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ЦИНК ТА ЙОГО РОЛЬ ДЛЯ ОРГАНІЗМУ ЛЮДИНИ

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ZINC AND ITS ROLE FOR THE HUMAN BODY

Анотація.
Серед есенціальних мікроелементів цинк грає найважливішу роль в регуляції гомеостазу організму людини, що пов'язано з структурною та каталітичною роллю цинкзалежних ензимів. Рівень світової смертності, внаслідок мікроелементозів становить 6%, а кількість людей, що страждають від гіпоцинкозів, – більше 1,1 млрд. Клінічні прояви недостатності цинку відображаються в комплексному порушенні роботи імунної, нервової, травної, серцево-судинної систем.

Abstract.
Among the essential trace elements, zinc is crucial in regulating the homeostasis of the human body, which is associated with the structural and catalytic role of zinc-dependent enzymes. The global mortality rate due to trace elements constitutes 6%, and the number of people suffering from hypozincosis represents more than 1.1 billion incidents. Clinical manifestations of zinc deficiency may exhibit complex disorders of the immune, nervous, digestive, and cardiovascular systems.

Ключові слова: *Цинк, ферменти, імунітет, ковід, патологія внутрішніх органів.*
Key words: *Zinc, enzymes, immunity, Covid-19, pathology of internal organs.*

Main part. Zinc is one of the most essential and indispensable trace elements for the human body. The first work on its study dates back to 1963. Its biological role was established in 1969 when J. Raulin showed the necessity of this element for the growth of the fungus *Aspergillus niger*. Subsequently, the importance of zinc for plant and animal growth was confirmed. The main symptoms of zinc deficiency of varying severity are the following: diarrhea [1], immune dysfunction [2], infection [3], memory loss [4], and cognitive impairment [5]. Zinc deficiency was considered a risk factor for anemia [6], gastrointestinal dysfunction [3], and hypogonadism [6].

The body of an adult contains 1.5-3 g of zinc. Zinc can be observed in all organs and tissues, but the most considerable amount is found in the prostate, semen, skin, hair, muscle tissue, and blood cells.

The content of zinc in the human body, according to the literature, is the following:

- in general: 1.3-2.3 g / 70 kg;
- in the blood: 4-8.6 mg / l;
- in urine: 0.005-0.85 mg / l;
- in the hair: 50-400 mg / kg.

In children during the first year of life, the serum zinc content averages 6.5-7.5 mg / l; this figure does not change with age. According to the WHO, the optimal intake of zinc in the body is recommended in the following quantities: for children under 6 months: 3 mg / d; 6 months - 1 year: 5 mg / day, 1 year - 6 years: 10 mg / day; for children from 10 years and adults: 15 mg / day.

Zinc enters the body with food. Food rich in mineral ***zinc*** includes beef, liver, seafood, rice bran, wholemeal flour, carrots, onions, and nuts. The need for micronutrients increases during intensive growth and pregnancy, amounting to 20-25 mg/day. Zinc deficiency can develop with insufficient intake of this element in the human body (1 mg/day or less), and the threshold toxicity is 600 mg/day.

Zinc plays an essential role in skin regeneration, hair and nail growth, and sebaceous gland secretion. The main supply of zinc (about 30%) in the human

body is contained in bone tissue. The zinc concentration promptly decreases when it is insufficient in the body or results from impaired absorption, so zinc deficiency leads to defects in the development of the skeletal system.

Zinc is required for protein synthesis, including collagen and bone formation; involved in the functioning of insulin and antioxidant enzyme superoxide dismutase, sex hormones, and dihydrocorticosterone; participates in hematopoiesis, and slows down the apoptosis of peripheral cells.

