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Article / Review

MICROELEMENTS AND THEIR PHYSIOLOGICAL SIGNIFICANCE FOR THE BODY OF CHILDREN AND ADOLESCENTS

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Abstract. This review article discusses the role of micro and macro elements in pediatrics. A thorough study of the biological role of MEs, carried out in recent years, has made it possible to accumulate factual material reflecting their influence on various physiological functions of the body and, in particular, on the metabolism of a growing organism. About 20 chemical elements take part in the formation and development of various body tissues and their physiological reactions. MEs take an active part in various types of metabolism of proteins, fats, and carbohydrates; influence the course of redox processes, the synthesis of hormones, the functions of the internal secretion organs and the nervous system. The effects of ME, which are part of physiologically active compounds, manifest themselves mainly in their influence on metabolic processes and their too high or too low content is fraught with far-reaching consequences. Knowledge of the physiological level of vitally important, irreplaceable MEs in the body of newborns, the parameters of their balance and significance in the processes of adaptation to extrauterine living conditions will contribute to the development of measures to prevent the implementation of maladaptive syndromes and those diseases in the genesis of which the main role is played by a lack or excess of MEs in the body, their imbalance.

Key words. microelements, children and adolescents, physiological reactions, microelementoses.

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The stability of the biochemical component in maintaining homeostasis of the body is one of the most important and mandatory conditions for its normal functioning(1–6). Accordingly, deviations in the content of certain chemical elements caused by environmental, climatic and geographical factors or occupational diseases lead to a wide range of health problems. Therefore, timely detection and adequate assessment of deviations in the metabolism of macro- and ME in the human body should be considered as a promising direction of modern medicine(1,3,7–10).

It is believed that the doctrine of ME was finally formed and received a promising scientific basis mainly after the innovative work of V.I. Vernadsky (1964). A thorough study of the biological role of MEs, carried out in recent years, has made it possible to accumulate factual material reflecting their influence on various physiological functions of the body and, in particular, on metabolism(6,11–14).

P.J. Aggett (1984) divided ME into three main groups: the first group - essential ME: Fe, Cu, Zn, Mn, Co, Cr, Se, Md, J; the second group is conditionally essential ME: As, B, Br, F, Ni, V and the third group is toxic ME: A1, Ca, Pb, Hg, Be, Ba. An element is considered essential if, in its absence or insufficient supply, the body stops growing and developing, and also cannot carry out its biological cycle(15,16). It should be noted that essential MEs themselves, under certain conditions, can cause toxic reactions, and individual toxic MEs, at a certain dosage and exposure, can exhibit the properties of essential ones(9,10,17).

About 20 chemical elements take part in the formation, development of various body tissues and their physiological reactions: O2, H, C, N, Fe, Cu, Cr, Ca, K, Na, CI, J, Zn, Mn, P, F, S(13,18,19).

It has been established that some MEs are distinguished by high biological activity. Their impact on physiological processes in the body is due to the fact that they actively interact closely with other biologically active substances, such as proteins, enzymes, hormones and vitamins(3,19,20).

MEs, forming organic and inorganic compounds in the body of animals and humans, play an important role in metabolism, including hormonal and enzymatic processes, and maintain a certain constancy of the osmotic stability of tissue fluids.

Most MEs are found in complex protein molecules or metal-protein compounds. This determines their extremely important role as catalysts in biochemical processes(13,21).

MEs take an active part in various types of metabolism of proteins, fats, and carbohydrates; influence the course of redox processes, the synthesis of hormones, the functions of the internal secretion organs and the nervous system(13,20). MEs are necessary to maintain the immunobiological reactivity and resistance of the body. For example, it has been established that the main factor for the occurrence of some endemic diseases of humans, animals and plants is the insufficient or excessive content of certain trace elements in a given area(6,12,13).

Depending on the percentage content of a particular chemical element in a living organism, scientists propose to distinguish between macro-, micro- (ME) and ultra elements(5,13). ME is a group of chemical elements that are contained in the tissues of humans and animals in very small quantities, in the range of 10~3 - 10~12 mg/kg. Changes in the content of ME in the human body can be traced throughout life. Moreover, both their excess and deficiency in some cases are accompanied by certain morpho functional problems. changes in individual systems and organs. MEs are not random ingredients of tissues and fluids of living organisms, but components of a naturally existing ancient and complex physiological system involved in regulating the vital functions of organisms at all stages of development(9,10,22).

One of the vital MEs for the human body is F. The physiological role of this ME is based on the fact that in the adult body, 60-73% of all Fe contained in it is found in hemoglobin. It follows from this that Fe is predominantly involved in the process of hemoglobin formation.

