Review Article

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Calcium: Nutrient in Adolescent Girls

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Abstract

Bone health is important to health and quality of life. It is important to optimize bone health throughout life cycle. Adolescence is a transitional journey from childhood to adult life along with physical development. This may be considered as physical, psychological and emotional rebirth. Nutrition in adolescence has preventive role related to diet causing chronic diseases like cardiovascular disease, cancer and osteoporosis. Diet and physical factors play a major role in promoting bone health, which begins in childhood and continues into old age. Calcium and protein in the diet with sunlight exposure and weight bearing exercises are important for building the peak bone mass in adolescents. Calcium as nutrient in adolescence is critical for prevention of osteoporosis and improving quality of life.

Keywords: Adolescence; Calcium; Vitamin D; Osteoporosis; Peak Bone Mass (PBM).

Introduction

Adolescence is a transitional journey from childhood to adult life along with physical development and sexual maturation. This may be considered as physical, psychological and emotional rebirth. The phenomenal growth that occurs in adolescence, second only to that in first year of life, creates increased demands of energy and nutrients. Total nutrient needs are higher during adolescence than any other time in the life cycle. Nutrition in adolescence has preventive role related to diet causing chronic diseases like

- Cardiovascular disease,
- Cancer
- Osteoporosis.

This emphasizes the importance of calcium as nutrient in adolescents in prevention of osteoporosis [1]. Although osteoporosis was once considered a disease of elderly, there is universal agreement that the condition has pediatric antecedents. 40% of Peak Bone Mass (PBM) is achieved around menarche in girls [2].

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Somatic Growth

Normal somatic growth is a complex process controlled by

1. Cellular factors
2. Genetic interactions
3. External factors such as

- Physical activity
- Infections
- Psychosocial and economic factors
- Chronic diseases
- Metabolic and hormonal factors
- Nutrition [3].

Height

In general, all people are born with a given genetic potential for growth, which may or may not be realized, depending on the living conditions to which they are subjected. Thus, it can be stated that the final height of a person is the result of interactions between their genetic load and those environmental factors

that allow them to express their genetic potential to a greater or lesser extent [4,5].

Short Stature

Infections and inadequate dietary intake are well-established causes of short stature [6,7].

Micronutrients

Notwithstanding, attention has recently been directed to the possibility that deficiencies of some micronutrients may play a role in delayed growth. This is because certain micronutrients are essential for physical growth, sexual maturity, neuromotor development and to the integrity and function of the immune system. Therefore, a child's capacity to realize full genetic potential for physical growth and mental development may also be compromised due to subclinical micronutrient deficiencies [8].

Rickets

One condition of note that results in short stature and is characterized by deficiency of a micronutrient is rickets caused by vitamin D deficiency. This is a disease that results in retarded growth, muscle weakness, skeletal deformities, hypocalcemia and tetany. An epidemic during the 19th century was almost completely eradicated by encouraging people to expose themselves to sunlight and fortifying milk with vitamin D. However, vitamin D deficiency has once more become epidemic among children and rickets has become a worldwide health issue. In addition to vitamin D deficiency, calcium deficiency also causes rickets [9]. Even before the development of rickets, dietary calcium and vitamin D deficiencies can compromise growth and development [10].

Calcium

Calcium is an element that is a fundamental part of the body and its importance is related to the functions it performs in bone mineralization, primarily related to bone health, which include formation and maintenance of the structure and rigidity of the skeleton [11,12].

Calcium has 2 major functions in bone health

1. *Structural*: calcium constitutes the largest portion of mineral content. Increasing mass is one parameter of increasing bone strength. Pubertal girls only partially adapt to low calcium intakes and suffer from negative calcium balance [13].
2. *Reduced bone resorption*: for every milligram of additional calcium absorbed in adolescents, bone resorption was decreased by a similar amount, resulting in more positive bone balance [14].

Reduced bone turnover by increased dietary calcium has been proposed to reduce skeletal fragility by a separate mechanism from change in bone mass [15]. The advantage to bone occurs long before differences in bone mineral density measures can be distinguished [16].

Prevention: Best Strategy

When making dietary calcium recommendations for bone health, it is important to remember that there is no cure for skeletal fragility fractures, only treatments. Therefore, prevention is the best strategy, according to the 2004 Surgeon General's report [17].

