# Macro &Trace Elements (Micro minerals)

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# Objectives

- Describe the biochemical role of Phosphorus, Magnesium, Sulphur , Copper, Zinc, Cobalt, iodine, fluoride, manganese and selenium .
- Outline absorption, transport, metabolism & excretion of the above elements
- State the adverse effect of excess or deficiency

# Phosphorus

Total body P is about 1kg; 80% in bone & teeth and 10% in muscles.

P is mainly intracellular ion.

Requirement is about 100 mg/day.

Vit. D. ( calcitriol) :increases P absorption.

PTH : increases Ca & P release from bone & decrease loss of Ca & increase loss of P in the urine .

Serum P level = 3 – 4 mg/dl in adults

5 – 6 mg/dl in children

RBCs & WBCs contain a lot of P

# Functions of Phosphorus

- 1- formation of bone & teeth
- 2- production of high energy P compounds ( ATP, CTP, GTP & creatine-P)
- 3- synthesis of nucleoside co-enzymes( NAD & NADP)
- 4- DNA & RNA synthesis
- 5- formation of P-esters ( Glu-6-P & phospholipids)
- 6- activation of enzymes by phosphorylation.

# Magnesium

- 1- Mg is mainly seen in intracellular fluid
- 2- total body Mg about 25 gm.
- 3-60% of it complexed with Ca in the bone.
- 4-1/3 of skeletal Mg is exchangeable with serum.
- 5- Mg orally produces diarrhea, but i.v. produces CNS depression.
- 6- Normal serum level = 1.8 – 2.2 mg/dl.
- 7- 70% of Mg exists in free state & 30% is protein bound ( albumin & globulin)

# Functions of Mg

- 1- activator for many enzymes requiring ATP ( ALP, hexokinase, adenyl cyclase, …etc)
- 2-neuromuscular irritability is lowered by Mg.
- 3- insulin- dependent uptake of glucose is reduced in Mg deficiency. Mg supplementation improves glucose tolerance.

# Sulfur

- Sulfur is an inorganic element and forms part of several molecules in the body, including amino acids, proteins, enzymes, vitamins, and more.
- Following calcium and phosphorus, sulfur is the third most abundant mineral in the human body, representing ~0.3% of total body mass.
- Dietary sulfur comes from protein where 2 of the 20 amino acids, methionine, and cysteine, contain sulfur (the sulfur-containing amino acids; SAAs).
- The number of SAAs in protein varies according to the source, e.g., dairy is 4% SAAs and egg whites 8% SAAs.
- Additionally, glutathione (a natural intracellular antioxidant) provides a source of dietary sulfur and is found in fruits and vegetables.
- Currently, there is no recommended dietary allowance (RDA) for sulfur. There is, however, a recommended daily intake for the sulfur-containing amino acids.
- The estimated requirement for methionine (combined with cysteine) was determined in 1989 to be 14 mg/day per kg body weight in adults.

# Is there enough Sulfur in the diet?

- It is vital that there is a good supply of sulfur in the diet to maintain synthesis of the SAAs.
- Methionine, cannot be synthesized in the body and therefore directly relies on an adequate intake of protein. While cysteine is synthesized in the body; the process requires a steady supply of sulfur.
- It's assumed that sulfur intake in the diet is adequate. However, this is based on SAAs, not sulfur directly.
- Further, the requirements for SAAs are based on nitrogen balance and likely under-estimate the dietary need for sulfur.
- As such, there is increasing evidence that the needs for methionine, specifically, are not being met through diet.
- This is further complicated by the admission that intakes don't have to be deficient to cause physiological disruption. Even marginally sufficient intake may not be enough.
- Furthermore, continued evidence show that dietary intakes have declined due to modern agricultural processes.

