Minerals

Dr. Raghad Emad Al-Deen Naji

Ph.D. Clinical Biochemistry

Objectives

- Understand the importance of the minerals in the body
- List the difference between trace and ultra-trace elements
- Classify trace elements according to the essentiality
- Outline calcium & phosphorus absorption, transport, metabolism & excretion
- State the adverse effects of excess or deficiency

Minerals

Are inorganic elemental atoms

that are ***Essential*** *nutrients*.

They are not changed by digestion or metabolism.

Functions of Minerals

1. participate with ***enzymes*** in metabolic processes (cofactors) Fe, Cu, Zn.
2. ***Structural*** functions (Ca, P in bone; S in keratin).
3. ***Acid-base*** and water balance (Na, K, Cl).
4. ***Nerve & muscle*** function (Ca, Na, K).
5. ***Blood clotting***: Ca.
6. ***Unique*** functions (Fe, Co).
7. Synthesis of ***Hormones***: thyroid hormones (iodine).

Classification of minerals

A- Macro or Major minerals

1. Present in body tissues at concentrations more than 50 mg/kg .

2. Required in amounts > 100 mg per day.

3. Ex: Calcium, Magnesium, Phosphorus, Sodium, Potassium, Sulfur

Classification of minerals

B- Micro or Trace minerals

1. Present in body tissues at concentrations less than 50 mg/kg.
2. Required in amounts < 100 mg per day)

3. Ex: Iron, Iodine, Copper, Manganese, Chloride, Zinc, Fluoride, Tin, Arsenic, Nickel…

Nutritionally Important Minerals

MACRO		TRACE	
ELEMENT	g/Kg	ELEMENT	mg/Kg
Ca	15	Fe	20-50
P	10	Zn	10-50
Mg	0.4	Cu	1-5
Na	1.6	Mo	1-4
K	2	Se	1-2
S	1.5	I	0.3-0.6
		Mn	o.2-0.5

I. Macrominerals: (are required in amounts > 100 mg per day)

#	Macro-minerals	Function	Disease/ Deficiency
1	Calcium	Component of bone and teeth, muscle contraction, gland secretion and hormone action.	osteoporosis
2	Phosphorus	Component of bone and teeth, ATP and other metabolites	General weakness
3	Magnesium	Component of bone, enzyme cofactor and ATP formation in mitochondria.	
4	[illegible]	[illegible]	
5	Sodium	Electrolyte balance, nerve and muscle regulation	Electrolyte imbalance
6	Potassium	Electrolyte balance, nerve and muscle regulation	

II. Micro- Minerals: required in amounts < 100 mg per day

#	Micro-Mineral	Function	Disease/ Deficiency
1	Iron	Heme, enzyme cofactor	Microcytic, hypo-chromic anemia
2	Iodine	Thyroid hormones	Goiter, hypothyroidism
3	Zinc	Enzyme cofactor, important for taste buds formation	Poor wound healing, loss of taste sensation
4	Copper	Enzyme cofactor, carried by ceruloplasmin	Menkes' disease Wilson's disease
5	Chromium	Present in glucose tolerance factor (GTF),necessary for the action of insulin	Diabetes mellitus and Impaired glucose tolerance test (GTT)

II. Micro- Minerals: required in amounts < 100 mg per day (Continous)

6	Selenium	Present in glutathione peroxidase enzyme in RBC's, acts as an antioxidant to get rid of cytosolic hydrogen peroxide (H_2O_2)	
7	Molybdenum	Enzyme cofactor (xanthine oxidase)	
8	Fluoride	Strengthens teeth and prevents dental caries	Dental caries
9	Cobalt	Component of vitamin B12	

Factors Affecting-Requirements

1. Physiological state.

2. Tissue storage: Bone, Liver , Specific proteins to hold and transport.

3. Form of food: organic or inorganic.

FACTORS AFFECTING-ABSORPTION

1. Amount of mineral present in the food.
2. Gastrointestinal diseases.
3. Physiological state and Tissue storage .
4. Substances in foods decrease absorption of minerals:

Oxalate, prevents absorption of calcium in spinach.

