CALCIUM, PHOSPHORUS AND MAGNESIUM

CALCIUM

A total of approximately 1-1.5kg of body weight is made up of calcium where 99% is found in the bones and teeth and remaining 1% is in the ECF and other compartments. Ca^{2+} exists as carbonates or phosphates of calcium within the body, while in the plasma they exist in either the ionized form(which is the physiologically active form), bound to plasma proteins(mainly albumin) or complexes with organic acids, all these forms being in equilibrium with each other.

SOURCES; milk and other dairy products (cheese etc), egg yolk, bone meal, cabbage, nuts, figs etc

ABSORBTION; dietary Ca^{2+} is absorbed mainly from the duodenum and first half of the jejunum under the influence of a carrier protein CALBINDIN – a calcium dependent ATPase against an electrical and concentration gradient. Absorption is affected by certain factors including;

1. Vitamin D- presence of vitamin D in the gut promotes calcium absorption.
2. PH-acidity increases the absorption of calcium salts which are more soluble in these condition, while in alkaline medium decreases absorption by causes the formation of insoluble salts of calcium.
3. Composition of diet-a high protein diet (amino acids particularly Lysine and Arginnine) and organic acids e.g. citric acid increases the solubility of Ca^{2+} salts, fatty acids on the other hand cause formation of insoluble Ca^{2+} salts thereby decreasing Ca^{2+} absorption.
4. Parathyroid hormone through its stimulation of 1, α-hydroxylase which increases the production of Calcitriol (1, 25-$(OH)_2$-D_3), the active form of vitamin D, increases calcium absorption.
5. Calcitonin decreases the absorption of Ca^{2+}
6. Glucocorticoids diminish intestinal transport of Ca^{2+} hence its absorption.
7. Phytic and oxalic acids- presence of phytates and oxalates especially in cereals (phytates) and vegetables (oxalates) cause the formation of insoluble calcium salts which are excreted in feces and decrease Ca^{2+} absorption.
8. Presence of other minerals such as phosphates, phosphorus, iron and magnesium decrease Ca^{2+} absorption.

FUNCTIONS

1. Ca^{2+} is involved in calcification or mineralization of bones and teeth.
2. Also involved in coagulation of blood as factor IV causing the chelating of prothrombin to form thrombin in the clotting cascade.

3. Plays a role in neuromuscular transmission of impulses particularly at the pre and post synaptic junctions.
4. It is actively involved in muscle contraction and relaxation that produces body movement.
5. It in addition regulates microfilament mediated processes such as degranulation,cell motility etc
6. It activates regulatory kinases with or sometimes without binding to the regulatory protein Calmodulin.
7. It is needed for the excitability of nerves.
8. It plays a role in permeability of gap junctions
9. It acts as a secondary and tertiary messenger in signal transduction and hormone action
10. It mediates secretion of hormones
11. It's involved in systolic myocardial contraction and general excitability of heart.
12. Affects (decreases) vascular permeability hence reduces allergic exudates.

REGULATION AND EXCRETION

Levels of calcium in the body and particularly in the blood are strictly regulated by vitamin D-Calcitriol,and hormones such as Parathyroid hormone and Calcitonin. Excess Ca^{2+} is normally excreted in urine with little amounts also excreted in stool.

Calcitriol increases blood levels of calcium by increasing its absorption from the intestine while parathyroid hormone which is secreted by the parathyroid gland acts at three principal sites- the bones, kidneys and intestines also to increase blood levels of Ca^{2+} the hormone causes demineralization of bone leading to the release Ca^{2+} into blood, increased absorption of Ca^{2+} from the intestines and reabsorption of the filtered ions from the glomerular filtrate at the kidneys.

Calcitonin is a peptide hormone secreted by the thyroid gland, it decreases blood Ca^{2+} concentration by inhibiting the resorbtion of bone having an opposite effect to parathyroid hormone together with which it causes remodeling of bone to achieve proper bone growth and development. Secretion and activities of these two hormones that regulate calcium blood conc. is under feedback regulation depending on the levels of blood Ca^{2+} and this influences quantity excreted.

Other factors that may influence blood Ca^{2+} conc. includes levels of Phosphorus ion which decreases Ca(Ca and P ions have almost completely reciprocal relationships with respect to regulation and excretion from the body),pregnancy which places greater demands on blood Ca hence reduce total amount in blood, presence and absence of serum proteins, Ph of the blood with alkalosis decreasing Ca blood level through its facilitation of complexing of Ca with organic compounds in the blood.

