Review Article

Calcium and its Role in Human Body

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ABSTRACT

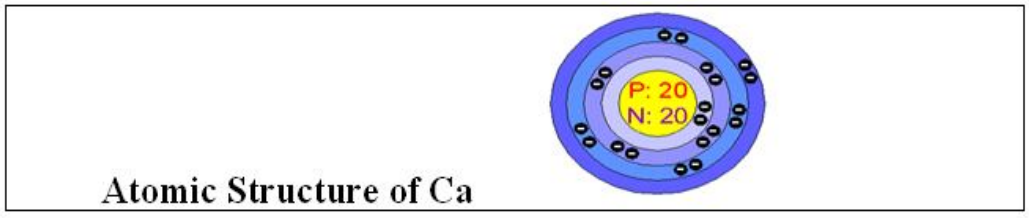
Calcium is very essential in muscle contraction, oocyte activation, building strong bones and teeth, blood clotting, nerve impulse, transmission, regulating heart beat and fluid balance within cells. The requirements are greatest during the period of growth such as childhood, during pregnancy, when breast feeding. Long term of calcium deficiency can lead to oestoporosis in which the bone deteriorates and there is an increased rise of fractures. Eating a well-balanced diet can provide all the necessary nutrients and help prevent calcium deficiency.

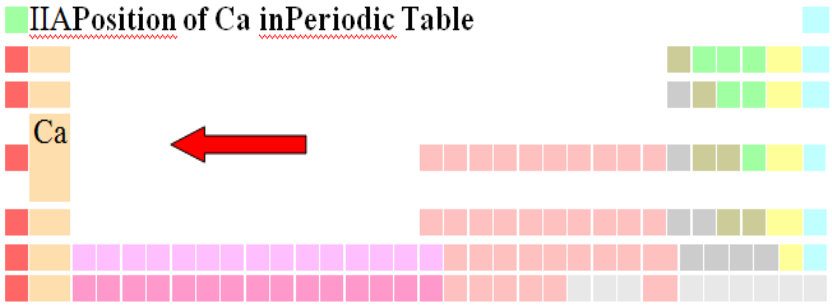
Key Words: Calcium, Oesteoporosis, Hypo and Hypercalcaemia, Parathyroid glands.

INTRODUCTION

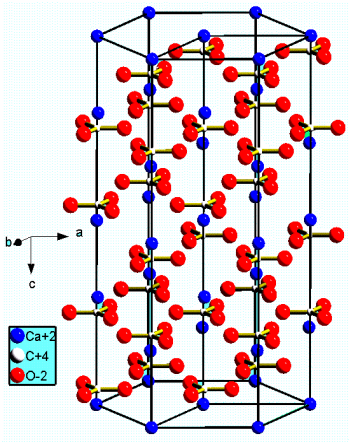
The group IIA of the periodic table contains the alkaline earth metals such as Ca, St, Ba and Ra. All the non metallic substances are insoluble in water and unchanged by five were called earths. Limes and magnesia showed alkaline reactions hence alkaline earths.

The name calcium is derived from latin word calas meaning lime was known as early as the first centuries when the ancient Romans prepared lime as CaO. It was not actually isolated until 1808 in England when Sir Humphrey Davy electrolyzed a mixture of lime and mercuric oxide. Davy was trying to isolate calcium along with magnesium, strontium and barium.Out of alkaline earth group, Ca has achieved the greatest use and tonnage.





Calcium ranks fifth in the order of abundance of elements in earth's crust, the percentage being estimated at 3.64. Calcium does not occur free in nature being an active element.It occurs largely in the form of carbomates and sulphates. As carbonates, it occurs in the form of lime stone, chalk, calcite, marble, Iceland spar, dolomite, stalactite, stalagmite etc. and sulphate, it occurs in the form of Gypsum and its anhydride form calcium also occurs as a phosphate in the phosphorite rock. $CaSiO_3$ in many complex rocks, fluoride in the form of fluorspar (Caf_2).



