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FUNCTIONING OF COENZYME IN HUMAN BODY

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Abstract:
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Physiological basis of the entire life of the body is the various biochemical reactions (processes) occurring in the body. Their course largely depends on the enzymatic systems of the body. These systems perform one of the important functions - maintaining homeostasis by accelerating biochemical reactions, as they are natural catalysts. Coenzymes in function, being enzymes, they serve as activators of physiological processes - hematopoiesis , coagulation and anticoagulation system of blood, defiring of cells, and the like. Koshland's research explained the high specificity and stable transition state, since enzymes are flexible structures. Some enzymes can only perform their functions in the presence of specific components - coenzymes or coenzymes. Coenzymes are non-protein compounds involved in the process of catalysis together with enzymes , they can also be called activators, assistants of biochemical transformations.

Coenzyme Q10 (Q10) is the most important element of our body. It is present in all cells, is the strongest antioxidant, protects against heart disease. As a person grows older, its concentration decreases. And it is not so easy to fill its deficit. The daily requirement is about 100-200 mg. Q10 deficiency causes diseases associated with various systems of the human body:

- Diseases of the cardiovascular system (ischemic heart disease, heart failure, arterial hypertension);
- Oncological diseases
- Diseases of the endocrine system (diabetes mellitus)
- Neurodegenerative diseases (Alzheimer's disease, Parkinson's disease);
- Violation of the contractile function of the myocardium;
- Decreased performance, apathetic mood;

- Reduced stress resistance, irritability, "moral" fatigue;
- Decreased attention, ability to concentrate;
- Decreased immunity, frequent colds and chronic diseases;
- Muscle weakness, increased fatigue;
- Disorders of the endocrine system;
- Violation of the work of organs and systems ;
- And much more.

Coenzyme Q10 consists of two parts: a quinoid component and ten carbon atoms. The main distinguishing feature of a substance is that it is capable of both accepting and donating hydrogen ions. When Q10 attaches hydrogen ions, it is called ubiquinol (reduced form). And when the process of ion recoil occurs, then Q10 is called ubiquinone (oxidized form).

By themselves, coenzymes are catalytically inactive, as are apoenzymes without coenzymes. Thus, the formation of an apoenzyme-coenzyme complex is one of the ways to regulate enzyme activity in the body.

It is also not uncommon for coenzymes to be divided into inorganic ions and complex organic molecules called coenzymes.

The group of inorganic coenzymes usually includes the following metal ions and their location in the human body:

Ions	Localization
Iron(Fe)	- Nitrogenase, catalase
Copper(Cu)	- Cytochrome oxidase
Zinc(Zn)	- DNA polymerase, carbonic hydrase
Magnesium(Mg)	- Hexokinase, glucose-6-phosphatase, DNA polymerase

Organic coenzymes are associated with enzymes and can only be separated by enzyme denaturation despite their small mass and therefore they are called prosthetic group. As an example, the following substances can be given: vitamin-like coenzymes (precursors of vitamins of group B, K, C), not vitamin-like (ATP, Ubiquinone, Heme)

Vitamin	Additional component	Coenzyme
Thiamine- B1	Pyrophosphate	Thiamine pyrophosphate
Riboflavin- B2	ADP	Flavin adenine dinucleotide
Riboflavin- B2	Amino acids	coenzyme F420
Riboflavin- B2		Flavin mononucleotide
Niacin- B3	ADP	NAD+ and NADH +

Pantheonic acid - B5	ADP	Coenzyme A
Pyridoxine - B6		Pyridoxal phosphate
Folic acid - B9	Residues of glutamate	Tetrahydrofolic acid
Cobalamin- B12	methyl group	Methylcobalamin
Cobalamin- B12		Cobalamin
Biotin- N		Biotin
Vitamin K		Menaquinone
Vitamin C		Ascorbic acid

Vitamin dissimilar coenzymes

Coenzymes	Chemical group
adenosine triphosphate	- Phosphate group
S – adenosylmethionine	- Methyl group
Coenzyme Q	- Electrons
Cytidine triphosphate	- Diglycerols
Gem	- Electrons

It is worth noting that some enzymes are active in combination with several coenzymes called complexes.

Clinical studies of the use of Q10 in many patients prove the essential role of ubiquinone deficiency in the development of cardiac pathology. It has been shown that if the level of Q10 falls by 25%, then the cells experience an energy deficit and the bioenergetic metabolism of the heart muscle worsens. A decrease in the content of Q10 by 75% leads to cell death. coenzyme Q10 improves mitochondrial energy production, shunts defective components of the respiratory chain, and reduces the effects of oxidative stress. coenzyme Q10 affects energy metabolism in the muscles of polio patients. Influences Q10 on peripheral blood circulation in muscles, mitochondrial phosphorylation and antioxidant effect. coenzyme Q10 stimulates the energy burning of fats, enriches adipose tissue with oxygen, which ensures effective weight loss.