Exercise

In addition to calcium intake, exercise is an important aspect of achieving maximal peak bone mass. There is evidence that childhood and adolescence may represent an important period for achieving long-lasting skeletal benefits from regular exercise [18]. For example, Welten et al [19] showed in a large Dutch cohort of children that regular weight-bearing activity had a greater influence on peak bone mass than dietary calcium.

Peak Bone Mass

The efficiency of calcium absorption is increased during puberty, and the majority of bone formation occurs during this period [20].

The maximal net calcium balance (plateau) is achieved with intakes between 1200 and 1500 mg/d. That is ,intake levels above this, almost all of the additional calcium is excreted and not used. At intakes below that level, the skeleton may not receive as much calcium as it can use, and peak bone mass may not be achieved [21]. The exact level that is best for a given person depends on other nutrients in the diet, genetics, exercise, and other factors [22].

99% of total body calcium is found in the skeleton, with only small amounts found in the plasma and extra vascular fluid.

Serum Calcium Exists in 3 Fractions

1. Ionized calcium (approximately 50%),
2. protein-bound calcium (approximately 40%), and

3. a small amount of calcium complexed to citrate and phosphate ions.

Serum calcium is maintained at a constant level by the actions of several hormones, most notably parathyroid hormone and calcitonin. Calcium absorption is by the passive vitamin D-independent route or by the active vitamin D-dependent route [23].

Ideal Calcium Requirement

The ideal calcium intake is that which results in adequate peak bone mass in adolescent, and maintains it during adulthood and minimizes losses when elderly [24].

Factors Affecting Calcium Requirement

The nutritional recommendations for calcium vary throughout lives, with higher requirements during periods of rapid growth, such as

1. During childhood and adolescence
2. During pregnancy and lactation
3. Calcium deficiency
4. Exercise that result in high bone density and increased calcium absorption and
5. In old age [25].

The calcium requirements were established based on three indicators: risk of fracture, measures of muscle mass and maximum calcium retention [10].

Calcium Absorbtion

Calcium absorbed from the diet is dependent on the balance between:-

1. Intake
2. Absorption (intake less losses in feces) and
3. Excretion [10]

Dietary factors affecting calcium balance

Calcium Intake

The gap between the recommended calcium intakes and the typical intakes of children, especially those 9 to 18 years of age, is substantial. Mean intakes in this age group are between approximately 700 and 1000 mg/d, with values at the higher side of this range

Dietary factors affecting calcium balance

	Reduces	Increases
Absorption	Fiber Phytates Oxalates Caffeine Fat Phosphorous Iron	Intake Lactose Carbohydrates Lysine Fat
Excretion	Phosphorous Alkaline ash	Protein Sodium Chloride Acid ash

Other Factors Influencing Bone Health	
Vit D	Vit C
Vit K	Phosphorous
Salt	Potassium
Homocysteine	Magnesium
Vit B 12	Copper
Protein	Zinc
Fatty Acids	Phytoestrogens
Fruit & Vegetable intake[16]	Oligosaccharides(especially inulin –type fructans)[27]

occurring in males [28]. Preoccupation with being thin is common in this age group, especially among females, as is the misconception that all dairy foods are fattening. Many children and adolescents are unaware that low-fat milk contains at least as much calcium as whole milk [22].

Since it cannot be produced endogenously, calcium can only be acquired by means of a daily intake of foods that contain it [24]. Among foods rich in calcium are milk and its byproducts (yoghurt and cheese) with low levels of fats [29].

The high bioavailability of calcium in dairy products is related to their vitamin D content and to the presence of lactose, which increase calcium absorption in the intestine [30].

Furthermore, since milk has an alkaline pH, calcium is kept in suspension due to formation of calcium caseinate, calcium citrate and a complex with lactose. Therefore, the lactose, caseinate and citrate in milk and dairy products appear to explain their better calcium absorption in relation to other dietary calcium sources [24]. Although cheese contains little lactose, the calcium it contains is freely available [11].

Knowledge of dietary calcium sources is a first step toward increasing the intake of calcium-rich foods. The largest source of dietary calcium for most persons is milk and other dairy products [31].

Other sources of calcium are, however, important, especially for achieving calcium intakes of 1200 to 1500 mg/d. Most vegetables contain calcium, although at low density. Therefore, relatively large servings are needed to equal the total intake achieved with typical servings of dairy products. The bioavailability of calcium from vegetables is generally high. An exception is spinach, which is high in oxalate, making the calcium virtually nonbioavailable. Some high-phytate foods, such as whole bran cereals, also may have poorly bioavailable calcium [32].