Properties

The tensile property of calcium metal are greatly affected by impurities and in the pure form by the methods of fabrication. Calcium metal work upon mechanical possessing. Bulk calcium is soft, crystalline metal. It may be readily extruded on heating to 420 – 460^{0}C. X-ray diffraction pattern of calcium samples exists in only two allotropic form – face centered cubic and Body centered cubic (464^{0}C). According to Debye-Scherer, Ca exists in three allotropic modifications i.e. α-Ca-face centered cubic, β-Ca-hexagonal close packed and γ-Ca-body centered cubic. It readily forms a white coating of nitrite in air, reacts with water by forming $Ca(OH)_2$, burns with a yellow red flame forming the largely the nitride. They are malleable, extrudable and machinable may be in rods, wires or plates. Calcium is cheapest of alkaline earth metals but more expensive than Sodium. Ca metal itself comates even in metallurgical work with some of its own compounds e.g. calcium silicide, calcium boride, calcium carbide, all of which are used as degasifiers, reductants and sources of calcium for alloys.

Isotopes

Calcium has four stable isotopes ^{40}Ca, ^{42}Ca, ^{46}Ca and ^{48}Ca that have such long half lives that for all practical purposes. They can be considered stable. It has also cosmogenic isotope radioactive ^{41}Ca which has a half life of 1,03,000 yrs. ^{41}Ca is produced by neutron activation of ^{40}Ca. It has received much attention in stellar studies because it decays to ^{41}K, a critical indicator of solar system anomalies. 97% of naturally occurring Ca is in the form of ^{40}Ca which is one of the daughter product of ^{40}K decay along with ^{40}Ar. While K-Ar dating has been used extensively in the geological sciences.

Proportions

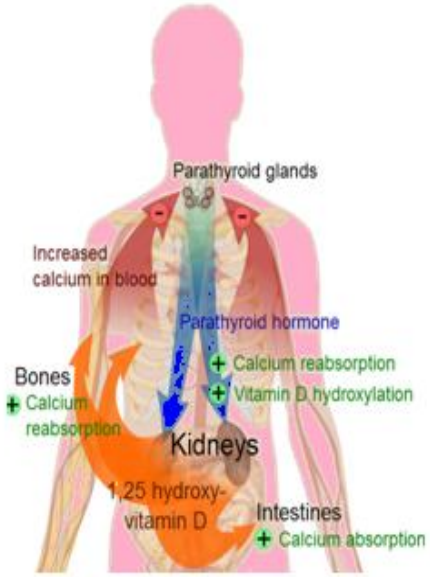
The body contains about 2% of Ca and 98% of this is in the bones. The cell and body fluid contains from 10 – 15 mg per 100 gm. The blood Ca is in two distinct forms, a part is bound with protein and is non diffusible while the diffusible moiety is found as undissociated phosphates and carbonates and as ionic calcium. The protein bound Ca does not diffuse. Out of the blood, the cerebrospinal fluid contains only 6 mg per 100 gm. The Ca in the blood and tissues and that in the skeleton are in equilibrium. The Ca of the bone can be drawn upon to make up deficiency of blood Ca and when the deficit is made up the Ca is redeposited in the bone. The medication of parathyroid is necessary for the withdrawal of Ca from the skeleton. In the body, there is a balance in various forms of Ca. The ionic forms of Ca is involved in the various physiological activities.

Physiological role

Daily body requirement is about 450 mg. The adult requirements of Ca vary. During pregnancy and lactation, there is greater depletion of Ca from the mother and the intake needs to be increased. On an average, 10 mg per Kg of body weight per day should be sufficient. Growing children would require from 40 to 60 mg per day. A Cow's milk contains 0.126% of Ca. A litre of Cow's milk provides therefore a full day's ration of Ca is readily assimilable form. Generally sufficient Ca gets ingested through the normal through the normal diet. It gets from upper intestinal tract and is excrete through urine and faeces. As the upper portion of intestine the condition is acidic, it tends to favour absorption of Ca. As Ca salts have better solubility. The alkaline condition brings about the precipitation of Ca salts and the absorption is retarded. Higher fatty acid contents also decreases the absorption due to formation of Ca salts of fatty acid which are insoluble.

