Minerals and Trace Elements in Human Nutrition

Dietary minerals and trace elements are chemical substances required by living organisms in addition to carbon, hydrogen, nitrogen, and oxygen that are present in nearly all organic molecules.

Minerals are present in up to tens of thousands of grams in the human body whilst only a few grams of trace elements are required by the body. The recommended dietary allowance of minerals (RDA) is usually greater than 200 mg/day whilst that for trace elements is less than 200 mg/day and this can be used to classify the difference between minerals and trace elements.

Minerals and trace elements are usually provided by dietary intake however they can be ingested in various forms including:

- these be supplied from foods in which they occur naturally,
- as complex compounds,
- in the from natural inorganic sources (such as calcium carbonate from ground oyster shells).

Main dietary Minerals in the body

Calcium

Function

- Calcium is the most abundant mineral in the human body, containing approximately 1200g. 99% of the calcium is present in bones and teeth present mainly as hydroxyapatite, with a calcium to phosphate ratio of 2:1. The calcium makes up the inorganic component of the bone and provides cross linkage between the collagen fibrils of bone and forming a more rigid structure.

Remodeling or bone turnover is the process of resorption followed by replacement of bone with little change in shape and occurs throughout a person's life. Osteoblasts and osteoclasts, coupled together via paracrine cell signalling, are referred to as bone remodeling units. The process of bone resorption by the osteoclasts releases stored calcium into the systemic circulation and is an important process in regulating calcium balance. As bone formation actively fixes circulating calcium in its mineral form, removing it from the bloodstream, resorption actively unfixes it thereby increasing circulating calcium levels.

In children and adolescents, the rate of bone formation predominates over the rate of resorption whilst in adult life the rate of resorption is greater which leads to the loss of bone strength and causes osteoporosis.

- Calcium also plays a role in several process such exocytosis, neurotransmitter release, and muscle contraction in smooth muscle.
- In the electrical conduction system of the heart, calcium works together with sodium as the minerals that depolarize the cell, proliferating the action potential and causing the plateau phase of the action potential.
- Calcium also reduces the neuromuscular excitation of neurons.
- Calcium plays a very important role in hemocoagulation in both the intrinsic and extrinsic pathways.
- Calcium is also thought to have a role in the prevention of colorectal cancer.

Sources of calcium

- Calcium is mainly found in milk and it is excellently absorbed.
- Soymilk and other vegetable milks are usually sold with calcium added so that their calcium concentration is as high as in milk.
- Leafy green vegetables are a very good source of calcium.

Deficiency of calcium

A deficiency of calcium can lead to disorders such as osteomalcia, osteoporosis, rickets, increased neuromuscular irritability, tachycardia, impaired blood clotting and increased carcinoma of the colon.

Greater amounts of calcium are required daily during:

- rapid growth in adolescence
- during pregnancy and lactation
- In elderly adult life

Potassium

Function

- Potassium is the primary intracellular ion with a concentration of 140mEq/l. It is the main ion involved in nerve and muscle repolarisation.
- Potassium also maintains homeostasis with intracellular osmotic pressure and fluid balance.
- Potassium ions also control the heart conduction system.

Sources of Potassium

- Potassium is present in all plant foods. Important sources include vegetables, fruits, pulses and nuts.

Deficiency of Potassium

Potassium deficiency can be caused by:

- gastrointestinal loses (vomitting, diarrhoea)
- the urinary system (Cushing's syndrome, osmotic diuresis, diuretics)
- Skin losses (excessive sweating, burns).

Clinical features of reduced levels of potassium include spasms, headache, and dehydration.

Magnesium

Functions

- Magnesium is essential for all biosynthetic processes including glycolysis, formation of cyclic AMP, energy dependent membrane transport and transmission of the genetic code.
- Greater than 300 enzymes are known to be activated by magnesium ion.
- Magnesium is also required for maintenance of electrical potentials of nerve and muscle and for the transmission of signals across neuromuscular junctions.

Source of Magnesium

Magnesium is found in green leaves, potato, nuts, legumes and whole grains.

Deficiency of Magnesium

Purely dietary magnesium deficiency has not been reported in people consuming natural diets.

