



Calcium – Needs Finest Maintenance

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Abstract

Calcium is one of the most vital elements of our body. It is mainly present as compound in the mineralized tissues and acts as reservoir and for maintenance. Calcium in its ionic form is also available in the extracellular compartments to orchestrate and sustain life activities. Calcium though regulated at multiple levels, requires a very fine maintenance near its optimal blood concentration.

Keywords:- Calcium, Plasma Calcium Level, Homeostasis, Hypercalcemia, Hypocalcemia,

Introduction

Calcium ions or its bound complexes are a key factor for various distinct life activities.^[1,2] The bone and teeth has calcium as an integral component, in the form of hydroxyapatite $[Ca_{10}(OH)_2(PO_4)_6]$ and it consists of about ninety-nine percent of total body calcium.^[3] About 1% of the skeletal calcium is available for exchange with calcium in the extracellular fluid.^[4] Plasma Calcium ion level orchestrates several human metabolic functions and an altered level of plasma calcium ion may cause distress (hypo- or hypercalcemia).^[1] Calcium requirement is regulated by a multi-factorial influence, which includes- diet, health, intestinal absorption, calcium sensing receptors, renal reabsorption, calcitropic hormones, sex hormones, and bone turnover e.t.c.^[1,2,4,5] An unclear signaling mechanism lies between the mineralized tissues and intestine, to regulate intestinal calcium absorption.^[3] A significant mineral deposition and depletion is evidenced in relation to the

physiological and pathological change in the body. The unspoken intricate mechanisms of homeostasis, maintaining a state of neutral calcium balance is achieved during the maintenance phase.^[3] The potential benefit of calcium and cholecalciferol supplement for increasing active intestinal calcium absorption, alarms a threat regarding the fear of hypercalcemia and ectopic calcification.^[6]

This brief review is in interest to discuss the diversifying role of calcium and to mention – calcium can be hazardous the same way it is beneficial.

Dietary Calcium Source, Bioavailability and RDA

All dairy products, poultries, cereals and pulses, green leafy vegetables, and sprouts are excellently good source of calcium,^[5] but its bioavailability vary considerably.^[7] Calcium content and bioavailability both are of concern when selecting a calcium source.^[5] Bioavailability is of

importance when dietary calcium intake is low.^[5] Oxalates and phytates, the chelators of plant calcium generally reduce the bioavailability by inhibition of absorption. Uronic acid has similar effect. In contrast, dietary components that enhance calcium absorption include lactose and non-digestible polysaccharides^{[5][7]}

Bioavailability is also affected by foods and drugs that affect the absorption of calcium. Fat reduces absorption of calcium and in contrast protein and phosphorous increase absorption.^[7] Long term administration of corticosteroid may lead to a deficit in calcium absorption. Osteoporosis medication (oral bisphosphonates) should be taken at least 2 hrs apart from calcium supplements to prevent interference in absorption.^[8] Phosphoric acid and phosphate available in a number commercially prepared beverages and foods jeopardize calcium absorption, as unlike calcium, phosphorus absorption is not as tightly regulated by the body. An increased blood phosphate level reduce the formation of calcitriol in the kidneys, and thereby reducing blood calcium level, leading to increased secretion of PTH which has detrimental effect on bone mass.^[5] The recommended daily intake of calcium is 1000 mg/day for adults. The requirements are higher during growth, lactation and elderly.^{[7][8]} A supplementary dose of 500-600 mg calcium/day may be required to meet the increased demand and/or to overcome deficit related to various physiological and pathological conditions. These supplements of calcium are commonly available in the form of calcium carbonate, calcium citrate or hydroxyapatite.^{[8][9]} Calcium carbonate requires acidic environment for absorption, therefore should be taken with meals. Absorption calcium citrate is not acid dependent, so can be taken at any time.^[8]

Intestinal Absorption of Calcium

Calcium is absorbed actively from the intestine and almost exclusively within the duodenum, jejunum, and ileum, as^{[7][4]} these intestinal segments have a high absorptive capacity for

calcium.^[4] The amount absorbed has direct implications for bone mass.^[7] A low intake of calcium during growth reduces bone mass, making it soft and pliable, susceptible to deformity and/or fracture.^[7] Peak Bone Mass - the point at which bones are at their highest density, is achieved by attainment of adult, and the proportion of mineral content declines after that.^{[7][8]} For women in particular, menopause is a time of more rapid bone loss, and this suggests the need for calcium supplements. Similarly, the efficacy of calcium absorption decreases in elderly, perhaps due to intestinal resistance to 1,25-dihydroxyvitamin D. This advocate the need to maintain calcium at a higher level.^{[8][10]} Calcium is absorbed from the intestinal epithelium by two routes - The paracellular pathway (between the cells) and the transcellular route (through the cell).^[4] A multi stage calcium regulatory mechanism including; calcium sensing receptors, renal re-absorption and hormones, (both calcitropic and sex hormones) lies in state of health to maintain an optimum serum calcium level and an adequate calcium reserve inside the mineralized tissues. Other factors mediating a crucial role in individuals variable Ca absorptive capacity includes - calcium intake, age, active form of vitamin D (calcitriol), dietary interactions, length of intestinal segment and the intestinal transit time.^{[4][5]}