Calcium is essential to maintaining total body health. Your body needs it every day not just to keep your bones and teeth strong over your life time but to ensure proper functioning of muscles and nerves. It even helps your blood clot. Many peoples think they are getting enough Ca every day but the fact is, they are not so. Ca deficiency is usually due to an inadequate intake of Ca when blood Ca levels drop too low, the vital mineral is borrowed from the bones. It is returned to the

bones from Ca supplied through the diet. If an individual's diet is low in Ca, there may not be sufficient amount of Ca available in the blood to be returned to the bones to maintain strong bones and total body health. Taking Ca regularly everyday is key to preventing and treating Ca deficiency. So how much daily Ca do you need? How much do you get? It is very important to your health.



According to the U.K. Dept. of Health recommended reference nutrients intake for Ca required according to age. The infants and children require 350 - 550 mg/day.

Teenage girls and boys : 800 – 1000 mg/day

Adult men and women : 700 mg/day

The Ca play an important role to maintain some important body functions such as

i) Ca controls nerve excitability. The effect is mainly on the peripheral neuromuscular mechanism. Fibrillary twitching can be produced by per fusing a muscle with Ca free fluid. Automatic ganglia also become hyper irritable.

ii) It is necessary for the maintenance of the integrity of the skeletal muscles. An increase in the ionized Ca results in an increase in contractility and vice varsa.

iii) It is very essential for maintaining the tone and contractility of heart. Ca is antidotal to the depressant action of K.

iv) It aids rennin in the coagulation of milk in the stomach.

v) It is essential for the clotting of food.It decreases cellular permeability. It is therefore used in allergic conditions to diminish exudation which produces wheals and rushes. Ca appears to serve as a constituent of the intercellular cement.

vi) Ca take part in the formation of certain tissue and bones. Normally 25 – 35% is excreted in the urine and the rest in the stools.

A high protein diet especially derived from animal foods causes Ca loss in the body. The higher sulphur to calcium ratio of metal increases Ca excretion and a diet righ in meal can cause bone demineralization. A report published in 1988 comparing the amounts of Ca excreted in the urine showed that, the animal – protein diet cause greater loss of bone loss and hence Oestoporosis. It is the major cause of bone fractures in the elderly. It is better prevented than treated and prevention includes an adequate intake of Ca throughout life but especially in childhood and young adult hood and minimizing risk factors e.g. smoking, heavy alcohol use and lack of physical exercise. Diet high in protein and in salt also increase Ca loss from the body and may have an effect on oestoporosis. Post menopausal women are more prone to osteoporosis because they produce less oestrogen which protects the skeleton in younger women.

Calcium Deficiency

Calcium deficiency is a condition in which the body has an inadequate amount of calcium. Calcium is a mineral that is essential for many aspects of health, including the health of bones and teeth, and a normal heart rhythm. This mineral is also required for muscle contractions and relaxation, nerve and hormone function, and blood pressure regulation.

Calcium must be ingested daily and absorbed effectively in order to maintain optimal health. Most people can get enough calcium by eating a variety of foods rich in calcium. Foods that naturally contain calcium include milk and other dairy products; green, leafy vegetables; seafood, nuts, and dried beans. Calcium is also added to orange juice, breakfast cereals, breads, and other fortified food products.

High dietary calcium intake is necessary for infants, children and adolescents in order to promote bone growth and formation. Pregnant women also have higher calcium needs, because it is required for the normal development of fetal bones. In addition, women who have reached menopause need to ensure an adequate amount of calcium intake to reduce the risk of osteoporosis.

Types of calcium deficiency

There are two types of calcium deficiency

- **Dietary calcium deficiency** is a condition in which there is an inadequate calcium intake, which can lead to depleted calcium stores in the bones, thinning and weakening of the bones, and osteoporosis.

