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Calcium, adolescence and puberty

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Abstract

Adolescence is a phase of life characterized by major physical, emotional, social, and cultural changes. In this period, the puberty process stands out, and due to the action of several hormones, great changes are observed in body structure. For all these changes to occur, it is necessary for adolescents to consume nutrients in sufficient quantity and quality to meet the body's demands. One of the most important micronutrients at this stage of life is calcium, involved in several metabolic and structural processes, and which must be ingested daily through an adequate diet. This article discusses the role of calcium in adolescent growth and development, considering metabolic and clinical characteristics, highlighting the importance of this micronutrient for the current and future health of adolescents.

Keywords: Calcium; Adolescence; Puberty; Bone tissue; Growth

1. Introduction

Adolescence is a phase of life characterized by major physical, emotional, social, and cultural changes that human being go through, chronologically determined during the second decade of life. In this period, the puberty process stands out, that is, the development of secondary sexual characteristics that, which may start at the end of childhood, is completed around 16 and 18 years of age among girls and boys, respectively. Even during puberty and due to the action of several hormones, mainly testosterone, great changes are observed in body structure, in size and composition, since adolescents manage to gain between 15% and 20% of their final height (due to an increase in growth speed equal to 9 cm/year for girls and 10.5 cm/year for boys), 45% of the skeletal mass and about 50% of the adult weight, which demands the ingestion of macronutrients and micronutrients in adequate amounts for the good evolution of these process [1].

2. Bone tissue

The human skeleton at the end of adolescence is made up of 206 bones and represents about 15% of body weight. Bones are structures made up of 50% to 70% hydroxyapatite - Ca10 (PO4)6(OH), 30% organic matrix and 10% cells (osteocytes, osteoblasts, and osteoclasts). In addition to being the fundamental elements of the skeleton, bones serve as the largest reservoir of calcium (Ca) to maintain the homeostasis of the extracellular compartment, transferring ions to the blood when the serum concentration of this element decreases [2].

Bone is a multifunctional, dynamic, metabolically active tissue that grows first in width and length and then in density, and which continuously undergoes a remodeling process that alternates resorption and accretion thanks to the actions of osteoblasts (which synthesize and mineralize the matrix). Protein, promoting longitudinal bone growth) and osteoclasts (which promote bone resorption by dissolving minerals and returning calcium and phosphorus to the

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extracellular fluid) that act by increasing the diameter of long bones. The organic matrix of bone contains 90% to 95% collagen fibers and ground substance (gelatinous) and proteoglycans (chondroitin sulfate and hyaluronic acid), while bone salts are composed of hydroxyapatite and magnesium, sodium, potassium, and carbonate ions [3].

Bone mineralization begins in the first weeks of life and stabilizes around 25 years of age, while remodeling is more intense in the second decade of life. During adolescence, approximately 300 mg/day of calcium are deposited, and adolescents incorporate approximately 40% of their bone mass, accumulating, by the end of this period, 80% of their final bone mass. The greatest intensity of accretion occurs about 6 months after peak growth velocity, during the pubertal spurt, and continues until the final height is reached. In girls, this phenomenon occurs about a year before menarche [4]. Between 45% and 50% of adult skeletal mass is formed during adolescence and during puberty bones change their mineral density, geometry, and architecture [5].

Peak adolescent height growth precedes peak bone mineral content velocity by 1 to 2 years. The calcium content in the body varies with the height of the individual, with 25% of peak bone mass being acquired during the 2 years around peak growth velocity, that is, 12.5 years for girls and 14 years. For boys, this process is influenced by the interaction of several factors: genetic, hormonal, nutrition, physical activity. Women have about 30% more Ca than men [6].

3. Calcium absorption and metabolism

As it is not produced endogenously, calcium must be obtained from the diet. Its absorption is controlled by physiological needs and can occur passively (in the ileum and when there is a large amount of calcium ingested) or actively (depending on the participation of vitamin A and specific intestinal receptors, occurring more at the level of the duodenum and jejunum). In addition to vitamin D, the amount acquired by the diet, intestinal transit time, parathyroid hormone (PTH), triiodothyronine (T3), thyroxine (T4), growth hormone (GH), prolactin, fibroblast growth factor 23 (FGF 23) and estrogens [7] are fundamental to the calcium absorption process [8].

Of all the calcium ingested in the diet, about 35% is bioavailable, that is, it will be absorbed. Some factors can help the absorption process that increases in the most demanding phases of the body such as pregnancy, lactation, and adolescence, such as acidic pH, presence of lactose, casein, galacto-oligosaccharides (GOS) and trans GOS in the diet.

On the other hand, there are factors that can compromise calcium absorption, such as: phytic acid (spinach, Swiss chard, beet leaves, rhubarb); oxalic acid; oxalates; tannins; caffeine, phosphoric acid (soft drinks); polyphenols; some drugs (neomycin, phenytoin, phenobarbital, primidone, prednisone, methotrexate), antacids, and glucocorticoids. Excessive sugar increases urinary calcium excretion [4]. Hormonal contraceptives can decrease accretion and reduce bone mineral density due to changes in estrogen and IGF1 concentrations [5].