Lactose Intolerance

Recently, lactose intolerance has been diagnosed with greater frequency which demands special care with ensuring that patients maintain an adequate calcium intake. This hypothesis is supported by results published by Medeiros, who found that calcium intake was lower q ($p < 0.001$) among children on diets free from cow's milk and dairy products [33].

Several alternatives exist for children with lactose intolerance. Lactose intolerance is more common in African American, Mexican Americans, and Asian Pacific Islanders than in whites [34].

Many children with lactose intolerance can drink small amounts of milk without discomfort. Other alternatives include the use of other dairy products, such as solid cheeses and yogurt that may be better tolerated than milk. Lactose-free and low-lactose milks are available. Increasing the intake of nondairy products, such as vegetables, may be helpful, as may the use of calcium-supplemented foods [22].

Recommended Calcium Intake

Current calcium intake recommendations for North America were published by the Institute of Medicine in 1997 [28].The panel considered calcium recommendations from several points of view, including published randomized, controlled trials (RCT), applying the factorial approach that accounted for daily calcium losses plus growth needs, adjusted for fractional calcium absorption, and the intake to achieve maximal calcium retention. The intake for maximal calcium retention was determined to be 1300 mg/d. Calcium retention largely reflects bone mass, because 99% of the body's calcium is in the skeleton and exists as a constant percentage of bone mineral. Bone mass is an important component of bone strength. Thus, the panel reasoned that achieving maximal calcium retention would remove dietary calcium as a limiting factor for maximizing peak bone mass within one's genetic potential to offer the greatest protection against fracture later in life [16].

Dietary recommendations for children with chronic illnesses or those taking medications, such as corticosteroids need to be evaluated. The provision of adequate vitamin D also may be important for children with chronic illnesses [22].

Discussion

Human body undergoes many structures in functional transformations as we age. Bones become strong as calcium and minerals are deposited from birth until around 30 years of age. After 30 years, bones naturally start to lose more calcium then are deposited. Therefore, greater the bone strength achieved by high calcium early in life, larger the reserve for later years.

Diet and exercise are two ways that woman can retain bone strength and slow age associated bone loss. Nutrition is of universal concern but it is challenging to design optimal diet and to maximize utilization of dietary nutrients [35].

Bone health is a combination of hormonal and dietary interplay and favorable internal milieu in the body especially during phases of growth [36]. We can therefore conclude that, during growth, adequate supplies of calcium and vitamin D are considered critically important to bone development and, if a child is going to fulfill their genetic potential for growth and peak bone mass, their diet must include a sufficient quantity of these nutrients.

The low dietary intakes of calcium and vitamin D among children and adolescents have deleterious effects on their skeletal health and bone metabolism. It is necessary to investigate the causes of low calcium and vitamin D intake among people in growth phases, such as childhood and adolescence, to establish nutritional strategies to increase their dietary intake and to make it possible for populations at nutritional risk to access foods rich in these nutrients [10].

Research is needed to elucidate how variability in overall dietary quality and composition of the diet might influence calcium intake requirements, bone acquisition, bone composition, and bone quality among children.

Limited information is currently available on interactions between diet and exercise. Multiple genetic loci are integral to bone accrual, and combinations of genotypes at several loci may be as important as a single genotype for determining BMD and BMC among children [37].

In children, polymorphisms of the vitamin D receptor Fok1 gene have been associated with variations in calcium absorption and rates of bone mineralization, and these effects may be dependent on usual calcium intake but have not been measured in calcium supplementation trials [38].

Increasing knowledge of the nutrients can facilitate improving nutritional health of the people residing in the country. Family should be the first place from where the children will learn about taking a healthy diet. So, the parents should be cooperative and play an active role, be more communicative and take necessary care to habituate their children to have a healthy diet. Media, both print and electronic, can play a key role for improving awareness in parents and children. Parent's education and family income are also major determinants in nutritional habits [39].

During childhood and adolescence, vitamin D is important for calcium absorption and bone growth and accretion [40].

Conclusion

Bone health is important to health and quality of life. Genetic factors and environmental factors affect bone health.

Diet and physical factors play major role in promoting bone health, which begins in childhood and continues into old age. It is important to optimize bone health throughout life cycle. Calcium and protein in the diet with sunlight exposure and weight bearing exercises are important for building the Peak Bone Mass (PBM) in adolescents. The process of osteoporosis may start early in life. So calcium as nutrient in adolescence is critical for prevention of osteoporosis and improving quality of life.

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