Sodium

Function

Sodium is an cation which is found in higher quantities extracellulary compared to intracellulary. Sodium is used in:

- depolarisation of nerve and muscle tissues
- maintenance of osmotic pressure and acid base balance in the body.
- Sodium also maintains the water balance in the body.
- It also prevents muscle and nerve irritability.

Sources of Sodium

Sodium is mostly found in table salt, salty foods, meat, eggs and milk.

Deficiency of Sodium

Magnesium deficiency can be caused by:

- gastrointestinal loses (vomiting, diarrhoea)
- the urinary system (Cushing's syndrome, osmotic diuresis, diuretics)

Clinical features of reduced levels of sodium include irritability, muscle weakness, paralysis and impaired heart function.

Sulfur

Function

Sulfur is a component of amino acids methionine and cysteine and has a role in detoxication processes as a component of glutathione.

Source of Sulfur

Sulfur is found in foods which are rich in protein.

Main dietary trace elements in the body

Iron

Function

Iron has several functions in the human body which include:

- being a constituent of the haemoglobin molecule - 70%
- myoglobin stored in muscles
- an activating molecule of several enzymes
- found in storage molecules such as ferritin and hemosiderin.

Sources of Iron

Meat, eggs, vegetables and cereals are all sources of iron. Haem and non-haem forms of iron are absorbed by different mechanisms. Haem iron is highly absorbed and averages 40% of the total iron in all animal tissues.

Deficiency of Iron

Three stages of impaired iron status have been defined:

- ferritin levels falling below 12 micrograms per litre but no functional impairment can be seen.
- Iron deficient erythropoiesis where the red cell protoporphyrine levels are elevated, transferrin saturation is reduced to less than 16% and work capacity performance may be impaired.
- Iron deficiency anemia - characterized by small red cells (microcytosis) with low haemoglobin (hypochromia).

Iron deficiency is observed mainly during the following conditions:

- 6 months - 4 years of age because the iron content of milk is low
- During the rapid growth of adolescence, because of needs of an expanding red cell mass and the need to deposit iron in myoglobin
- During the female reproductive phase, because of menstrual loses of iron
- During pregnancy because of the expanding blood volume of the mother, the demands of the fetus and placenta and blood loss during childbirth.

Excess quantities of Iron

Excess quantities of iron cause iron overload and hemochromatosis.

Iron overload can also be caused my genetic mutations (HfE mutation on chromosome 6).

Copper

Function

Copper is a constituent of many enzymes. It is also a constituent of many pigments and is important for immune functions.

Sources of copper

Copper is found in organ meats, especially liver. It is also found in seafood, nuts and seeds.

Deficiency of :

In exceptional circumstances, copper deficiency is seen in malnourished children and causes anaemia, bone demineralisation, impaired immunity, and lack of hair and nail growth.

Fluoride

Function

Fluoride is required for bone and teeth formation

Sources of Fluoride

Fluoride is found in foods such as water tea, and fish.

Deficiency of Fluoride

A lack of fluoride in the diet will cause increased caries formation and poor bone mineralization.

Iodine

Function

Iodine is a major component of thyroid hormones.

Sources of Iodine

Iodine is mainly found in seaweed, seafood and sea fish, eggs, milk and iodised salt.

Deficiency of Iodine

A lack of Iodine will cause a variety of conditions including cretinism, goitre, miscarriages, still births of children and mental retardation

Selenium

Function

Selenium is present at the active site of glutathione peroxidase that catalyses the breakdown of hydroperoxidases and prevents the damage caused by free radicals.

Sources of Selenium

Selenium is found in seafood, kidneys and liver. It is found in grains and other seeds.

Deficiency of selenium

A lack of Selenium will cause decreased lymphocyte numbers and natural killer activity and decreased interferon formation. It also causes Keshan's disease and Kashin Beck disease.

Zinc

Function

Zinc is involved in 200 enzymatic reactions. It is a component of superoxide dismutase and prevents oxidative stress. It positively influences tissue growth and healing and participates in insulin formation and spermatogenesis.

Sources of Zinc

foods containing zinc include meat, liver, eggs and seafood. Wholegrain products contain zinc in a less available manner.

Deficiency of Zinc

Zinc deficiency causes growth retardation, impaired immune functions, loss of appetite and skin, nail and hair change(white spots on nails),acrodermatites enteropathica(hair loss,diarrhoea,anorexia).

Links

Related articles

Bibliography

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