Zinc and Vitamin D are essential for correct functioning of the body, especially in children

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Abstract

Background: Micronutrients are vitamins and minerals that are necessary for the body in very small amounts. Their impact on the health of the body is critical and a deficiency in any of them can lead to severe/irreversible life-threatening conditions.
Aim: The aim of this paper is to review the current literature on the role of zinc and vitamin D in the proper functioning of the body in children.
Methods: The study employed a quantitative research method, distributing an electronic questionnaire to all TSU students in June 2021, which included internationally recognized ACEs-related questions along with additional questions related to health, behaviors, and learning.
Results:Vitamin D is steroid hormone, which makes a major contribution to human physiology, immunomodulation, cell differentiation and proliferation. Zinc is an important component of enzymes involved in the stabilization of DNA, RNA, in the structure of ribosomes and membrane structures, in the synthesis and metabolism of carbohydrates, lipids, proteins, nucleic acids, and other microelements.
Conclusions: Unhealthylifestyle and unbalanced nutrition, especially in children, lead to a violation of the nutritional status, which can become the cause of psychomotor and growth-developmental delay of the adolescent. **(TCM-GMJ June 2025; 10 (1): P6-P10)**

Keywords: Nutrition, Zinc (Zn), Children, Growth, Psychomotor, Vit. D .

Introduction

Micronutrients are vitamins and minerals that are necessary for the body in very small amounts. Their impact on the health of the body is critical and a deficiency in any of them can lead to severe/irreversible life-threatening conditions. They participate in all cellular/biochemical processes [1], allow the body to produce enzymes, hormones, cofactors and coenzymes that promote maintenance, formation, homeostasis of body tissues, to perform metabolic activites, such as cell signaling, motility, proliferation, differentiation, and apoptosis [2].Micronutrient deficiencies can lead to a variety of visible and dangerous health conditions, as well as less clinically noticeable "silent epidemics", during which a decline in physical and mental abilities, normal growth and developmentinhibited, problems in educational attainment, work productivity, and other with increased health risks are observed [3].

Micronutrient deficiencies affect about two billion people in the world, the main cause of this condition being unhealthy diet. Nutrient-rich food is the basis for good health, high reproduction and longevity.

Methods

A literature search was conducted in PubMed, Scopus, and Google Scholar databases using the following keywords: "Zinc," "Trace elements," "Child," "Adolescent," "Growth," and "Nutrition."

Results and discussion

Although the main focus of nutritionists is on healthy diet, the World Health Organization (WHO) has published data showing that micronutrient deficiencies are at alarming levels.About 1.7 million (2.8%) of total deaths are caused by micronutrient deficiencies, which is among the top ten causes of global mortality [4]. According to WHO data, iron (Fe), zinc (Zn), vitamin A (beta-carotene), vitamin D, selenium (Se), iodine (I) are the most common micronutrients, the deficiency of which is commonly observed in living organisms.

The main risk-factors of micronutrient deficiencies are:

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- Low prevalence of the breastfeeding.
- Nutritional condition in which the protein and energy balance is disturbed.
- Single-component diet leading to reduced intake of micronutrients and poor bioavailability, especially of minerals.
- Absence of products of animal origin in the diet.
- Increased demand – during any viral infection (especially if the child is often sick), in case of chronic diseases.
- Malabsorption (due to diarrhea or intestinal parasites)
- Increased excretion (schistosomiasis)
- Bad economic situation / poverty
- Social deprivation, illiteracy.

A balanced diet is necessary for health and proper functioning of the body. This means taking all the necessary substances. That is, to provide the body with all the nutrients, because it cannot produce these substances itself. Micronutrients are important, because they participate in the regulation of homeostasis of the human body [5].

