Peertechz

MEDICAL GROUP

ARCHIVES OF
Preventive Medicine
OPEN ACCESS JOURNAL

ISSN: 2640-7868 DOI: https://dx.doi.org/10.17352/apm

Research Article

Methods of prevention of calcium deficiency in pediatric practice

TE Taranushenko[1]*, NG Kiseleva[2] and TV Ovchinnikova[3]

[1]Dr. Med. Sci., Professor, Krasnoyarsk State Medical University, Named After Voino-Yasenetsky, Partizan Zheleznyak Str., Krasnoyarsk, Russian Federation

[2]Associate Professor, Krasnoyarsk State Medical University, Named After Voino-Yasenetsky, Partizan Zheleznyak Str., Krasnoyarsk, Russian Federation

[3]The Doctor Pediatrician, The Center of Maternal and Child Health, Academician Kirensky Str., Krasnoyarsk, Russian Federation

Received: 26 May, 2022
Accepted: 30 June, 2022
Published: 01 July, 2022

***Corresponding author:** TE. Taranushenko, Dr. Med. Sci., Professor, Krasnoyarsk State Medical University, Named After Voino-Yasenetsky, Partizan Zheleznyak Str., Krasnoyarsk, Russian Federation, Email: tetar@rambler.ru

ORCID: https://orcid.org/0000-0003-2500-8001

Keywords: Phosphorus-calcium metabolism, Bone tissue, Calcium, Children, Adolescents

https://www.peertechzpublications.com

Check for updates

Abstract

It is known that the prevention of deficiency conditions in children is one of the most urgent tasks of preventive pediatrics. The importance of timely recommendations for optimizing the replenishment of microelements and vitamins is undeniable, and understanding the importance of using calcium and vitamin D supplements significantly reduces the risk of adverse health effects in childhood and later life.

The value of calcium

Calcium is an important macronutrient involved in various physiological processes and is one of the minerals with a high content in the human body. Calcium accounts for up to 9% of total body weight. The main part of calcium is deposited in the bones (99%), a small amount - in the teeth and soft tissues (1%), in the intercellular fluid and plasma (0.08%) [1-5].

In blood plasma, calcium circulates in a free form and in a bound state with albumin and chelate compounds (sulfate, citrate, phosphate, lactate, etc.). These fractions reflect the total content of total calcium in the blood. Free calcium makes up approximately 50% of the total plasma calcium concentration and is a biologically active form involved in the physiological processes of neuromuscular conduction and blood coagulation. The concentration of total and free calcium is in a narrow range - 2.2-2.6 mmol/l and 1.0-1.2 mmol/l, respectively [1-7].

Calcium homeostasis

Maintaining a stable level of calcium in the blood is provided by a number of mechanisms, the most important of which are 1-6]:

1. Adequate absorption in the small intestine/excretion in the gastrointestinal tract as part of the secrets of the liver and pancreas.
2. Filtration in the glomerulus/reabsorption in the tubules of the kidneys.
3. Mobilization from the bone depot to the bloodstream/ transport to the bone tissue (mineralization).
4. Diffusion into soft tissues and release from them.
5. Activation and functioning of the calcium-sensitive receptor.

The main hormonal regulators of calcium homeostasis that control the functions of target organs include parathyroid hormone, calcitonin, and calcitriol. In the literature, the influence of parathormone-like peptides and calcium-sensitive receptors on mineral metabolism is considered, and the importance of sex and thyroid hormones, insulin, growth hormone, corticosteroids, cytokines, and insulin-like growth factors is discussed [1-7].

Citation: Taranushenko TE, Kiseleva NG, Ovchinnikova TV (2022) Methods of prevention of calcium deficiency in pediatric practice. Arch Prev Med 7(1): 001-005. DOI: https://dx.doi.org/10.17352/apm.000029

Physiological functions of calcium in the body

The physiological effects of calcium are generally known and include [1-7]:

1. Ensuring the strength of bone tissue.
2. Implementation of neuromuscular conduction, and muscle contraction.
3. Participation in the mechanism of blood coagulation.
4. Regulation of intracellular signaling systems and functions of calcium channels.
5. Activation of calmodulin (messenger of hormonal regulation of enzymatic systems).

