-sulfur proteins are another important group of iron-containing proteins.
- Humans also use iron in the hemoglobin of red blood cells

- Iron is also an essential component of myoglobin to store and diffuse oxygen in muscle cells.
- The human body needs iron for oxygen transport

- A proper iron metabolism protects against bacterial infection.
- Disease-causing bacteria have releasing iron-binding molecules called siderophores and then reabsorbing them to recover iron.

- Most well-nourished people 4-5 grams of iron in their bodies.
- Of this, about 2.5 g is contained in the hemoglobin needed to carry oxygen through the blood.

- Another 400 mg is devoted to cellular proteins that use iron for important cellular processes like storing oxygen (myoglobin), or performing energy-producing redox reactions

- 3-4 mg circulates through the plasma, bound to transferrin.

- Most stored iron is bound by ferritin molecules; the largest amount of ferritin-bound iron is found in cells of the liver hepatocytes, the bone marrow and the spleen.
- The total amount of loss for healthy people is estimated average of 1 mg a day for men and 1.5–2 mg a day for women.

- Absorbed in the duodenum by enterocytes of the duodenal lining.
- To be absorbed, dietary iron can be absorbed as part of a protein such as heme protein or must be in its ferrous Fe2+ form.
- A ferric reductase enzyme on the enterocytes' brush border, reduces ferric Fe3+ to Fe2+.
- These intestinal lining cells can then either store the iron as ferritin.

- Increased demand for iron, which the diet cannot accommodate.
- Increased loss of iron (usually through loss of blood).
- Nutritional deficiency. This can result due to a lack of dietary iron or consumption of foods that inhibit iron absorption, including calcium

- When *body* levels of iron are too low, then hepcidin in the duodenal epithelium is decreased. This causes an increase in ferroportin activity, stimulating iron uptake in the digestive system. The reverse occurs when there is an iron surplus.