# THE ROLE OF SULFUR IN THE BODY

- Historically, sulfur has been considered important in soil and plant health, rather than human health.
- However, its role – direct and indirect – is significant. Best known is the role of sulfur and its benefits for skin, including appearance (skin structure), acne, wound healing, and overall skin health.
- Sulfur provides structure and elasticity at a molecular level. Disulfide bonds link skin proteins, like collagen and elastin, and are critical for skin's strong, yet flexible characteristic.
- These bonds can be stretched, yet retain shape once released.
- Additionally, as an integral part of the antioxidant and detoxification processes, sulfur is necessary to protect and maintain proper skin growth.
- Similarly, sulfur supports connective tissue. Tendons and ligaments rely on sulfur for proper cross-linking (disulfide bonds) in addition to extracellular matrix proteins like glycosaminoglycan's (GAGs) and hyaluronic acids (HA), which are highly sulfonated, and provide strength and cushion.

- In the liver, sulfur plays two critical roles:
- As a significant component of glutathione, the most prevalent antioxidant in the body, sulfur helps the body react to oxidative stress and maintain homeostasis, which is particularly relevant to exercise and aging.
- And as part of phase 2 detoxification, sulfur is essential to the metabolism and excretion of harmful substances.

- There are many other roles, such as free radical scavenging, and regulation of gene expression.
- Sulfur indirectly influences all processes of compounds or metabolites in which it is a key component. This includes Ꞷ-3 and Ꞷ-6 polyunsaturated fatty acids, and minerals such as Selenium, Zinc, Copper, and Magnesium.
- *Bottom line, the role of sulfur in the body is broad, impactful, and should not be underestimated.*

# Copper

- 1- plasma Cu = < 30 µg/L
- 2- the recommended dietary intake for adults=0.9 mg/day.
- 3- associated with number of metalloproteins ( e.g. Ceruloplasmin )
- 4-present in the biological system in Cu+ & Cu++, the easy exchange between these ions give the element important redox properties.
- 5- absorption in the small intestine, then transported to the liver in portal blood bound to albumin

# Functions of Cu

- 1- Energy production : Cytochrome-C-oxidase.
- 2- Connective tissue formation : Protein-lysine-6-oxidase , essential for extracellular matrix.
- 3- Iron metabolism : copper containing enzymes (ferroxidase I)
- 4- Central nervous system : Dopamine monooxygenase (DMO)
- 5- Melanin synthesis : Tyrosinase.
- 6- Antioxidant functions : SODs & ceruloplasmin

# Zinc

- 1- Total body content of Zn is 2 – 2.5 g , and the metal is present  in cells of all metabolically active tissue and organs.
- 2- Regulation of the net intestinal uptake of Zn is by control of absorption efficiency and usually ranges from 20 %– 50% of dietary content.
- 3- Iron at supplemental dosage ( up to 65 mg/day) may decrease Zn absorption so that pregnant & lactating women taking iron may require Zn supplementation.

# Zinc

- 4- About 80% of plasma Zn is associated with albumin and the rest bound to the high molecular protein α2-macroglobulin.
- 5- About 55% of total Zn found in muscles & 30% in bone.
- 6- Zn present in more than 300 metalloenzymes ( ALP, RNA & DNA polymerase & carbonic anhydrase)
- 7- Zn has a role in the synthesis & action of many hormones, via Zn transcription factors ( fT4, testosterone, IGF-1)

# Cobalt

- Necessary for biological activity of vit. B12
- Dietary source: liver and vit B12
- There is no recommended dietary allowance for cobalt
- The only known function of cobalt is that in the integral part of vit.B12
- Dietary Co is poorly absorbed and is stored in the liver & excreted in bile.
- Co deficiency is accompanied by all signs and symptoms of vit. B12 deficiency.
- The most important is anemia.
- Excess of cobalt lead to polycythemia.

# Fluorine (F)

- In the form of fluoride, fluorine is incorporated into the structure of teeth & bone.
- Dietary source: The body receive fluorine mainly from drinking water. Some sea fish and tea also contain small amount of fluoride .
- Recommended dietary allowance  1.5—4 mg/day or 1-2 ppm ( since it is present in water in ppm)
- Inorganic fluoride is absorbed readily in the stomach and small intestine and distributed almost entirely to bone and teeth. About 50% of the daily intake is excreted through urine .
- Fluoride is required for proper formation of bone and teeth.
- It becomes incorporated into hydroxyapatite, the crystalline mineral of bone and teeth to form fluoroapatite.
- Fluoroapatite increases hardness and provide protection against dental caries and attack by acids.