It should be noted that the biological significance of calcium continues to be studied. The subject of scientific research is calcium-dependent proteins that affect the function of the vascular endothelium and connective tissue, and the metabolism of fats and carbohydrates. The activity of these proteins correlates with the level of calcium supply. The nootropic and neuroprotective role of calcium is discussed, as well as its participation in the processes of inflammation, apoptosis, and immune and allergic reactions [1,2].

One of the urgent problems of modern pediatrics is the assessment of the importance of an adequate intake of calcium to ensure the strength of the skeleton and the formation of tooth resistance to caries in children and adolescents.

The value of calcium for bone tissue

Calcium is the main component of the mineral matrix, which makes up more than half of bone mass and provides a complete skeletal structure. It is known that the skeletal system is constantly updated (remodeled). During bone remodeling, calcium plays a key role in ensuring adequate ossification of the protein matrix. According to some authors, calcium activates calcitriol and growth factors, enhances the proliferation and differentiation of osteoblasts, and reduces the rate of bone resorption. Maintaining osteoid mineralization requires a constant stable concentration of minerals in the plasma [2,9].

The processes of bone remodeling are most active in children and adolescents and are accompanied by an increase in the need for calcium. The formation of peak bone mass before the age of 15-17 determines the strength of the bone in the future. At the same time, about 40% of Russian children without somatic pathology affecting phosphorus-calcium metabolism have reduced bone mineral density (BMD), and osteoporosis was diagnosed in 11% of adolescents. According to a number of authors, in 45% of cases with fractures of tubular bones in childhood, a decrease in BMD is diagnosed, and osteoporosis is verified in 7% of those examined. With scoliosis, a decrease in BMD is detected in 12% of children, and severe curvature of the spine - in 70% of patients [1-9].

One of the leading causes of imbalance in bone remodeling and a decrease in BMD in childhood is an alimentary deficiency of calcium and/or vitamin D against the background of rapid growth. It has been established that the physiological need for calcium can be met by daily consumption of at least three different dairy products (milk porridge, milk drink, cottage cheese, cheese, yogurt) and an additional intake of fish twice a week. However, not everyone gets dairy products on a daily basis. An additional cause of dietary calcium deficiency is the consumption of foods that interfere with the absorption of this mineral in the intestines. Insufficient content of calcium in the diet causes the development of latent hypocalcemia, which leads to a compensatory increase in the secretion of parathyroid hormone, activation of osteoclasts, and mobilization of calcium from bone depots into the bloodstream [8-10].

The effect of calcium on dental health

Currently, close attention is paid to the effect of calcium supplementation and dental health. One of the leading causes of caries is a violation of tooth morphogenesis mediated by calcium deficiency [11-13].

It is known that calcium is deposited in dentin and enamel as part of hydroxyapatite crystals. Adequate mineralization and maturation of dental tissues are provided by the content of this macroelement in blood serum and saliva. The transport of minerals from the oral fluid to the tooth enamel occurs along a concentration gradient, so remineralization is possible only with high calcium content in saliva. The literature provides the results of studies that have shown a direct correlation between the activity of caries and the level of calcium intake in adolescents. It has been established that alimentary mineral deficiency is accompanied by the appearance of foci of demineralization in the hard tissues of the tooth, a violation of the acid resistance of the enamel, and a decrease in caries resistance even with a satisfactory level of oral hygiene. It is important that the content of calcium ions in the oral fluid depends on the calcium index, which is an early marker of mineral metabolism disorders, and a predictor of caries [11-13].

Prevention of calcium deficiency

Methods of prevention of calcium deficiency

1. **Balanced diet:** To maintain mineral metabolism and prevent the loss of trace elements from bones, regular alimentary calcium supplementation is necessary. It is known that approximately 50-75% of dietary calcium is absorbed in the small intestine. Adequate diffusion of calcium from the intestine into the bloodstream is provided by vitamin D. The absorption of cholecalciferol occurs in the small intestine and duodenum. The absorption of the mineral from different foods is almost the same, calcium is absorbed somewhat worse in the presence of phytic and oxalic acid [4,14,15].