A number of studies conducted in the late 80's - early 90's of the last century found a correlation between the content of minerals in the bones of the forearm with the absorption of zinc in postmenopausal women, indicating the effect of this trace element on bone mass. It has also been shown that zinc absorption decreases with age, especially in women, and is negatively associated with postmenopausal bone loss. A randomized, double-blind, multicenter, prospective ZENITH study conducted at four research centers in France, Italy, and Northern Ireland demonstrated the relationship between zinc nutritional status and biochemical markers of bone remodeling [7].

A study by Ceylan MN, Akdas S, Yazihan N. showed significant associations between zinc supplementation and alkaline phosphatase levels, osteocalcin levels rather than parathyroid hormone levels, and alkaline phosphatase levels in bone. It is the mineral density of the femoral neck, not the lumbar spine that could benefit from the consumption of zinc supplements in the general population [8].

The skin contains 5% of zinc of its entire amount in the human body. It is involved in the synthesis of collagen, and ulcers, burns, wounds, and other skin lesions result from a deficiency in this element. Therefore, Zn is a part of wound healing agents and is actively used in medicine. Applying this substance in large or small quantities can lead to androgenic and focal alopecia. In addition, zinc deficiency, as well as its overdose, adversely affects hair growth and health.

Zinc can be an extracellular structural element and an intracellular signaling element. Free Zn is found in low concentrations, i.e., from nanomoles to micromoles. The ability to participate in the processes of ligand formation with organic molecules explains the extensive range of its participation in various biological systems. This is accompanied by the relative safety of this element, especially the lack of oxidative properties (unlike iron and copper), which improves the transport and metabolism of zinc in the body and the rapid biological uptake by cells. Zinc deficiency is associated with the development of severe diseases of organs and systems, premature aging, pathology of fetal development, the emergence of genetic defects, and in recent years also, the pandemic COVID-19.

Zinc acts as a secondary messenger for immune cells [3]; its ions are critical for the processes of formation and regulation of the activity of cellular enzymes and transcription factors. Thus, the normal range of zinc content is necessary for the immune system to work. The element also has detoxifying properties, i.e., it promotes the excretion of carbon dioxide, absorption of vitamin E in the intestine, and maintaining its average concentration in the blood. In addition, zinc is well known as an antioxidant and stabilizer of cell membranes.

Immunological disorders are the earliest preclinical signs of zinc deficiency. Studies suggest that zinc deficiency causes lymphopenia, thymic atrophy, and suppression of T-cell immune function. Many papers discuss possible mechanisms of zinc-dependent depression of the T-immune system. Animal experiments and in vitro studies have shown that zinc deficiency induces Fas / Apo1-mediated apoptosis of many cell lines, and the restoration of reduced zinc concentrations inhibits the mechanism of programmed cell death.

Zinc deficiency adversely affects the immune response, such as phagocytosis, intracellular destruction of pathogens, cytokine production, T-helper activation, clinically accompanied by atrophy of the thymus, lymphoid tissue, and increased risk of infection [5]. The work of Bruce Korant (1973) proved the presence of antiviral activity in zinc, which is realized by inhibiting the replication of viruses. Zinc has an antiviral effect against herpes simplex virus type 1 and 2, enterovirus and others.

Given the above facts, the administration of zinc drugs in treating coronavirus infection seems clear. Decreased zinc levels facilitate the interaction of SARS-CoV 2 spike protein with ACE2, and elevated zinc levels inhibit ACE2 expression, which counteracts virus binding [8]. Several studies suggest that low blood zinc levels correlate with more severe disease. Therefore, researchers propose to determine the level of zinc in the blood as a biomarker for predicting the course of COVID-19 and call for randomized clinical trials of zinc as a promising treatment and prevention.

In case of additional zinc intake at <20 mg per day, the incidence of acute respiratory infections in children decreased by 35% [8]. In particular, the incidence and prevalence of pneumonia were 13% and 41% lower, respectively, in children receiving zinc [10]. However, low doses of zinc could not to significantly reduce the risk of lower respiratory tract infections in children [11].