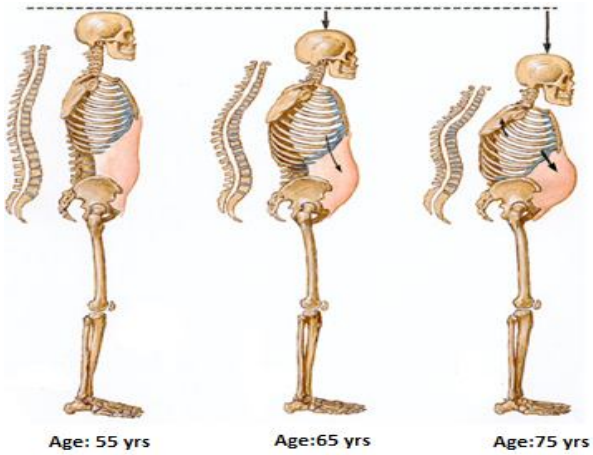
- **Hypocalcemia** is a low level of calcium in the blood. It can occur from taking medications, such as diuretics; medical treatments; or disease processes, such as renal failure or hypo-parathyroidism.

An insufficient amount of calcium in your diet will generally not cause hypocalcemia. This is because normal amounts of calcium in the blood are so critical to many vital body functions of the nerves, muscles, brain and heart, that your body will pull calcium from the bones as needed to maintain normal blood calcium levels. This enables important processes in the body to continue. However, ongoing dietary calcium deficiency can eventually lead to thinning of the bones and osteoporosis because calcium stores in the bones are not replaced as they are used by the body.

Untreated calcium deficiency can lead to serious complications, such as osteoporosis, hypertension and cardiac arrhythmias and follow your treatment plan to reduce the risk of serious complications from calcium deficiency.If you, or someone you are with, have chest pain a seizure, difficulty breathing, or an unusual change in alertness or consciousness.

Sign of Deficiency in Calcium,

All humans lose bone density starting between the ages of 30 and 40. Excessive bone loss affects over 20 million people, mostly women who are 45 and older.



Sign no.1: Muscle Cramping

One of the first signs of a deficiency is a nervous affliction called tetany, which is characterized by muscle cramps, numbness and tingling in the arms and legs.Muscle Cramping can be an early sign that you are developing a calcium deficiency. These types of cramps generally occur at night, especially in the legs

Sign no.2: Dry Skin and Brittle Nails

A common calcium deficiency sign can be seen in your skin and your nails. When your skin becomes dry and your fingernails become brittle (break easily), you could be lacking from calcium. If these symptoms are present, you may also want to check to see if your teeth are becoming yellow. The teeth and the bones can be severely affected from a lack of calcium.

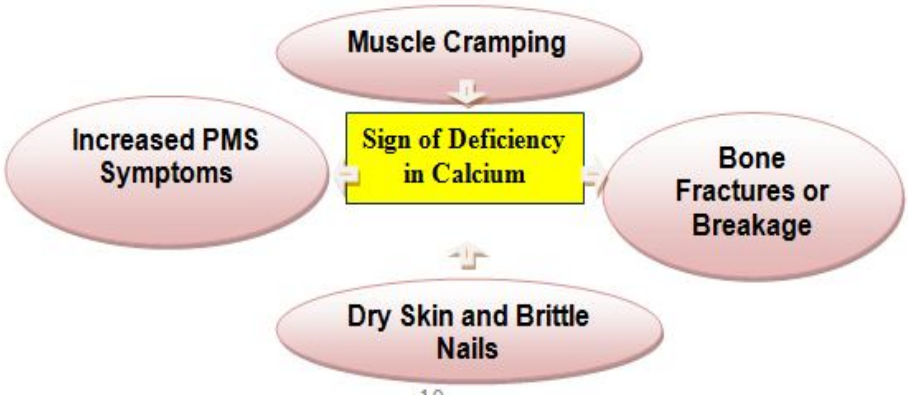
Sign no.3: Increased PMS Symptoms

A woman may begin experience more cramping or a change in her menstrual flow if she is suffering from a calcium deficiency. Adding more calcium to a diet may ease these symptoms.