The main dietary sources of calcium are dairy and seafood, nuts, legumes, seeds, herbs, dried fruits, mineral water, halva, and chocolate. The most optimal calcium donor in childhood is dairy products [14,16,17] [Table 1].

Foods that provide vitamin D include cod liver, fatty fish (salmon, tuna, mackerel, herring, mackerel, halibut, trout, eel, sea bass), egg yolk, and fatty dairy products (cream, sour cream, cream cheese butter) and animal liver [Table 2].

Citation: Taranushenko TE, Kiseleva NG, Ovchinnikova TV (2022) Methods of prevention of calcium deficiency in pediatric practice. Arch Prev Med 7(1): 001-005. DOI: https://dx.doi.org/10.17352/apm.000029

2. Restriction in the diet of products that disrupt the absorption and transport of calcium in the intestine (fats, caffeine, phytates, oxalic acid, alcohol, etc.) [Table 3].

3. Timely diagnosis and correction of somatic diseases that disrupt mineral metabolism (pathology of the gastrointestinal tract, urinary organs, respiratory system, etc.)

4. Sufficient insolation.

Pharmacological prevention of calcium deficiency

With insufficient calcium content in the diet, somatic pathology, as well as an increase in the need for minerals during periods of intensive growth, pharmacological calcium salts are indicated. According to the literature, the effects of dietary calcium and calcium tablets are similar [14,15,18-21].

Calcium salts are divided into 2 groups - organic (citrate, lactate, and calcium gluconate) and inorganic (phosphate and calcium carbonate). According to a number of authors, the effectiveness of all calcium salts is the same, other researchers consider organic salts (for example, lactate) to be the most preferable since they dissolve better in liquids, have high bioavailability, and the absorption of calcium from them does not depend on the pH of the medium [1,14,15,22].

When choosing a pharmacological preparation, the content of elemental calcium in the salt should be taken into account [Table 4]. For example, calcium gluconate contains only 89 mg of elemental calcium, so this oral form cannot be considered an optimal calcium donor [1,15].

The characteristics of some calcium salts are presented in Table 5.

The dose of the calcium preparation is calculated individually, depending on age, physiological needs [Table 6], and the degree of consumption of calcium-containing products. For maximum absorption, the daily dosage of the drug is divided into 2-3 doses, with a single dose of elemental calcium not more than 500-600 mg [1,14,15,24]. The processes of growth and osteomodeling in children occur mainly at night, and therefore, it is preferable to take calcium supplements in the afternoon. Courses of preventive intake of calcium salts are 1-3 months 2-3 times a year [1,14,15,24].

It is known that the absorption of calcium in the proximal small intestine and its subsequent transport to the bone tissue are determined by the activity of vitamin D [4]. This

Table 1: Calcium content in some foods [1,6,7,14,15,16].

Product	Calcium content, mg/100 g
MILK PRODUCTS	
parmesan cheese	1300
hard cheeses	1000
milk ice cream	140
cow's milk (2.5-3.5%)	120
SEAFOOD	
Atlantic sardines (canned)	380
crabs	100
shrimps	90
NUTS	
sesame	1150
hazelnut	290
almond	254
walnuts	83
pistachios	130
SEEDS	
sunflower seeds	100
pumpkin seeds	60
DRIED FRUITS	
dried apricots	170
raisin	56
SPICES	
basil	370
parsley	245
celery	240
watercress	180
chives	130
dill	126
BEAN	
soya beans	240
beans	194
peanut	70
OTHER PRODUCTS	
milk chocolate	240
dark chocolate	60

Table 2: Vitamin D content in some foods [15].

Product	Vitamin D content, IU
Cod liver oil (1 tablespoon)	1360
Atlantic herring (120 g)	680
Salmon (cooked) (120 g)	360
Sardines in oil (120 g)	270
Whole milk (200 ml)	98
Margarine (20 g)	60
Egg (yolk)	25
Braised beef liver (120 g)	12–30
Butter (20 g)	10

Table 3: Factors affecting calcium absorption in the small intestine.