PHOPHORUS

P levels in the body represent about 1kg of total body eight with 80% of this quantity found in the bones and teeth and about 10% in the muscles is found mainly intracellular, it occurs in either the organic (nucleic acids, phospholipids etc) or inorganic form.

SOURCES;milk,cereals, nuts, meat etc

Absorption; asorption is mainly from the jejunum and is influenced by Calcitriol which increases it. P in blood is mainly protein bound the skeleton is the major reservoir of P.

FUNCTIONS.

1. It is involved in the formation of bones and teeth .
2. It is an energy source as high energy phosphate bonds in ATP and other high energy compounds (CTP,GTP and CP) that maintain muscle contractility, neurological functions, electrolyte transport etc
3. It is a constituent of cyclic adenine and guanine nucleotides,cGMP,cAMP .
4. Composition of nucleoside coenzymes e.g. NAD,NADP
5. Involved in DNA and RNA synthesis
6. Forms physiologically important phosphate esters such as Phospholipids, Phosphoproteins , Glucose-6-phophate,Nucleic acids etc.
7. It also helps to maintain the critical intracellular concentration and provides substrate for bone mineralization.
8. It is also the source of the phosphate buffer system of the blood.
9. It helps in the activation of some enzymes by phosphorylation and is involved in the activities of several enzyme systems e.g. adenylate cyclase and 1, α-25-hydroxy vitamin D-hydroxylase.

REGULATION

Serum levels of P depends on levels from diet and on its excretion and reaborbtion from the kidney tubules which is under the influence of parathyroid hormone and calcitonin.

MAGNESIUM

This is the fourth most abundant cation in the body of animals and is second to potassium inside the cell. 60% of the body Mg is located in bones, 20% in skeletal muscles, 19% in other cells and 1% in ECF. It is an alkaline earth metal distinct from other transition elements in that it interacts with other chemical species with a stronger electrostatic bonding component and prefers oxygen to N atoms.

SOURCES; vegetables, cereals, nuts, beans, Bone Meal, dairy products etc.

20-30% of ingested Mg is absorbed from the small intestine, and this is influenced by malabsorbtion syndromes and other factors that affect passage of food. Other minerals such as Ca and Phosphates also decrease Mg absorption, while presence of proteins, lactose and vitamin D increases Mg absorption.

FUNCTIONS

1. It chelates important intracellular anionic ligands especially ATP. (Convert adenosine triphosphate (ATP) to adenosine pyrophosphoric acid (ADP), with the subsequent release of energy.)

2. It catalyses and activates more than 300 enzymes-being an essential cofactor for enzymes concerned with respiration,glycolysis and transmembrane transport of other cations e.g. Na and Ca. Mg affects enzyme activity by binding to the active sites of enzymes, ligand binding or induction of conformational changes during catalytic process as well as promotion of aggregation of multiple enzyme complexes

3. It helps to maintain low resting concentration of intracellular calcium by competing with Ca for binding sites on proteins (troponin molecule found at regular intervals along actin filaments) and membranes hence sequestering Ca into the sarcoplasmic reticulum. Magnesium acts to relax muscles after calcium stimulates contraction

4. It helps maintain normal muscle and nerve function.

5. Mg is known to play a crucial role in the maintenance of cell integrity such that deficiencies of Mg lead to development of cancer. Glutathione requires magnesium for its synthesis. Low magnesium is associated with dramatic increases in free radical generation without the cleaning and chelating work of glutathione (magnesium), cells begin to decay as cellular filth and heavy metals accumulate.

6. Magnesium has an effect on a variety of cell membranes through a process involving calcium channels and ion transport mechanisms. Magnesium is responsible for the maintenance of the trans-membrane gradients of sodium and potassium.

   The major excretory pathway for Mg is through the kidneys, but60-80% orally taken Mg is lost through feces while up to 0.75mEq/l is lost through sweat.

   Deficiency of Mg manifests as impairment of neuromuscular functions such as hyperirritability, tetany, convulsions and electrocardiographic changes. In cattle an endemic disease called grass staggers or grass tetany characterized by restlessness and convulsions followed by death frequently occurs.