Sign no.4: Bone Fractures or Breakage

If you begin to suffer from several small bone fractures or full bone breakage, you should really evaluate the amount of calcium in your diet. This is a severe symptom of calcium deficiency.

Calcium is needed to build bones and to keep them strong. Without this calcium, our bones will become weak. As they weaken, fractures and breakage can occur i.e osteoporosis, in which the bones become porous and fragile because calcium is withdrawn from the bones and other areas faster than it is deposited in them. Moderate cases of calcium deficiency may lead to cramps, joint pains, heart palpitations, increased cholesterol levels, slow pulse rates, insomnia, impaired growth, excessive irritability or nerves, muscle cramps, brittle nails, eczema and numbness of the arms and or legs.A deficiency may be due to a lack of vitamin D or abnormal concentrations of hormones that regulate the availability from the bones to the blood, not to a dietary inadequacy.



Regulators of Blood Calcium

Prompt diagnosis and treatment of dietary calcium deficiency reduces the risk of developing serious complications, such as hypertension and osteoporosis. Treatments involve replacing the body's depleted calcium stores and may include:

Calcium is the most abundant mineral in the human body and has several important functions. Calcium is the top macro mineral when it comes to your bones. This mineral helps build strong bones, so you can do everything from standing up straight to scoring that winning goal. Calcium is a primary structural constituent of the skeleton, but it is also widely distributed in soft tissue where it is involved in neuromuscular, enzymatic, hormonal, and other metabolic activity. Calcium absorption is dependent upon the calcium needs of the body, the foods eaten, and the amount of calcium in the foods eaten. Vitamin D from diet or exposure to the ultraviolet light of the sun increases calcium absorption. Calcium absorption tends to decrease with increased age for both men and women. More than 99% of total body calcium is stored in the bones and teeth where it functions to support their structure. The remaining 1% is found throughout the body in blood, muscle, and the fluid between cells. Because of its biological importance, calcium levels are carefully controlled in various compartments of the body. The three major regulators of blood calcium are parathyroid hormone (PTH), vitamin D, and calcitonin.

Disorders of calcium metabolism

It occur when the body has too little or too much calcium. The serum level of calcium is closely regulated within a fairly limited range in the human body. In a healthy physiology, extracellular calcium levels are maintained within a tight range through the actions of parathyroid hormone, vitamin D and the calcium sensing receptor. Disorders in calcium metabolism can lead to hypocalcemia, decreased plasma levels of calcium or hypercalcemia, elevated plasma calcium levels.

Hypocalcemia

Hypocalcemia is common and can occur unnoticed with no symptoms or, in severe cases, can have dramatic symptoms and be life-threatening. Hypocalcemia can be parathyroid related or Vitamin D related. Parathyroid related hypocalcemia includes post-surgical hypothyroidism, inherited hypoparathyroidism,pseudohypopara thyroidism and pseudo-pseudohypoparathyroidism. Post-surgical hypoparathyroidism is the most common form, and can be temporary (due to suppression of tissue after removal of a malfunctioning gland) or permanent, if all parathyroid tissue has been removed. Inherited hypoparathyroidism is rare and is due to a mutation in the calcium sensing receptor. Pseudohypoparathyroidism is maternally inherited and is categorized by hypocalcemia and hyperphosphatemia. Finally, pseudo-pseudohypoparathyroidism is paternally inherited. Patients display normal parathyroid hormone action in the kidney, but exhibit altered parathyroid hormone action in the bone. Vitamin D related hypocalcemia may be associated with a lack of vitamin D in the diet, a lack of sufficient UV exposure, or disturbances in renal function. Low vitamin D in the body can lead to a lack of calcium absorption and secondary hyperparathyroidism. Symptoms of hypocalcemia include numbness in fingers and toes, muscle cramps, irritability, impaired mental capacity and muscle twitching.