Increased intake of sodium chloride and animal proteins may also increase urinary loss of calcium.^{[5][9]} Excessive caffeine consumption acutely increases urinary calcium loss in adults and postmenopausal women. Caffeine may also suppress calcium absorption. The adverse effect of caffeine is ameliorated by the milk.^[5] Alcohol also has adverse effect on calcium absorption.^[8] Calcium absorption was found to be varying with ethnicity. A fractional absorption was much higher in Chinese women compared to the Whites. A conclusive reason was not obvious in this regard, as to whether this shows ethnic variance or an adaptation to chronically low dietary calcium intakes.^[5]

Calcium Homeostasis and Bone Turnover

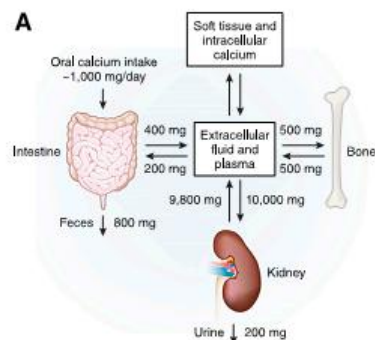


Figure A - Zero calcium balance

The intake which provides just enough absorbed calcium to meet loss is achieved in a state of health and is meant for the maintenance of exchange from the mineralized tissues and extracellular spaces. [5] The condition where the total intake equals that of excretion is called zero calcium balance. (fig-A)

Ionic calcium warrants a very close maintenance. Homeostasis is tightly regulated to ensure that plasma concentrations of calcium ions are maintained within a set range (i.e. 1.1–1.3 mmol/L). [7][5] This is controlled at three main sites: the gastrointestinal tract, the kidneys, and bones. [7]

A reduced serum calcium concentration stimulates the parathyroid hormone (PTH) to increase and maintain the serum calcium level. [9][5] PTH maintains normal circulating calcium concentration during calcium deprivation in one of three ways: [5]

- 1) It increases the production of calcitriol (1,25-dihydroxycholecalciferol), causing an increased calcium absorption in gut and tubular reabsorption in kidneys.
- 2) It increases bone resorption, releasing more calcium at the expense of skeletal mass. [5]
- 3) PTH decreases urinary excretion of calcium. It also increases urinary excretion of phosphorus encouraging conversion of vitamin D to its active form in the kidneys.

Deficiency

Inadequate intake, poor calcium absorption and excessive calcium losses contribute to reduced mineralization of bone. For example, in rickets and osteomalacia, vitamin D deficiency causes poor absorption of calcium and reduced mineralization of bone. [5] Low levels of free ionized calcium in the blood (hypocalcaemia) can also result in tetany, which is manifested by intermittent muscle contractions, muscle pain, spasms and numbness in the hands and feet. There is also evidence that implicates low plasma calcium with chronic diseases such as hypertension and colon cancer. [5] Chronic calcium deficiency due to inadequate intake or poor intestinal absorption is one of the causes of reduced bone mass and osteoporosis [9][5] Other factors causing decrease serum calcium level and bone mineral content includes inadequate exposure to sunlight and poor kidney function. [8] Calcium absorption increases with exercise and immobility accelerates loss. [7]

Potential Adverse Effects of Calcium

The amount of calcium intake and absorption are inversely proportional. [5] This self dominating inverse relationship provides a tightly regulated protective mechanism and therefore reduces the chance of calcium toxicity. [5] Calcium metabolism though tightly regulated inside the body, but an excessive dose of calcium may be detrimental. [8] Calcium supplements are usually well tolerated. [8] The use of calcium supplements at a dose of 500-600 mg /day is considered to be safe and effective. [8] Calcium supplements in a dose of 1500 mg /day or more is discouraged for causing abdominal pain and diarrhea. [7] On the other hand, it may cause abdominal bloating or constipation. [5] As a rare event, calcium supplements may cause kidney stones (nephrolithiasis) in predisposed people. [8] A positive correlation was found between occurrence of stone formation and Intestinal calcium absorption and/or negative calcium balance. [10] The other effects of excessive calcium intakes are milk-alkali syndrome and interaction

of calcium with absorption of other essential minerals such as iron, zinc, magnesium and phosphorous.^[5] Data on excessive accumulation of calcium in blood or tissues secondary to over consumption is unknown. Chances of abnormally high calcium accumulation may occur but are usually secondary to diseases e.g.; bone cancer, hyperthyroidism and hyperparathyroidism.^[5] Recently studies have suggested that, calcium supplements increases the risk of heart attack. A further study needs to be conducted with a large sample size to provide a sound report.^[8]

Conclusion

Calcium the fifth most abundant element in the body, makes up 1.9% of the body by weight.^[5] Calcium in the form hydroxyapatite provides structure and strength to the skeleton.^[5] Bones act like a calcium bank and helps in ion exchange.^{[8][5]} Calcium ions on the surface of bone interact with those in body fluids and help to maintain constant blood calcium concentration.^[5] Blood calcium plays an important role to regulate vital physiological process.^{[5][4][2][8][9]} Calcium though available in majority of our foods, is also available as supplements to meet the increased demand or deficiencies. A balanced diet supports absorption of calcium, and on the other hand imbalances in diet may have detrimental effect on the calcium.^[9] Calcium imbalances have a direct detrimental effect and therefore needs a very fine maintenance.

Research Recommendations

The following priority areas of research are recommended:

- 1) Data on calcium content of the locally available foods along with the bioavailability and recommended dose should be made available to the general population.
- 2) Recommended daily dose for the specific population and for different age group should be made available.

Interaction of calcium with meals and junk foods needs to be acknowledged.

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