Reduce calcium absorption:	Enhance calcium absorption:
■ Fitin (grain products) ■ Oxalic acid (cocoa, sorrel, spinach, rhubarb, etc.) ■ Iron ■ Excess fats, phosphates (sausages, phosphoric acid in cola, baking powder, etc.), fiber	■ Vitamin D ■ Lactose ■ Citric acid ■ Physical activity ■ Protein ■ Low intestinal pH

Citation: Taranushenko TE, Kiseleva NG, Ovchinnikova TV (2022) Methods of prevention of calcium deficiency in pediatric practice. Arch Prev Med 7(1): 001-005. DOI: https://dx.doi.org/10.17352/apm.000029

Table 4: The content of elemental calcium in salts.

Calcium salt	Elemental calcium (mg) in 1 gram of calcium salt
Calcium carbonate	400
Calcium triphosphate	399
Calcium citrate	211
Glycerophosphate	191
Calcium lactate	130
Calcium gluconate	89

Table 5: Characteristics of Various Calcium Salt Tablets [1,15, 22].

calcium salt	Advantages
1. ORGANIC SALT	
1.1. Calcium citrate	■ absorption does not depend on the pH of the medium ■ high bioavailability ■ dissolves in water ■ quickly eliminates calcium deficiency with low dietary intake
1.2. Calcium lactate	■ good absorption at various pH values
1.3. Calcium gluconate	■ economic accessibility
2. INORGANIC SALT	
2.1. Calcium carbonate	■ highest calcium content ■ dissolves in an acidic environment (active at normal and hyperacidity of gastric juice)
2.2. Calcium phosphate	■ dissolves in an acidic environment ■ an additional source of phosphorus

Table 6: Norms of the physiological need for minerals for children and teenagers in Russia [16].

Age	calcium (mg per day)	phosphorus (mg per day)	magnesium (mg per day)	zinc (mg per day)	copper (mg per day)
0 – 3 months	400	300	55	3	0.3
4 – 6 months	500	400	60	3	0.3
7 – 12 months	600	500	70	4	0.5
1 – 3 years	800	700	80	5	0.5
3 – 7 years	900	800	200	8	0.6
7 – 11 years	1100	1100	250	10	0.7
11 – 14 years	1200	1200	300	12	0.8
14 – 18 years	1200	1200	400	12	1.0

circumstance determines the feasibility of combined therapy of calcium salts with cholecalciferol. According to modern recommendations, the prophylactic dose of vitamin D for children of different ages is 1000 IU 23].

Modern calcium preparations are presented in tablet and liquid dosage forms. The advantages of liquid versions should be considered as a uniform dispersed distribution of the active substance, increased absorption surface area, a higher degree of absorption, as well as the possibility of use in children with difficulty in swallowing solid forms.

According to the literature, all calcium salts have a high safety profile. Side effects, in the form of intestinal dysfunction (flatulence, hypomotility, constipation), are most common with calcium carbonate, less often with calcium citrate. The risk of stone formation occurs with the consumption of calcium salts in a dose exceeding 2500 mg per day, on an empty stomach, and/or separately from meals. Therefore, it is recommended that these drugs be taken during or immediately after a meal, with a sufficient amount of liquid [1,14,15,24].

Indications for prescribing calcium supplements for prophylactic purposes [2,3,8-10,14,16,21]:

1. SGA (small gestational age) and/or history of prematurity.
2. Insufficient dietary intake of protein, calcium, and vitamin D.
3. Infantile rickets and their consequences (in history).
4. Periods of accelerated growth.
5. Idiopathic growth retardation.
6. Lack of weight, anorexia nervosa.
7. Low physical activity.
8. Endocrine diseases (hypogonadism, diabetes mellitus, somatotropic insufficiency)
9. Malabsorption syndrome, lactase deficiency, CMPA
10. Chronic kidney disease with renal osteodystrophy.
11. Taking corticosteroids, anticonvulsants, cytostatics
12. Fractures in history, repeated or occurring with minor trauma.

Contraindications to the use of calcium preparations:

1. Hyperparathyroidism.
2. Decalcifying tumors.
3. Urolithiasis.
4. Renal failure.
5. Severe hypercalciuria.
6. Osteoporosis due to immobilization.

