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CALCIUM METABOLISM AND FEATURES OF ITS ABSORPTION IN THE BODY OF ATHLETES

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ABSTRACT

Calcium is certainly one of the most important elements of the human body. Calcium is necessary for the transmission of nerve impulses, blood clotting, secretory activity, cell differentiation and death, the implementation of the immune response, some enzymatic processes, the process of muscle contraction, etc. The concentration of calcium in the blood can vary by no more than 3% and is subject to strict control by the homeostasis system, and is also regulated by the hormonal system.

The level of calcium in the blood is regulated by two hormones, as well as calcitriol. In addition, the level of calcium in the blood can change under the influence of heavy metals. The process of calcium absorption and the processes of its removal from the body are influenced by many factors - the state of the hormonal system, the quality of food, the intensity of the training process, etc. At the same time, uncontrolled consumption of calcium by athletes entails extremely negative consequences.

KEYWORDS

Calcium, calcitriol, parathyroid hormone, calcitonin, homeostasis, hormones, muscles, transport systems.

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INTRODUCTION

Calcium is one of the most important elements of the human body. Calcium is involved in the processes of transmission of nerve impulses, blood clotting, secretory activity, cell differentiation and death, immune response, muscle contraction, etc. The concentration of calcium in the blood can vary by no more than 3%, which is the result of control of the internal environment of the body by the homeostasis system, as well as the hormonal system. The level of calcium in the blood is regulated by two hormones: calcitonin (produced by the thyroid gland, reduces the concentration of calcium in the blood by reducing bone resorption, transfers calcium ions from the blood to bone tissue, reduces the level of tubular reabsorption in the kidneys, reduces the absorption of ions in the intestines) and parathyroid hormone (on the contrary, it increases the level of calcium in the blood, acting inversely to calcitonin), as well as calcitriol (the active form of vitamin D in animal organisms, works as a signaling molecule and regulates the exchange of calcium and phosphate in the body). Calcium metabolism in the body can be represented by the following main sequential stages: absorption of calcium from the digestive tract and its entry into the bloodstream; removal of calcium from the bloodstream into tissues and its release back; excretion in urine and feces. All these processes are regulated by hormonal factors and biologically active substances. Classic hormonal regulators of calcium metabolism include parathyroid hormone, calcitriol and calcitonin. Parathyroid hormone activates the process of calcium reabsorption in the distal parts of the nephron and increases the affinity of ATPase for calcium [27]. Parathyroid hormone can induce bone resorption, thereby increasing the differentiation and activity of osteoclasts. Calcitriol has an alternative type of action necessary for the process of bone remodeling, suppressing the growth and differentiation of osteoblasts, the synthesis of collagen, osteopontin, casein kinase, and mineralization of the bone matrix. Calcitriol activates monocytes, stimulates their transformation into macrophages and osteoclasts, and the number of vitamin D receptors in these cells decreases as they differentiate and transform into osteoclasts [5,6]. Calcitonin inhibits the processes of resorption of both calcium and the protein matrix. This is manifested by a decrease in hydroxyproline excretion and calcium levels in the blood [5-7]. Calcitonin also inhibits the activity of osteoclasts and reduces their number. Already 1 hour after calcitonin administration, the formation of osteoclasts from progenitor cells decreases [61]. Other hormones can also affect calcium levels in the body. For example, prostaglandins mimic the effect of parathyroid hormone and cause bone resorption. Low doses of glucocorticoids promote

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bone growth. They inhibit the development of bone tissue only when their excess production persists for a long time [5,6,17,20,21]. Currently, the family of calcium-regulating hormones has been expanded. A new member is klotho, due to its ability to regulate intracellular Ca transport through modulation of cation channels [24]. The regulation of calcium metabolism in the intestines and kidneys is carried out by almost the same hormones and biologically active substances. For example, modulation of paracellular permeability is carried out by bacterial toxins, growth factors, cytokines, etc. It has been shown that parathyroid hormone stimulates passive calcium transport, increasing the electromotive force and thereby increasing the efficiency of intercellular transport [28].