Hypercalcemia

Hypercalcemia is suspected to occur in approximately 1 in 500 adults in the general adult population. Like hypocalcemia, hypercalcemia can be non-severe and present with no symptoms, or it may be severe, with life-threatening symptoms. Hypercalcemia is most commonly caused by hyperparathyroidism and by malignancy, and less commonly by vitamin D intoxication, familial hypocalciuric hypercalcemia and by sarcoidosis. Hyperparathyroidism occurs most commonly in postmenopausal women. Hyperparathyroidism can

be caused by a tumor, or adenoma , in the parathyroid gland or by increased levels of parathyroid hormone due to hypocalcemia. Approximately 10% of cancer sufferers experience hypercalcemia due to malignancy. Hypercalcemia occurs most commonly in breast cancer, lymphoma, prostate cancer, thyroid cancer, lung cancer, myeloma, and colon cancer. It may be caused by secretion of parathyroid hormone-related peptide by the tumor or may be a result of direct invasion of the bone, causing calcium release. Symptoms of hypercalcemia include anorexia, nausea, vomiting, constipation, abdominal pain, lethargy, depression, confusion, polyurea, polydipsia and generalized aches and pains.

Plasma Calcium

The amount of biologically active calcium varies with the level of serum albumin, a protein to which calcium is bound, and therefore levels of *ionized calcium* are better measures than a *total calcium*; however, one can correct a *total calcium* if the albumin level is known.

- A normal *ionized calcium* is 1.12-1.45 mmol/L (4.54-5.61 mg/dL).
- A normal *total calcium* is 2.2-2.6 mmol/L (9-10.5 mg/dl).
  - Total calcium of less than 8.0 mg/dL is hypocalcaemia, with levels below 1.59 mmol/L (6 mg/dL) generally fatal.
  - Total calcium of more than 10.6 mg/dL is hypercalcaemia, with levels over 3.753 mmol/L (15.12 mg/dL) generally fatal.

Long-term calcium deficiency can lead to osteopenia, which is a loss of bone density. Osteopenia may progress into osteoporosis, a health condition where bones become weak and brittle. Most adults need from 1,000 to 1,200 milligrams of calcium every day. That need can be met when you eat a balanced diet that includes dairy products

When you don't get enough calcium over an extended period of time, you may increase your risk of osteopenia and osteoporosis, which in turn increase your risk of bone fractures. But you probably won't feel any actual symptoms of calcium deficiency, unless you have hypocalcemia (low blood calcium), which is usually due to health conditions or certain medications and treatments. The symptoms of hypocalcemia include muscle cramps, lethargy, numbness and tingling in the fingers, and problems with heart rhythm. These can all be signs of other health conditions too, so if you have them, you need to see your health care provider.

Calcium as a Natural Tranquilizer

Calcium acts as a Natural Tranquilizer. It tends to calm the nerves. When taken 20-40 minutes before bedtime it promotes a deep sleep. The production of energy and the maintenance of the immune system benefit from calcium. By lowering cholesterol, calcium is thought to be beneficial in the treatment of cardiovascular disorders. Calcium supplements up to 1500 mg have lowered blood pressure in people with or without hypertension and are thought to do so because of the condition of the smooth muscle that surrounds the blood vessels. Early supplementation may help prevent arthritis. Rheumatism may also be helped positively with calcium therapy. The hormones involved are stimulated by the concentration of calcium ions in the blood. Problems of menopause such as nervousness, irritability, insomnia and headaches have been overcome with administration of calcium, magnesium and vitamin D. Prevention of premenstrual tension and menstrual cramps has also been noticed.Absorption takes place in the duodenum and ceases in the lower part of the intestinal tract when food content becomes alkaline.