Hypocalcemia is not a rare pathology; it may accompany a number of chronic somatic conditions, endocrinopathies, pathologies of the kidneys (chronic renal failure) and the digestive system (malabsorption syndrome, bowel disease), etc. Along with this, disorders of calcium metabolism can occur in relatively healthy children as a result of hypovitaminosis (especially vitamin D), dietary habits (refusal of dairy products), an unbalanced diet, and high growth rates at an early age or during puberty. At the same time, it is important to understand that calcium deficiency in a child at different periods of life can exacerbate somatic problems and lead to the development of other pathological conditions, of which the most significant is a decrease in growth rates, a decrease in bone mineral density, a change in tooth enamel, a violation of neuromuscular transmission, dysregulation of intracellular signaling systems

Citation: Taranushenko TE, Kiseleva NG, Ovchinnikova TV (2022) Methods of prevention of calcium deficiency in pediatric practice. Arch Prev Med 7(1): 001-005. DOI: https://dx.doi.org/10.17352/apm.000029

and the function of calcium channels, a negative impact on the morphological and functional maturation of organs and systems of the child's body.

Satisfying all the needs of a growing organism during childhood is not always possible only with the help of food products. In some cases, even with good nutrition, laboratory assessment of nutritional status indicators indicates significant microelements or hypovitaminosis. In this regard, it should be recognized that the presence of any risk factors for the development of hypocalcemia in a child (a period of rapid growth, the formation of the physiological functions of the body, irrational and malnutrition, the presence of deficient conditions, changes in nails, hair, teeth, etc.) e.) should be considered from the standpoint of timely prevention and correction of subsequent disorders of mineral metabolism and vitamin D hypovitaminosis.

Conclusion

One of the most relevant areas of preventive pediatrics is the prevention of deficient conditions in children, i.e. timeliness of recommendations for optimizing the replenishment of trace elements and vitamins during their increased need. The use of calcium and vitamin D supplements can significantly reduce the risk of adverse health outcomes in childhood.

The purpose of this publication: Presentation of summarized data on the prevention of calcium deficiency in children and adolescents.