Fe is also part of a number of respiratory enzymes that catalyze respiration processes in cells and tissues: catalase, peroxidase, cytochromes. Oxidation processes in tissues can occur only in the presence of oxidases, which contain Fe in the form of a metal complex.

Functional and anatomical disorders of the gastrointestinal tract, including low acidity and various pathomorphological changes associated with it, ultimately leading to gastritis of varying degrees of severity, atrophy of the mucous membrane of the stomach and duodenum, have long been observed in iron deficiency anemia(21,23). To this we can add that the development of atherosclerosis of the coronary vessels is combined with a decrease in the content of Fe in the blood serum and an increase in cholesterol levels. There is an opinion that this fact can be explained by increased accumulation of Fe in bile(14).

For many years it was believed that a decrease in hemoglobin levels was a direct consequence of insufficient iron levels in the body. It is believed that other heme-containing proteins are, to one degree or another, involved in the processes under consideration.

It has now been established that under conditions of limited supply of Fe in tissues, the content of various iron-containing enzymes noticeably decreases. Most often, these changes are the leading reason for the lack of correspondence in some patients between the severity of clinical symptoms of the disease and indicators of anemia(3,20).

It is known that Zn is essential for the body's ME. It is found in all human organs. The most important aspect of the biological activity of Zn is its participation in the construction of the enzyme carbonic anhydrase. Zn is also an activator of other enzymes involved in the metabolism of carbohydrates and proteins. Zn ions themselves have a catalytic effect. With Zn deficiency in animals and humans, the intensity of protein and nucleic acid synthesis decreases, and, as a consequence, growth retardation is observed(1,10).

Zn, along with other metals (Cr, Mn, Ni), is part of RNA and stabilizes its structure. Zn is able to inhibit the activity of ribonuclease, and in the liver of animals, with insufficient Zn content, the rate of RNA decay increases. The rate of protein synthesis also determines the regeneration process: it was found that the administration of Zn sulfate contributed to faster healing of wounds(10,16,24). It is assumed that Zn is one of the elements that initiates the process of esophageal cancer. There is an opinion that changing the nature of Zn bonds with protein disrupts the normal inclusion of Zn in the mitotic process, and this can cause malignant degeneration of cells(25).

The mechanism of Zn participation in physiological processes is explained. its presence in the tissues of the endocrine glands (deposited in the pituitary gland, testes, pancreas), in enzymes (it is part of carbonic anhydrase, dehydropeptidase and many others), as well as in vitamins (it interacts with thiamine and ascorbic acid),(9,21). Cu is an essential element, a biotic, the lack of which in the body leads to very significant metabolic disorders(2,6,9). Cu has a comprehensive effect on the human body, taking into account existing biochemical connections with enzymes, hormones and vitamins.

This ME is found in all human organs and tissues, and most of it is found in the liver(1,26). It is this organ that is considered as a "depot" of Cu in the body, from which, if necessary, this ME can be transported to other organs(3,27).

The importance of Cu in the body is varied; its participation in the processes of tissue respiration and blood circulation is most important. Cu is an essential component of a number of oxidative enzymes, for example, ascorbic oxidase, which oxidizes ascorbic acid (vitamin C), as well as an enzyme that catalyzes the first steps of the oxidative conversion of lower fatty acids into acetic acid, and a number of others(5,21,28). In addition, Cu is necessary for the formation of such important respiratory enzymes as cytochrome and cytochrome oxidase. These; enzymes participate in the oxidative breakdown of substances that make up the process of tissue respiration(29,30). Cu in the body is also necessary for the normal process of blood formation(1,9). It is this important role that is associated with the accumulation of Cu in the bone marrow (especially in children), as well as in the liver of the embryo. Although not part of the blood coloring substance hemoglobin, Cu is nevertheless necessary for its formation(6,9). The importance of Cu for the process of formation of young forms of red blood cells—reticulocytes—is obvious(14,21,30).

Cu has a noticeable effect on increasing the immunobiological stability and resistance of the body to the harmful influence of environmental factors. The participation of Cu in the body's defense reactions is especially noticeable(3,15,24). It has been proven that in this case there is a natural increase in the Cu content in the blood. It is assumed that the protective effect of Cu may manifest itself in the active formation of antitoxins(2,8). A number of authors consider an increase in the content of Cu in the blood of pregnant women as a protective reaction of the body against the accumulation of toxic metabolic products in the fetus(10,18,20). The presence of Mn has been detected in all plant and animal organisms. So, according to A.P. Avtsina, (1991), N.A. Agadzhanyan, (1998), A.V. Kudrina, (2000), the Mn content in the human body averages 10-12 mg/70kg. The liver is the main organ where this ME accumulates. It is known that Mn binds to certain enzymes, hormones, and vitamins and through these connections reveals its influence on various functions of the body. The participation of Mn in enzymatic systems manifests itself in the form of nonspecific activation or its inclusion as an essential metal locomotive in the composition of their molecules(13).