After taking more than 20 mg of zinc daily, adults with acute viral respiratory infections (including COVID-19) were 1.83 times more likely to recover than placebo, and there was also a clinically significant reduction in median duration and symptoms were also observed at day 3 [12].

It is interesting to note that in case of eating disorders, especially in vegetarian diets, there may be a violation of zinc absorption, which may negatively affect the development of gastroduodenal pathology. A number of researchers indicate that hypertrophic, subatrophic, erosive (according to endoscopy) and diffuse (according to morphological studies) changes in the duodenal mucosa and antrum of the stomach correlated with lower serum zinc. The exacerbation phase of chronic gastritis and duodenitis was more common in patients with low serum zinc. The inclusion of therapeutic doses of zinc in the complex treatment contributed to the emergence of positive clinical and laboratory dynamics [13].

Neurological pathology in zinc deficiency is actively studied by many researchers. Scientists suggest that zinc may enhance DNA / RNA polymerase activity in neurons, as well as protect cell membranes from oxidative stress and inflammation. Other mechanisms include regulation of neurotransmitter activity, increase in gamma-aminobutyric acid, a neurotrophic factor of the brain, and simulation of antidepressant activity to normalize brain function. Thus, zinc may be indicated to treat mood disorders and neurodegenerative diseases [14-17].

Clinical neurological signs of zinc deficiency in children are dysarthria, depression, emotional lability, and impaired concentration ability. Zinc deficiency in the antenatal period contributes to the violation of the formation of behavioral reactions, reduced intellectual potential, and impaired motility. Autism spectrum disorders are among the most common in pediatric neurology. The pivotal place in developing these disorders occupies the intrauterine deficiency of minerals, primarily zinc, which complicates pregnancy and defects in fetal development, and dysfunction of its organs and systems [18]. Zinc deficiency in pregnant women may coincide with low iron, folic acid, changes in copper levels, and antibiotics [19].

Supplemental zinc intake above 20 mg per day was not associated with improved sperm viability or increased sperm count. However, adequate zinc supplements for adults improved sperm motility, concentration, morphology, and volume compared with no intake. Thus, it was found that the clinical incidence of pregnancy increased sharply by 343% [20-22].

Paying attention to lipid metabolism indices, the addition of zinc in high doses is associated with a decrease of 10.92 mg/dl, 6.87 mg/dl, and 10.29 mg/dl for triglycerides, low-density lipoprotein cholesterol, and total cholesterol (TC), respectively. In contrast, an unobvious increase in high-density lipoprotein cholesterol has also been identified [19].

Atherosclerotic plaque (AP) instability is a major cause of myocardial infarction (MI) and stroke. The tendency of carotid atherosclerotic plaque to rupture is an independent risk factor for coronary atherosclerosis and MI. There has also been an association between zinc deficiency in various bio-substrates and the development of obesity, type 2 diabetes, hypertension, coronary heart disease (CHD), and atherosclerosis [24-25].

A significant inverse correlation was found between the thickness of the intima-media complex of the common carotid artery and the zinc content in the serum, which is consistent with the literature. In the case of atherosclerosis progression, the degree of impressions increases, whereas the level of zinc in the serum decreases, which is associated with a reduction in zinc level in atherosclerotic plaques. Decreased zinc concentration in hair is accompanied by a reduction in zinc levels in biopsies of atherosclerotic plaques [26].

The results of the study can help select patients at high risk of cardiovascular incidence, and the use of appropriate analytical approaches makes it possible to predict the instability of atherosclerotic plaque [27].

Zinc also plays a vital role in alcohol metabolism, so a deficiency in this trace element can increase the susceptibility to alcoholism (especially in children and adolescents). The catalytic role of zinc concerning alcohol dehydrogenase activity, changes in its substrate activity, and oxidizing properties have been proved.

Conclusions. Thus, the trace element zinc is one of the essential trace elements, which has anti-inflammatory, antiviral, antioxidant, and immunomodulatory properties.

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