# Fluoride

- Deficiency of fluoride leads to dental caries and osteoporosis
- Excessive amounts of fluoride can result in dental fluorosis.
- This condition results in teeth with a patch, dull white, even chalk looking appearance. A brown mottled appearance can also occur.
- It is known to inhibit several enzymes especially ***enolase*** of glycolysis .

# Iodine

- The adult human body contains about 50 mg of iodine.
- The blood plasma contains 4—8 µg of protein bound iodine (PBI) / 100 ml
- Dietary source : seafood, drinking water, iodized table salt, onions & vegetables .
- Recommended dietary allowance / day : 100-150 µg for adults .
- The most important role of iodine in the body is in the synthesis of thyroid hormone, triiodothyronine (T3) and tetraiodothyronine (T4), which influence a large number of metabolic function .
- Iodine in diet absorbed rapidly in the form of iodide from small intestine .
- Normally, about 1/3 of dietary iodide is taken up by the thyroid gland, a little by the mammary and salivary gland. The rest is excreted by the kidneys.

# Iodine

- Nearly 70—80% of iodine is excreted by the kidneys, small amount are excreted through the bile, skin and saliva.
- Milk of lactating women also contains some iodine.
- Deficiency of iodine occurs in several regions of the world, where the iodine content of soil and therefore of plants is low.
- Deficiency of iodine in children leads to cretinism ; severe deficiency in mothers leads to intrauterine of neonatal hypothyroidism results in cretinism in their children. Cretinism is cch by mental retardation, slow body development, dwarfism and cch facial structure.
- Deficiency in adults leads to goiter; a goiter is an enlarged thyroid with decreased thyroid hormones production.

# Manganese

- The adult human body contains about 15—20 mg of manganese.
- The liver and kidney are rich in Mn.
- Mn is mainly found in the nuclei, where it gives stability to the nucleic acid structure.
- Dietary source : meat (liver and kidney ), wheat germs and nuts.
- Recommended dietary allowance : 2.5 – 5 mg / day
- Mn acts as a cofactor or activator of many enzymes such as arginase, pyruvate carboxylase, glycosyl transferase, mitochondria superoxide dismutase, decarboxylase, etc.
- Mn is required for synthesis of glycoproteins, proteoglycans, Hb, and cholesterol.
- Mn is required for the physical growth and reproductive function.
- It plays important role in the formation of connective and bony tissue.
- Mn also functions with vit. K in the formation of prothrombin .

# Manganese

- Dietary Mn is absorbed poorly from the small intestine.
- Most of the Mn is excreted rapidly in the bile and pancreatic secretion in the feces.
- Because of wide distribution of Mn in plant and animal foods, the deficiency of Mn is not known in human.
- However, in animals, Mn deficiency leads to sterility and bone deformities.

# Selenium

- Dietary source: liver, kidney, seafood are good sources of Se.
- Grains have variable content depending on the region where they are grown.
- Recommended dietary allowance: 50—200 µg / day
- Se functions as an antioxidant along with vit. E
- Se is a constituent of glutathione peroxidase. Which has a cellular antioxidant function, that protects cell membrane, against oxidative damage by H2O2 and a variety of hydroperoxides.
- Se, as a constituent of glutathione peroxidase is important in preventing lipid peroxidation and protecting cells against superoxide (O2-) and some other free redicals .
- Se also is a constituent of iodothyronine deiodinase, the enzyme that converts thyroxine to triiodothyronine .

# Selenium

- The principal dietary forms of Se selenocysteine and selenomethonine are absorbed from GIT. Se homeostasis is achieved by regulation of its excretion via urine .
- Se deficiency has been associated in some areas of China with *keshan disease,* a cardiomyopathy, that primarily affects children and women of childbearing age.
- Its most common symptoms include dizziness, loss of appetite, nausea, abnormal electrocardiograms, and congestive heart failure.
- Se toxicity ( selenosis): Excessive Se intake results in *alkali disease* , cch by loss of hair, skin lesions, liver and neuromuscular disorders that are usually fatal .


THANK YOU!