Phytate, a form of phosphorous in most plants makes phosphte poorly available.

5. Substances increase absorption of minerals:
   Vit. C, increase iron absorption.

Deficiencies and Excesses

1. Most minerals have an optimal range.

   Ca = 8.5-10.5 mg/dl, Cu = 80-150 ug/dl, Mg = 1.8-2.4 mg/dl, Ph= 2.5-4.5 mg/dl, Fe = 70- 180 ug/dl

1. Below leads to deficiency symptoms.
2. Above leads to toxicity symptoms.
3. Deficiency or toxicity symptoms May take many months to develop.
4. Time impacted by body stores.
5. Physiological state.

Calcium

- Total ca in the body about 1-1.5 Kg.
- 99% seen in the bone
- 1% in extracellular fluid
- An adult need 500 mg/day and child 1200 mg/day
- Requirement increase to 1500 mg/day during pregnancy & lactation
- After age of 50 there is a general tendency for osteoporosis , which may be prevented by increase Ca (1500 mg/day) + vit. D. (20 micro g/day)

Ca absorption

Absorption is taking place in the 1st & 2nd part of the duodenum.

Ca is absorbed against a concentration gradient & require energy.

Absorption requires a carrier protein (Calbindin), helped by Ca-dependent-ATPase

Factors increase absorption

- 1-Vit. D: calcitriol induces the synthesis of carrier protein (calbindin) in the intestinal epithelial cells, so facilitate the absorption of Ca.
- 2- PTH : increase Ca transport from intestinal cells
- 3- Acidity: favors ca absorption
- 4- amino acids: lysine & arginine increase ca absorption.

Factors decrease absorption

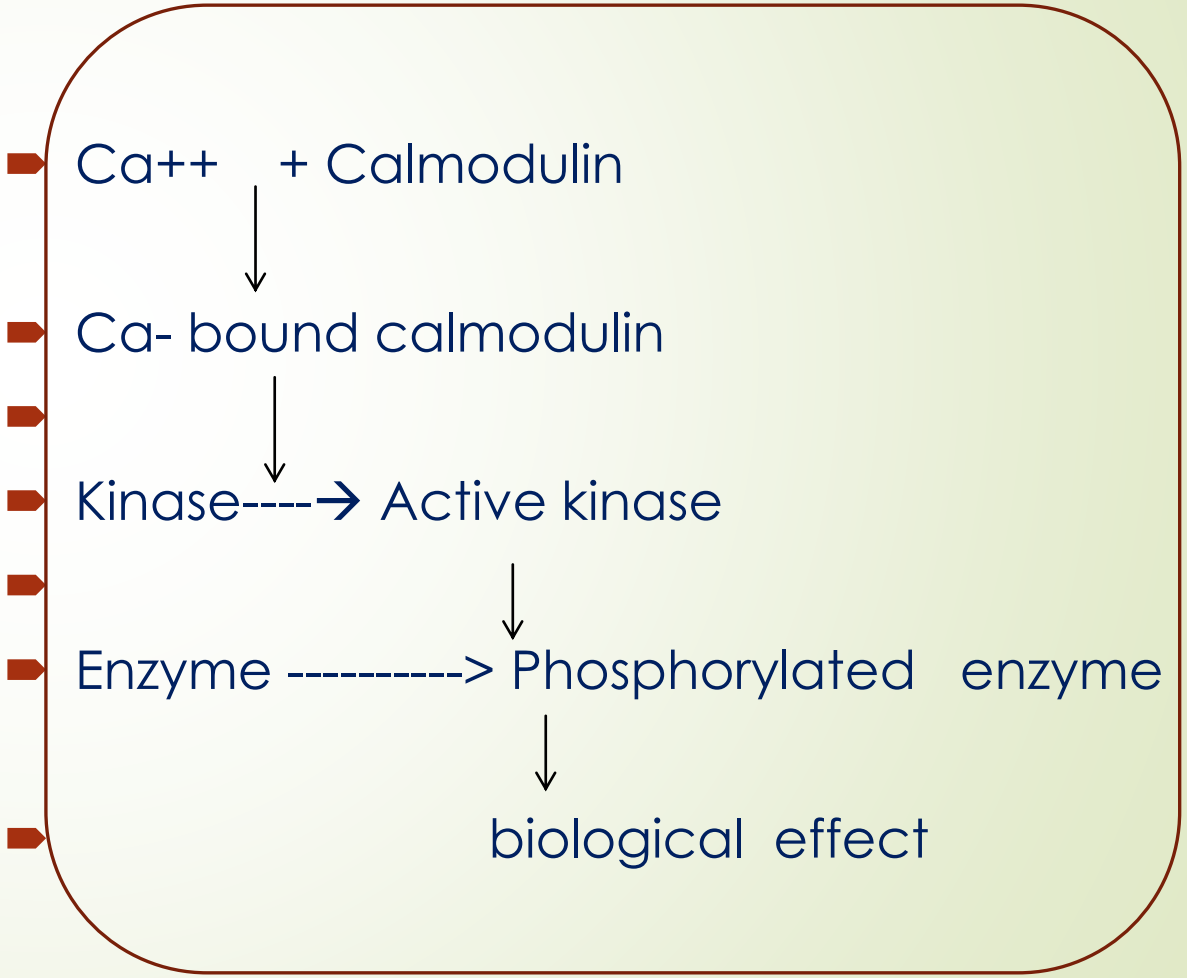
- 1- Phytic acid: present in cereals, fermentation & cooking reduce phytate.
- 2- Oxalate: present in some leafy vegetables , cause formation of insoluble calcium oxalate
- 3- malabsorption syndromes: fatty acids is not absorbed, causing formation of insoluble calcium salt of fatty acid
- 4- phosphate: high Pi content will cause precipitation of Ca-phosphate.