Vitamin D is steroid hormone, which makes a major contribution to human physiology, immunomodulation, cell differentiation and proliferation [6]. It is produced in the skin from a cholesterol-like precursor (7-dehydrocholesterol) by exposure to sunlight, its main part (90%) is synthesized on the human skin by exposure to ultraviolet light, the rest (10% or less) depends on food [7]. There are two forms of vitamin D necessary for the human body: D_3 (cholecalciferol), the main source of which is exposure to the sun's ultraviolet B (UVB) light on the skin, and vitamin D_2 (ergocalciferol), which is supplied to the body from food and is produced in plants and mushrooms. Both forms of the substance are metabolized in the same way in the human body, with equal potency and can be considered equivalent. Vitamin D synthesized in the skin or taken from food is not biologically active, for activation it needs to be enzymatically transformed, i.e., to connect the -OH group, i.e., to be hydroxylated, which takes place in the liver and kidneys. Vitamin D is first metabolized in the liver to 25-hydroxyvitamin-D (25-OH-D or calcidiol), hydroxylation requires two cytochrome P-450 enzymes (CYP2R1 and CYP27A1), 25-OH-D is the inactive and most circulating form of vitamin D and it's usually measured when assessing vitamin D level, which has ahalf-life period of about 15 days [8]. 1,25-dihydroxyvitamin (1,25-(OH)2D) is the biologically active form of vitamin D, with the second hydroxylation, produced by the enzyme 25-OH-1 alpha hydroxylase, in the proximal tubules of the kidneys. 1,25-(OH)2D, like all vitamin D metabolites, is in the blood, connected to vitamin D by the specific protein α-globulin [9]. 1,25-(OH)2D is believed to act on target cells and participate in the regulation of various cellular functions, similar to a steroid hormone. Vitamin D receptors are found in most organs: blood vessels, B and T lymphocytes, heart, muscles, skin, brain, thymus, colon, genitalia, etc [10].

The production of vitamin D from the skin is universal, it is produced as a result of direct exposure to ultraviolet light of the sun on bare skin, this process is accompanied by many interfering factors. In particular, the synthesis of vitamin D is hindered by: pigmentation (dark skin, needs 3 -5 times more sun exposure, because melanin absorbs UVB radiation), use of sunscreen (SPF30 reduces the synthesis of vitamin D more than 95%), depends on time of year (autumn/winter), time of day, geographical location (higher latitude), weather (cloudy/foggy), skin damage (burn), subcutaneous fat (obesity reduces vitamin levels), lifestyle, physical activity, air pollution, and wearing clothes, practically complete skin coverage for medical, social, cultural, or religious reasons inhibits vitamin synthesis. In children (especially under 5 years of age) growth retardation, improper development of the musculoskeletal system [11], rickets, osteomalacia, osteoporosis, diabetes, cardiovascular disease, autoimmune diseases - this is a small list, the risk of developing of which increases during vitamin D deficiency [12]. A meta-analysis of randomized controlled researches comparing the effects of vitamin D_2 and D_3 supplements on blood levels showed that D_3supplements increased blood vitamin D concentrations more and maintained them longer [13]. Therefore, vitamin D received from the sun stays in the body twice as much as absorbed from the intestine. Vitamin D status is assessed, as described above, by determining plasma levels of 25 hydroxyvitamin D (25OHD). Epidemiological and experimental data indicate that in order to maintain a healthy status, the necessary level of vitamin D is >30 ng/ml, 20-30 ng/ml is insufficient, when the content is <20 ng/ml, there is a vitamin deficiency [14].

The best and most effective way to get vitamin D physiologically is its endogenous synthesis, especially for children this it is enough to directly expose the arms to sunlight for 25 minutes once a day (without using sunscreen) [15].Food, products containing vitamin D should also be taken into account. Unfortunately, its presence is described in few products, the largest amount is found in oily fish, and a smaller amount can be found in: beef liver, egg yolk, cheese, plants and mushrooms [16].Vitamin D is a fat -soluble substance, it is better absorbed when it is taken with food containing a certain amount of fat. Finally, if vitamin D cannot be corrected, it needs to be taken exogenously, in the form of a drug, taking into account age/sex/ deficiency. We should always keep in mind, that vitamins and minerals have recommended individual safe doses, mode and duration of administration, different indicators of bioavailability and the influence of internal factors of the body on their acceptance.

Vitamin D, cholecalciferol, steroid prohormone, plays an important role in mineral metabolism. Nowadays, the microelements, in the absorption of which vitamin D participates (in the small intestine), are determined, namely: calcium, iron, phosphorus, zinc and magnesium.

Zinc is a thirtieth chemical element in the Mendeleev's periodic table and the Latin abbreviation – Zn. It is a silvery-gray slightly brittle metal, when oxidationremoved. Zinc is an important element for the vitality of all living organisms. The total content of zinc in the human body is estimated at 30 mmol (2 g) [17].It is the second vital element, after iron, which has the largest amount in the body.