Blood calcium levels can be affected not only by hormonal influences, but also by many heavy metals. It is known that divalent metals are capable of so-called "mimicry" - imitating the action of calcium, and even displacing calcium in some physiological processes, and using its specific transport systems to penetrate the cell [20,21,22]. Lead, cadmium, molybdenum, etc. compete with calcium for common binding sites with intestinal glycoproteins, which are necessary in the absorption process. With a massive intake of heavy metals into the body, which is observed during chronic intoxication, they use the transcellular pathway of calcium transport, load its transport systems and limit the consumption of the element, so hypocalcemia may develop. However, they displace calcium from bone tissue, so the level of calcium in the blood remains unchanged or in some cases may even increase. We have shown that under conditions of intoxication with lead, cadmium, zinc and other xenobiotics, there is a significant accumulation of heavy metals in the femurs of rats, associated with their pronounced demineralization [25,26,27]. Thus, we can conclude that no matter how diverse and important the functions of calcium are in the body, the system of maintaining its homestasis is so complexly organized. The need for such strict control is dictated by a rather narrow range of fluctuations in the concentration of calcium in the blood, which would not cause significant changes in the human body.

Total blood calcium, which is normally 2.1-2.6 mmol/l, is the sum of calcium associated with bicarbonates, lactate, citrates, phosphates, the proportion of calcium in such compounds is 7%, associated with blood plasma proteins (mainly albumin) the proportion of calcium is 46% and the ionized fraction of calcium is about 47% [1, 2]. However, the bulk of calcium is concentrated in bone tissue, which serves as a kind of buffer for calcium ions circulating in the bloodstream. Calcium is also exchanged between the bone matrix and extracellular fluid - more than 500 mmol of the mineral. There is a rapidly exchanging calcium pool of approximately 500 mmol and a slowly exchanging pool of 7-7.5 mmol [3]. The total content of the element in tissue cells can reach 10 mmol/kg. Most of it is represented by soluble ligands and cell membranes and is concentrated in intracellular depots. The volume of intracellular calcium consists of: calcium localized inside cellular organelles; chelated calcium (associated with an anion or cytoplasmic protein molecule); ionized calcium (free) [4]. Calcium metabolism in the body consists of three stages: 1) absorption from the digestive tract and its entry into the bloodstream; 2) entry from the bloodstream into the tissues of the body (and vice versa); 3) excretion in urine and feces [5]. A mature person needs 20-37.5 mmol (0.8-1.5 g) of calcium daily; in pregnant and lactating women this need is twice as high [1, 6]. The calcium requirement for athletes is higher on average by 20-25%.

Calcium metabolism is regulated by three main transport systems: intestinal absorption, renal reabsorption and metabolism in bone tissue. In the gastrointestinal tract, during the process of digestion and absorption, only half of the total calcium received is absorbed [5,7,8]. Its transport through intestinal enterocytes into the blood occurs more intensively than the transport of iron, manganese and zinc, but 50 times slower than sodium. It is believed that calcium absorption in humans and other mammals occurs mainly in the small intestine, primarily in the duodenum, where the intensity of this process per unit length is highest, although more calcium is absorbed in the jejunum and ileum due to their considerable extent . In addition, calcium absorption also occurs in the large intestine [7,8,9,10,19]. Therefore, the state of the digestive tract is important in the process of absorption of consumed calcium. Absorbed calcium enters the general bloodstream and is distributed to various tissues of the body. The bulk of calcium enters bone tissue, where it accumulates, increasing bone mineralization. Here calcium works together with phosphorus. Calcium and phosphorus are the main components of bone tissue, forming, firstly, hydroxyapatite crystals, which are deposited in the bone matrix and provide skeletal strength, and secondly, more soluble amorphous calcium phosphate, which is a labile reserve of calcium and phosphorus ions. In addition, these elements can regulate the cellular composition of bone - the ratio of osteoclasts and osteoblasts [17,18,23].