Socially accepted drugs such as nicotine and alcohol, which are part of the universe of adolescents, interfere with the body's use of calcium. Nicotine inhibits the production of osteoblasts. Alcohol, acting on the liver, promotes metabolic changes that compromise the activation and bioavailability of micronutrients. Acute ingestion of alcohol causes an increase in plasma calcitonin. Chronically, it interferes with vitamin D absorption and intestinal calcium absorption [9].

In plasma calcium is 40% bound to albumin, 50% in the ionized form responsible for various intra and extracellular physiological functions and 10% forming complexes with phosphate, citrate and bicarbonate [10].

Several elements such as vitamin D, PTH, FGF factor 23, insulin like growth factor-1 (IGF1), prolactin, calcitonin, and phosphorus, among others, play an active role in maintaining adequate circulating calcium levels. Metabolism involving three main organs: intestine, kidney, and bone [11]. PTH stimulates bone resorption by releasing calcium into the plasma; promotes activation of vitamin D which, in turn, increases intestinal reabsorption; increases the reabsorption of calcium in the distal renal tubules, decreasing the renal exception of Ca. Vitamin D acts in synergism with PTH, increasing calcium absorption through active transport in the GI tract and decreasing renal Ca and P excretion. Calcitonin tends to decrease plasma Ca concentration (opposite effects to PTH), decreases bone resorption, and increases urinary excretion, that is, it blocks the release of calcium from bone and decreases intestinal Ca absorption, while phosphorus inhibits intestinal Ca absorption.

When the concentration of calcium in the extracellular fluid (ECF) decreases, the parathyroid glands are stimulated to release PTH which, acting at the bone level, promotes the release of calcium salts into the plasma. Furthermore, there is activation of vitamin D with consequent increase in intestinal reabsorption and decrease in renal calcium excretion [2]. On the other hand, when the concentration of Ca in the ECF increases, PTH decreases, and Ca deposition occurs in bones [12].

Ca excretion occurs mainly through the digestive (90%) and urinary (10%) pathways. The high concentrations of magnesium and potassium found in vegetables and fruits help to reduce urinary calcium losses, which makes magnesium one of the most important adjuvants in bone mineralization, as 1/3 of the body's magnesium is in the bones [13].

4. Adolescent and Ca intake

During adolescence, calcium needs reach 1300 mg/day, which can be obtained from a diet rich in milk and dairy products, vegetables (broccoli, cabbage, spinach, watercress, soy, chickpeas, chia, oats, flaxseed, almonds), sardines and seafood [14-16].

Despite the great importance of calcium during the process of growth and pubertal development, adolescents in many regions of the world have shown a low intake of this mineral. Among Spanish adolescents Romero-Marco P et al [17] found mean levels of calcium intake around 640 mg/day. Similar results were reported by Palacios C et al [18] in a review study, highlighting several countries such as Brazil, Colombia, Canada, China, Italy, Japan, Malaysia, and Mexico, where adolescents also ingested lower daily amounts of calcium than recommended.

As a consequence of low Ca intake, adolescents may have acute repercussions with metabolic and chronic changes such as bone fragility, fractures, osteoporosis [14,19].

In view of their physical and emotional characteristics, adolescents can be considered at nutritional risk due to some factors such as [20-24]:

- your dietary practices are usually inappropriate
- restrict food groups such as milk and dairy products
- they prefer foods that are high in energy, processed and with strong flavors
- stay away from home for a long time, eat what is affordable or within your budget
- change the composition of meals, replacing them with quick snacks
- consume large amounts of soft drinks and nutritional supplements
- practice few physical activities
- are very interested in alternative diets
- omitting food, especially breakfast

Adolescence is a time of great importance for the prevention of chronic diseases in adulthood. Therefore, whether to maintain current good health conditions or to prevent diseases throughout life, it is recommended that adolescents consume a correct diet with adequate amounts of calcium and vitamin D. In addition, associated measures such as control weight, regular physical activity and avoiding alcohol consumption and smoking should be part of the daily life of adolescents who want to stay healthy [25].

In some special situations, calcium supplementation may be necessary, with the use of compounds such as Ca carbonate (contains 40% elemental Ca), Ca citrate (contains 21% elemental Ca), phosphate, lactate, or aspartate, of according to medical prescription and adequate clinical follow-up.

Also, due to increase the supply of calcium in the diet, it is possible to find several fortified foods such as flour (wheat flour), maize, corn meal, rice [25-28].

5. Conclusion

Although the importance of calcium for adolescent bone growth and development is widely documented, it is observed that the intake of this micronutrient is still neglected during the early stages of life, with implications for bone mineral density. Whereas osteoporosis is a global health problem that is reported to originate during childhood and adolescence, increased bone mass accumulation in the second decade of life is fundamental to prevent problems in older age.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest.

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