Plasma zinc makes up about 0.1% of the total body content, it is this small percentage that helps us maintain homeostasis. The microelement is found in almost all human organs and plays an important role in the functioning of each organ. Human bone and muscle mass, which is about 60% of total body weight, contains 1.5-3 μmol/g (100-200 μg/g) of zinc, with the highest amount found in the eye at 4.2 μmol/g (274 μg/g). c), genitalia 4.6-7.7 mmol/g (300-500 mg/l) and pancreatic islets of Langerhans 10-20 mmol/g [18,19]. Zinc is also found: in the skin, kidneys, liver, blood cells, zinc content is ten times higher in erythrocytes than in plasma.

Zinc is an important component of enzymes involved in the stabilization of DNA, RNA, in the structure of ribosomes and membrane structures, in the synthesis and metabolism of carbohydrates, lipids, proteins, nucleic acids, and other microelements. Zinc is an essential trace element required for maintaining both optimal human health and genomic stability. Zn plays a critical role in the regulation of DNA repair mechanisms, cell proliferation, differentiation and apoptosis involving the action of various transcriptional factors and DNA or RNA polymerases [20]. Zinc is an integral component of many metalloenzymes in the body. More than 300 metalloenzymes require zinc as a catalyst, and ~2500 transcription factors, or 8% of the human genome, require zinc for their structural integrity [21].The role of zinc is great in the binding of steroid hormone receptors and other transcription factors to DNA [22]. It participates in the realization of hormonal functions, directly affects the production/functioning of insulin and the entire spectrum of insulin-dependent processes, alleviates the action of the pancreas. Also, for normal spermatogenesis, in the synthesis of testosterone (male sex hormone), it inhibits 5-alpha-reductase, thereby regulating the level of testosterone metabolite dihydrotestosterone [23]. Zinc contains receptors for estrogens (female sex hormone), which is why it is considered a regulator of estrogen-dependent processes.Zinc is a necessary component for the functioning of the thymus (thymus gland) and the normal state of the body's immune system, it participates in formation of B lymphocytes and Th1 cytokines (Th1cytokinesare associated with autoimmune diseases, including rheumatoid arthritis, multiple sclerosis, inflammatory bowel disease, and type 1 diabetes) [24].Zinc is a microelement that contains the enzyme involved in the crucial reaction of heme biosynthesis contained in hemoglobin, as well as superoxide dismutase – animportant antioxidant enzyme that prevents formation of free radicals [25].It participates in the processes of smell and taste perception, has a healing effect on wounds and ulcers, prevents the formation of acne, improves the structure of the skin, strengthens nails and hair and adds gloss. Zinc is found in the brain, where it contributes to the structural development and proper functioning of the brain, it directly participates in the process of neuron myelination and impulse conduction, improves visual acuity, vision in the dark, is used to prevent myopia, promotes digestion and absorption. It has a pronounced effect on fetal growth and embryo development [26].

Zinc absorption occurs in the small intestine and depends on its concentration. The diet may not necessarily be low in zinc, but its bio-availability plays a major role in its absorption. Phytic acid is the main known inhibitor of zinc. Compared to adults, infants, children, adolescents have increased requirements for zinc and thus, are at increased risk of zinc depletion [27].Zinc taken in the morning before meals is more efficiently absorbed in liquid form (60-70%) than when taken in solid form.Zinc is excreted from the body through the kidneys, skin and intestines. Its loss from the intestines depends on the amount taken (7-45 μmol/day), through urine and through the skin about 7-10 μmol/day. Strenuous exercise and high ambient temperatures can cause loss through sweating. The body does Starvation and catabolism in muscles increase zinc loss through urine not have a supply of zinc [28]. Normally, zinc released during tissue catabolism and/or bone resorption can be reabsorbed and used. Randomized studies have shown that with a small amount of zinc intake of 2.6-3.6 mg/day (40-55 μmol/day) circulating zinc levels and the activity of zinc-containing enzymes were maintained within the normal range for 5-6 months, which emphasizes the mechanism of effective zinc homeostasis. However, the mechanism of where zinc deficiency first appears is still unknown. Researchers are trying to find zinc-dependent enzymes that can help identify zinc deficiency at an early stage.