Mn helps to increase the breakdown of tissue proteins and enhances the excretion of nitrogen from the body. This ME also has a significant impact on hematopoietic processes. Mn salts help increase the titer of hemolysin and agglutinin in the blood of actively immunized animals. It has now been proven that during the body's protective reactions there is a natural increase in the blood content of a number of trace elements, including Mn. The increase in Mn content in the blood observed in some diseases is obviously a protective reaction of the body against the accumulation of toxic products. Toxic doses of Mn cause leukocytosis, a shift of neutrophils to the left (9,18) .

Co belongs to a group of elements widespread in nature. Being a vital biotic, it accumulates in the largest quantities in the liver and kidneys, less in the pancreas and even less in other tissues. This ME is an important factor in the implementation of the hematopoiesis process. It is considered as a catalyst that promotes a more rapid transition of deposited iron into the hemoglobin of new red blood cells(4,21).

Co preparations are valuable medicines, very successfully used in combination with Fe and Cu in the treatment of anemia. This confirms the assumption that there is a connection between anemia and a lack of Co and Cu in the diet of children(9,14).

Co is associated with the activity of enzymes, vitamins, and hormones. It affects protein, fat, carbohydrate metabolism; its influence affects the reproduction function and growth of the organism. Co promotes the synthesis of muscle proteins, has a positive effect on nitrogen assimilation and increases basal metabolism; in small concentrations it promotes the accumulation of protein in the body(1,12,27,28). Co has the property of activating some enzymes and inhibiting others, thus affecting metabolic processes. Under the influence of Co, the activity of bone and intestinal phosphatase, carboxylase, arginase, catalase and many other enzymes increases(29). The first reports on the level of Ni content in plants were made by V.I. Vernadsky (1938). According to data from A.O. Voinar (1964), the main organs that deposit Ni in the human body are the liver and kidneys(2,9,11,12).

V.V. Kowalski (1970) experimentally studied the effect of Ni on the activity of digestive juices. Depending on the dose used, the ME in question had an activating or inhibitory effect on the activity of digestive enzymes. It was shown that in low concentrations (0.02-0.5 mg) Ni chloride increased, and in high concentrations (from 0.5 to 20 mg) weakened the activity of pancreatic amylase and salivary amylase. Ni salts in amounts from 0.001 to

10 mg increased the activity of pancreatic lipase. Low concentrations of Ni salts (0.001-1 mg) activated, and high concentrations (from 2 to 20 mg) inhibited pepsin(13).

The assumption about the specific participation of Ni in hematopoiesis was made by A.O. Voinar (I960), V.A. Leonov (19631, A.V. Skalny (1996), A.P. Avtsyn (1991), N.A. Agadzhanyan (1998), Gaerfner A., Weser U. (1986), Oberleas D. (1996).' Ni salts administered parenterally caused an increase in the number of red blood cells and hemoglobin in the blood of rabbits and guinea pigs. When Ni salts were administered to donors (0.005 mg per day), not only the levels of hemoglobin and red blood cells increased, but also plasma proteins(1,4,5,12,27).

Interest in Cd, Pb and Hg is most often limited to the idea of their toxic effects on various organs and systems of the human body. Contact with these MEs in people of childbearing age increases the likelihood of mutations in female and male germ cells(12,14,17). Conditions for the accumulation of higher concentrations of lipophilic substances. Clinically, this is manifested by infertility, spontaneous abortions, stillbirths of children with signs of congenital deformities].

Data from experimental studies indicate that even small amounts of Pb and Cd entering the mother's body reach the developing structures of the embryo and, as a rule, cause its death(14).

Epidemiological studies have shown that women exposed to combined exposure to metal pollutants (which include Pb) are more likely to experience spontaneous abortions, infertility and stillbirths, as well as the birth of low-birth-weight children(1,3,6,19,22,24).

Thus, the actions of ME, which are part of physiologically active compounds, manifest themselves mainly in their influence on metabolic processes and their too high or too low content is fraught with far-reaching consequences.

Therefore, knowledge of the physiological level of vitally important, irreplaceable MEs in the body of newborns, the parameters of their balance and significance in the processes of adaptation to extrauterine living conditions will contribute to the development of measures to prevent the implementation of maladaptive syndromes and those diseases in the genesis of which the main role is played by a lack or excess of MEs in body, their imbalance.

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