Interfering factors in absorbing Calcium

When excess amounts of fat, protein or sugar combine with calcium an insoluble compound is formed which cannot be absorbed. Insufficient vitamin D intake or excess phosphorus and magnesium hinder the absorption of calcium. Large amounts of phytic acid present in unleavened grains may also inhibit absorption by the body.Other interfering factors include lack of exercise, physical and emotional stress, excitement, depression and too rapid a flow of food through the intestinal tract.

The parathyroid glands in the neck help adjust the body's storage of calcium. If these glands are not functioning properly, accumulation may occur. Calcium needs acid for proper assimilation. If acid in some form is not present in the body, the mineral will not be dissolved and therefore cannot be used as needed by the body. Instead it may build up in tissues or joints as deposits, leading to a variety of disturbances. Drugs affecting absorption include caffeine, diuretics, fatty acids, fibre oxalates, glucocorticoids, fluoride, losec, Mylanta, protein, thyroxine.

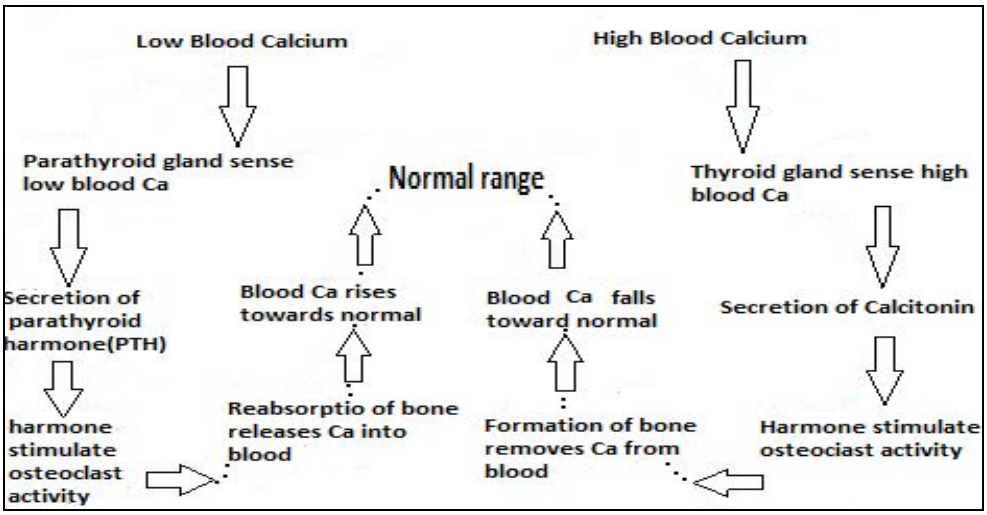
Absorption of Calcium and Harmone

Absorption depends upon the presence of adequate amounts of Vitamin D, which works with the parathyroid hormone to regulate the amount of calcium in the blood. Phosphorus is needed in the same amount but should not exceed the exact amount of calcium. The body uses them together to give firmness to the bones. If excess amounts of either mineral is taken, that excess cannot be used efficiently.Vitamins A & C are also necessary for absorption. Fat content in moderate amounts, moving slowly through the digestive tract, helps

facilitate absorption as does bile and bile salts. To function properly, Calcium must be accompanied by magnesium, phosphorus, boron and the Vitamins A,C,D, K and possibly E.

If the intake of calcium is too high, magnesium levels also need to be high. Too little magnesium results in calcium accumulations in the muscles, heart and kidneys. Too much calcium can interfere with the functions of the nervous and muscular systems. An excess amount in the blood causes calcium rigour, which is characterized by muscles that contract and cannot relax. When an excess is added to blood plasma, coagulation does not take place. Too much calcium will decrease the body's absorption of zinc and iron.

The parathyroid and thyroid glands function to control the level of blood calcium



Hormones that affect bone growth and development include those secreted by the pituitary gland, thyroid gland, parathyroid glands, and the ovaries and testes . The pituitary gland, for instance, secretes growth hormone (GH), also called somatotropin, which stimulates activity in the epiphyseal plates.