To achieve higher peak bone mass, in some sports, vitamin D (600 IU/day) is prescribed in combination with sufficient calcium (1200 mg/day), especially at a young age[9,13,15]. However, a number of studies have found that excess calcium in brain cells can lead to the formation of toxic clusters that are a hallmark of Parkinson's disease. An international team led by the University of Cambridge has found that calcium may mediate interactions between small membrane structures inside nerve endings that are important for neuronal signaling in the brain and alpha-synuclein, a protein associated with Parkinson's disease. Excess levels of calcium or alpha-synuclein can cause a chain reaction that leads to the death of brain cells. Also, some investigators have found that patients with calcium detection also had higher rates of obstructive coronary artery disease, revascularization, and/or other major adverse cardiac events in subsequent years[14,16,20].

Several studies have suggested that taking calcium supplements may help with weight loss. This hypothesis has gained some currency and was based on the idea that high calcium intake may reduce calcium concentrations in fat cells, reducing the production of parathyroid hormone and the active form of vitamin D. Reducing intracellular calcium concentrations, in turn, may increase fat breakdown and inhibit fat accumulation in these cells. Also, calcium from food or supplements, according to some hypotheses, may bind small amounts of dietary fat in the digestive tract and interfere with the absorption of this fat [17,23,24,25,26,27]. Dairy products, for example, may contain additional components that have an even greater effect on body weight, regardless of their calcium concentration. Protein and other components of dairy products can modulate hormones that regulate appetite and thus indirectly influence weight. A 2014 study of 15 healthy young men found that diets high in milk or cheese (providing a total of 1,700 mg/day calcium) significantly increased fecal fat excretion compared to a control diet that provided 500 mg calcium/day. day. However, results from clinical trials that examined the effects of calcium on body weight were largely negative. For example, a 1500 mg/day supplement was studied among 340 overweight or obese adults with mean baseline calcium intakes of 878 mg/day (treatment group) and 887 mg/day (placebo group). Compared with placebo, calcium supplementation for 2 years had no clinically significant effect on weight.

The removal of calcium from the body is ensured mainly by its secretion from the blood into the intestinal lumen and subsequent removal with excrement, which accounts for 70-80%. However, the kidneys also play an important role in calcium excretion. In humans, about 240 mmol of calcium per day is filtered in the kidneys, 97-99% of the filtered calcium (about 234 mmol) is reabsorbed by tubular epithelial cells, and only 6 mmol is excreted in the urine [9,10,11,12,24].

Calcium absorption depends on vitamin D intake and status [17]. The efficiency of absorption is related to the physiological requirements for calcium and depends on the dosage. Dietary calcium absorption inhibitors include substances that form complexes in the intestine. Protein and sodium may also alter calcium bioavailability, as high calcium levels increase urinary excretion. Although the amount absorbed in the intestine is increased, the net result may be a decrease in the proportion of calcium directly used by the body [22,28,29]. The absorption, as well as the processes of calcium excretion in the body, depend to some extent on other food components. For example:

Caffeine may increase urinary calcium loss and decrease calcium absorption. However, the effects of caffeine remain relatively modest, and this effect was primarily noted in women with insufficient calcium intake during menopause.

Lactose – promotes calcium absorption.

Magnesium – Moderate to severe magnesium deficiency can lead to hypocalcemia. However, according to some studies in which magnesium was artificially removed from the diet, it was found that even a small decrease in the amount of magnesium consumed can lead to quite a serious decrease in serum calcium concentrations.

Oxalic acid can also interfere with calcium absorption. Foods rich in oxalic acid include spinach, sweet potatoes, rhubarb and beans.

Phytic acid. May interfere with calcium absorption. Found in unleavened bread, raw beans, nuts, grains and soy products.

Protein - there is an opinion that dietary protein can lead to increased excretion of calcium in the urine, but this issue is still being studied by scientists and there is no clear answer yet.

Sodium. Moderate and increased consumption of sodium chloride (salt) leads to an increase in the amount of calcium excreted from the body in the urine. However, there are no published recommended calcium intakes based on salt intake.

Zinc. Since calcium and zinc are absorbed in the same part of the intestine, they can mutually influence the metabolic process. Large doses of zinc consumed may interfere with absorption.

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