References

1. Gromova OA, Torshin I.Yu. Vitamin D is a paradigm shift. Under. ed. acad. RAS E.I. Gusev, prof. I.N. Zakharova. M. TORU PRESS, 2015.
2. Kiseleva NG, Taranushenko TE, Golubenko NK. Diagnosis of osteoporosis in childhood. Medical advice. 2020;(1): 186-193. doi: 10.21518/2079-701X-2020-1-186-193.
3. Calcium deficiency and osteopenic conditions in children, diagnosis, treatment, prevention: scientific and practical program of the Union of Pediatricians of Russia, Moscow, 2006.
4. Cattail VM, Arki RA. Pathophysiology of the endocrine system. Per. from English. M.G. Koroleva, EV. Kuchinskaya. SPb.-M. Nevsky dialect - Binom Publishing House, 2001.
5. Guide to pediatric endocrinology. Ed. I.I. Dedova VA. Peterkova. Moscow: Universum Publishing, 2006.
6. Guide to pediatric endocrinology. Ed. Charles G.D. Brooke, Rosalind S. Brown: Trans. from English. Ed. VA. Peterkova. M. GEOTAR-Media, 2009.
7. Reference book of a pediatric endocrinologist / I.I. Dedov, V.A. Peterkov. 3rd ed., rev. and dorab. M. Literra, 2020.
8. Klyuchnikov SO, Kravchuk DA, Ogannisyan M.G. Osteoporoz u detey i ego aktual'nost' dlya detskoy sportivnoy meditsiny. Rossiyskiy vestnik perinatologii i pediatrii. 2017; 62 (3): 112-20. https://DOI: 10.21508/1027-4065-2017-62-3-112-120.
9. Mal'tsev SV, Mansurova GSH. Snizhenie mineral'noy plotnosti kosti u detey i podrostkov: prichiny, chastota razvitiya, lechenie. Voprosy sovremennoy pediatrii. 2015; 14 (5): 573-8. https://DOI: 10.15690/vsp.v14i5.1442.
10. Physiology of growth and development of children and adolescents (theoretical and clinical issues): in 2 vols. Ed. A. A. Baranov, L. A. Shcheplyagina. 2nd ed., revised. and additional M.: GEOTAR-Media, 2006.
11. Evaluation of caries resistance of hard tissues of teeth and the state of phosphorus-calcium metabolism in adolescents: dis. ...cand. honey. Sciences I.A. Alekseeva Moscow: B.I., 2014.
12. Kisel'nikova LP, Alekseeva IA, Shcheplyagina LA. Otsenka obespechennosti kal'tsiem detey podrostkovogo vozrasta s vysokoy aktivnost'yu kariesa. Rossiyskaya stomatologiya. 2013; 2: 31-4. Rezhim dostupa: https://elibrary.ru/contents.asp?id=33916684.
13. Ippolitov Yu.A., Plotnikova Ya.A., Aleshina EO, Markina TV. The use of mineral complexes in endogenous and exogenous methods of prevention in order to prevent the development of primary demineralization of hard tooth tissues. Bulletin of new medical technologies. 2016; 23(2):164-170.
14. JOURNAL OF NEW MEDICAL TECHNOLOGIES 2016; 23(2):164-170. DOI: 10.12737/20443.
15. Taranushenko TE, Kiseleva NG. Osteoporosis in childhood: features of skeletal mineralization in children, prevention and treatment. Medical advice. 2020;(10):164–171. doi: 10.21518/2079-701X-2020-10-164-171.
16. Lesnyak OM, Benevolenskaya LI, Benevolenskaya LI. Osteoporosis in the Russian Federation: Problems and Perspectives. Rheumatology Science and Practice. 2010;48(5):14-18. (In Russ.) https://doi.org/10.14412/1995-4484-2010-725
17. National program to optimize the provision of vitamins and minerals for children in Russia, 2017. M .: Pediatr.
18. Shcheplyagina LA, Samokhina EO, Sotnikova EN , Kruglova IV. Ehffektivnost' pishchevoy profilaktiki narusheniy rosta v doshkol'nom vozraste. Pediatriya. 2008; 87 (3): 68-72. Rezhim dostupa: https://pediatriajournal.ru/archive?show=290&section=2122.
19. Dydykina IS, Dydykina PS, Alekseeva OG. Vklad mikroehlementov (medi, margantsa, tsinka, bora) v zdorov'e kosti: voprosy profilaktiki i lecheniya osteopenii i osteoporoza. Ehffektivnaya farmakoterapiya. 2013; (38). Ehndokrinologiya. Spetsvypusk № 2 «Osteoporoz»: 42-9. Rezhim dostupa: https://elibrary.ru/item.asp?id=22485862.
20. Zakharova IN, Tvorogova TM, Vorob'yova AS, Kuznetsova OA. Mikroehlementoz kak faktor formirovaniya osteopenii u podrostkov. Pediatriya. 2012; 91 (1): 67-75. Rezhim dostupa: https://elibrary.ru/item.asp?id=17308025.
21. Shcheplyagina LA, Chibrina EV, Rimarchuk GV, Samokhina EO, Kruglova IV. Efficacy of a combined calcium and D3 preparation in children with reduced bone strength. Questions of practical pediatrics. 2009; 4(4):20-3. Access mode: https://elibrary.ru/item.asp?id=12978084
22. Osteoporosis: clinical recommendations of the Ministry of Health of the Russian Federation, Moscow, 2016.
23. Gromova OA, Torshin I. Yu, Pronin AV, Egorova E. Yu., Volkov A.Yu. Differentiated approach to the choice of soluble calcium preparations of the second generation. Practical doctor. 2014; 11:60-65.
24. National program "Vitamin D deficiency in children and adolescents of the Russian Federation: modern approaches to correction", Moscow, 2018.
25. Korovina NA, Tvorogova TM, Gavryushova LP, Vorobieva AS, Appl J. Safety criteria for calcium preparations for the prevention of osteopenia in adolescents. Pediatrics. 2006; 5(14): 81-86. Access mode: http://www.pediatriajournal.ru No. 5/2006, Appendix No. 14.

Citation: Taranushenko TE, Kiseleva NG, Ovchinnikova TV (2022) Methods of prevention of calcium deficiency in pediatric practice. Arch Prev Med 7(1): 001-005. DOI: https://dx.doi.org/10.17352/apm.000029