This hormone is the main regulator of height. Somatotropin plays many roles in the body: it stimulates bone and muscle growth, maintains the normal rate of protein synthesis in all body cells, and speeds the release of fats as an energy source for growth. Other hormones play a part in maintaining the strength and health of the bone matrix by functioning to control the level of blood calcium. In fact, calcium is needed for a number of metabolic processes other than for bone formation, including blood clot formation, nerve impulse conduction, and muscle cell contraction. When a low blood calcium condition exists, the parathyroid glands respond by releasing parathyroid hormone (PTH). This hormone stimulates osteoclasts to break down bone *tissue*, and as a result, calcium salts are released into the blood. On the other hand, if the blood calcium level is excessively high, the thyroid gland responds by releasing a hormone called calcitonin. Its effect is opposite that of parathyroid hormone; it inhibits osteoclast activity allowing osteoblasts to form bone tissue. As a result, the excessive calcium is stored in bone matrix. The actions of these hormones are both excellent examples of some important negative feedback loops present in our bodies. Without adequate supplies of these important chemicals, the bones will not develop or grow normally.

How to prevent deficiency of Calcium especially in Women ?

Menopausal Woman

Drop in estrogen production after menopause result in increased bone resorption, and decreased calcium absorption. Estrogen therapy works to restore postmenopausal bone remodeling levels back to those of pre-menopause, leading to a lower rate of bone loss. Estrogen appears to interact with supplemental calcium by increasing calcium absorption in the gut. However, including adequate amounts of calcium in the diet may help slow the rate of bone loss for all women.

Amenorrheic Women and the Female Athlete Triad

Amenorrhea is the condition when menstrual periods stop or fail to initiate in women who are of childbearing age. Secondary amenorrhea is the absence of three or more consecutive menstrual cycles after menarche occurs (first menstrual period). The secondary type of amenorrhea can be

induced by exercise in athletes and is referred to as "athletic amenorrhea". Potential causes of athletic amenorrhea include low body weight and low percent body fat, rapid weight loss, sudden onset of vigorous exercise, disordered eating and stress. Vitamin D helps prevent calcium loss from your bones. It is sometimes called "the sunshine vitamin" because it is made in your skin when you are exposed to sunlight. If you get outside in the sunlight every day for 15 to 30 minutes, you should get all the vitamin D you need. However, in northern locations in winter, the sunlight may be too weak to make vitamin D in the skin. Vitamin D may also be obtained from your diet or from multivitamin preparations. Most milk is fortified with vitamin D.

CONCLUSION

A good accumulation of calcium in the bones at early stages in life is the best prevention of age related bone loss and fractures. it is important for vegans to include adequate amounts of non-dairy sources of calcium in their daily diet. It is more efficient to take calcium in smaller doses several times a day and at night before bedtime, which also promotes a sound sleep. The key is prevention and prompt diagnosis. Consult your nutritionist or dietitian to plan your diet accordingly. Always take away from tannin rich beverages, to help ensure maximum absorption.

When there is not enough calcium absorbed in the body, the output of estrogen decreases. As is the case with postmenopausal women, older men are often deficient in calcium. Even it also can be encourages moderate exercise .Although dairy products are the main source of calcium in the diet, other foods also contribute to overall calcium intake. Calcium is also used in muscle contraction, blood clotting, and maintenance of cell membranes. Long-term calcium deficiency can lead to osteoporosis, in which it is remarkable that there should be so much controversy over the roles of calcium and vitamin D in human nutrition in general and in osteoporosis in particular, given that both are acknowledged to be essential nutrients. No sooner have osteomalacia and osteoporosis been satisfactorily distinguished than evidence of their overlapping aetiologies becomes apparent. Low calcium absorption may be the result of moderate vitamin D insufficiency and that high calcium excretion may be due to dietary factors (such as protein and sodium intakes) or to hormonal effects (such as estrogen deficiency). Seen in this light, the worldwide pattern of osteoporosis becomes comprehensible, but carefully targeted fieldwork - exemplified by studies on the relationship between calcium intake and bone density in the Gambia.

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