The prevalence of zinc microelement deficiency is the main challenge for human health in the 21stcentury. Zinc deficiency was first observed in the food rationin 1961, and it was identified in humans in Asia and Africa. If we fill 90% of the zinc deficiency, we will reduce the mortality in children by 5%[29]. Research by the World Health Organization showed that due to widespread zinc deficiency, approximately 30% of children had stunted growth and reduced educational level, delayed sexual and bone maturation, skin lesions, diarrhea, alopecia, decreased appetite, and increased susceptibility to bacterial infections.Zinc deficiency is not only in food products, but also in the soil. On the example of a number of countries, where the soil composition was studied, it was found that zinc deficiency is different in different places and varies from 10% to 50%. This itself creates a problem with the content of zinc in the food products grown on this soil[3]. The cause of zinc deficiency in children can be nutritional, iatrogenic, genetic diseases. Deficiency and/or insufficiency of zinc contributes to the development of severe diseases in the intranatal period, such as: hydrocephalus, microcephaly, anencephaly, and in children of pediatric age – physical and cognitive development delay, motor developmental delay, attention deficit, behavioral problems, perception of space.

It should be noted that zinc has a significant effect on growth and development[30]. In case of its deficiency, the synthesis of collagen changes, it affects the bone metabolism, it causes a disturbance in the formation of the skeleton. Zinc affects the metabolism of growth hormone, and

vice versa, growth hormone affects the metabolism of zinc, the latter being a reversible process. Zinc deficiency also causes a decrease in insulin-like growth factor (IGF_1). Zinc, growth hormone, function of the genitalia and $IGF_1$are interrelated complex[31]. Two of the most severe diseases, pneumonia[32] and diarrhea[33], due to their long duration and severe course, can be fatal in childhood, the severity of their course is reduced by 30-50% by providing adequate amounts of zinc and vitamin D.

According to the recommendation of the US Institute of Health, the daily requirement of zinc in pediatric age is on average 3-5 mg. However, with the change of age, the level of zinc also changes (increases, for example: 0-6 months – 2 mg; 1-3 years – 3 mg; 4-8 years – 5 mg; 9-13 – 8 mg.) Male adolescents need more zinc daily (+1-2 mg) than female ones. Under normal conditions, the amount of zinc is 12-24 μmol/l (70-159 μg/deciliter)[25].

These deficiencies can be avoided by creating a healthy food ration and eating a balanced diet. Meat, shellfish, nuts and legumes are important sources. Wheat bran, sprouts, sunflower, pumpkin seeds (130-202 mg/kg), beef liver, rabbit and chicken meat, seafood, some types of fish (30-85 mg/kg), beans, peas, green tea, walnuts, eggyolks, cocoa (20-50 mg/kg)[]. The absorption of zinc is related to the intake of food rich in proteins, soluble low-molecular organic substances, such as amino and hydroxy acids, and absorption is hindered by organic compounds that form poorly soluble complexes with a strong bond with zinc. It should also be taken into account that the absorption of zinc from food products is reduced by phytates, oxalates, iron and copper, various medicines, penicillamine, sodium valproate and ethambutol[25].

It is important to take preventive measures: inclusion of vitamins and microelements as supplements in target populations, enrichment of soil and food products with microelements. In short, we can consider agriculture as the main tool of public health[35].

Proper nutrition is one of the most important elements of a healthy lifestyle that affects human health and well-being from the moment of conception, through childhood, adulthood, and old age. Food should be safe, not only in terms of broadly understood health quality, including microbiological and technological purity but mainly in terms of nutritional value[36].Good nutrition plays the main role in the formation of nutritional status. As mentioned, good nutrition does not imply only the amount of food, but also a sufficient amount of vitamins and microelements in the daily diet. Food of the 21stcentury is rich in calories and poor in nutrients. The global problem is overweight, and managing obesity involves reducing calories, and an unbalanced and low-calorie diet is the cause of a deficiency of micro-macro elements and vitamins, and on the contrary, when there is a deficiency of micronutrients, uncontrolled weight gain is common.[37]Therefore, childhood is a period of critical vulnerability, but also an opportunity for establishing and consolidating healthy eating habits[38].

Conclusion

Unhealthylifestyle and unbalanced nutrition, especially in children, lead to a violation of the nutritional status, which can become the cause of psychomotor and growth-developmental delay of the adolescent.

Conflict of Interest

The authors declared that there is no conflict of interest.

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