Ca in cells

- Ca present in extracellular & intracellular compartments, but mainly extracellular.
- The cell membrane is generally impermeable to Ca ion.
- Ca influx into the cell is by Na+/Ca++ exchange mechanism. This mechanism is rapid but has low affinity for Ca.
- Entry of Ca++ into mitochondria is by Ca uniport system .
- But Ca ions exit by Na+ /Ca++ antiport system, which in turn depend on Na+ /H+/ATPase pump.

Functions of Ca

- 1- activation of enzymes:
- Calmodulin is Ca binding regulatory protein, can bind with 4 Ca ions.
- This binding leads to activations of enzymes.
- Calmodulin is part of various regulatory kinases



Functions of Ca

- 2- Muscles : Ca mediates ***excitation &***
- ***contraction*** of muscle fibers.
- Ca is released from sarcoplasmic reticulum.
- Ca activates ATPase, increase action of actin & myosin and facilitates excitation-contraction coupling.
- Ca decreases neuromuscular irritability, and its deficiency causes tetany.

Functions of Ca

- 3- Nerve conduction.
- 4-Secretion of hormones.
- 5- Second messenger.
- 6- Vascular permeability.
- 7- Coagulation.
- 8- Myocardium.
- 9- Bone & Teeth.

Ca in Blood

- 1- Normal level = 9—11 mg/dl (10 mg/dl 0f Ca++ = 5 mEq/L).
- 2- Ionized Ca : about 5 mg/dl of Ca in ionized form and metabolically active . Another 1 mg/dl is complexed with phosphate, bicarbonate & citrate.
- These 2 forms are diffusible from blood to tissues.
- 3- Protein bound Ca: about 4 mg/dl is bound to proteins and is non-diffusible.

Factors regulating blood ca level

- 1- *Vit. D. (Calcitriol)* : increase absorption
- 2- *PTH* : causes demineralization & decalcification.
- 3- *Calcitonin* : released from thyroid gland , decrease blood Ca level.
- 4- Phosphorus .
- 5- Children .
- 6- Serum protein.
- 7- Alkalosis & acidosis.
- 8- Kidney threshold .


THANK YOU!