One can note the ability of Q10 to “reduce” the toxicity of drugs. Many drugs used in modern medicine have an undesirable effect on the mitochondrial respiratory chain. At the same time, the site of action of such pharmacologically active compounds is usually the same sections of the respiratory chain, in which the transfer of electrons between Q10 and other electron carriers occurs. Therefore, the additional amount of Q10 helps to reduce drug toxicity.

The consumption of ubiquinone increases in cases of an increase in the body's need for cellular energy: during physical and emotional stress, with colds, prolonged stress, during periods of recovery and rehabilitation, during pregnancy, during periods of growth and development of children, etc. Lack of Q10 leads to a

decrease in cellular energy production, which directly affects the functioning of all body systems. A slight decrease in ATP production leads to disruption of energy-dependent processes in the cell, it cannot fully perform its physiological functions.

The progression of various cardiac diseases is based on an increase in the number of reactive oxygen species and a decrease in the possibilities of biological protection - the antioxidant system.

The reduced form of Q10 is found in all cell membranes, blood plasma and lipoproteins. coenzyme Q10 successfully protects membrane phospholipids and low density lipoproteins from peroxidation, as well as mitochondrial membrane proteins and mitochondrial DNA from damage by free radicals.

From a physiological point of view, coenzymes play an important role , as they are components of the tricarboxylic acid cycle for energy production as ATP (NAD^+, FAD^+, thiamine pyrophosphate and others). A decrease in the amount of vitamins, and therefore, coenzymes, leads to a decrease in the efficiency of biochemical reactions, the production of ATP, and a decrease in the permeability of biomembranes. This leads to various disturbances in the functioning of the body observed in symptoms and diseases. Ubiquinone (Q10) is a representative of benzoquinines containing isoperyl groups and in humans there are 10 of them (coenzyme Q10), it is a fat-soluble substance, as well as an antioxidant regenerated by the body itself, it should be borne in mind that in the reduced form it is much stronger than the oxidized form. It is found in the mitochondria of eukaryotes, takes part in oxidative phosphorylation. By chemical nature, it is similar to vitamins E and K. The main source is its biosynthesis in the body from mevalonic acid and derivatives of phenylalanine and tyrosine.

Today, two main functions of Q10 in living organisms are known. It is involved in the production of energy in any of the cells. The discovery of the role of Q10 in the electron transport chain, that is, its energy -forming function, was awarded the Nobel Prize. coenzyme Q10 in mitochondria is involved in ATP synthesis as an electron carrier, conjugating the processes of electron transport and oxidative phosphorylation . Another important function of Q10 is antioxidant. Q10 is the only fat-soluble antioxidant that can be synthesized in the body of humans and animals, as well as constantly regenerated from the oxidized form with the help of enzyme systems. The immediate (direct) antioxidant effect of Q10 is to scavenge free radicals. Due to its ability to dissolve in fats, Q10 is most represented in lipid structures - membranes, liposomes, low density lipoproteins (LDL). Plasma Q10 concentration is proportional to LDL concentration . Oxidation of plasma LDL is one of the starting points in the development of atherosclerosis and other diseases associated with increased formation of free radicals. Q10 is able to prevent the development of chain reactions of free radical oxidation, including peroxidation of cell membrane phospholipids and plasma lipoproteins. Another unique property

of Q10 is the constant regeneration of its oxidized form with the help of the body's enzyme systems and non-enzymatic antioxidants, which restores its antioxidant activity. The indirect antioxidant action of Q10 is to prevent the formation of phenoxyl radicals of alpha-tocopherol, that is, to prevent the possible pro- oxidant action of alpha-tocopherol. Alpha-tocopherol, or vitamin E, is another fat-soluble antioxidant (in human blood plasma), along with Q10, which is present in large quantities in the inner membrane of mitochondria. With a lack of Q10, alpha-tocopherol in the reduced form begins to act as a pro-oxidant, triggering lipid peroxidation reactions, including the oxidation of atherogenic LDL. Thus, Q10 as an antioxidant inhibits the development of atherosclerosis through two mechanisms, trapping free radicals and preventing the prooxidant action of vitamin E.

Q10 deficiency dietary, since it is contained in food in trace amounts . The recommended dose of Q10 per day in the world has not been established, which is associated with the body's ability to synthesize it. coenzyme Q10 is closely related to the work of such organelles as mitochondria and its deficiency causes a decrease in ATP production, as a result of which this leads to a decrease in the activity of organs and tissues. The regulation of Q10 is carried out by genes, and in various genetic pathologies, its metabolism is disturbed (Down's Syndrome). This is due to autosomal recessive mutations, mitochondrial diseases, various carcinogens .

Pathologies of the cardiovascular system are a prime example of coenzyme Q10 deficiency . Studies have shown that the cause of diseases of the cardiovascular system is a low concentration of Q10 , as a result of which energy production in mitochondria decreased. It is also worth noting that oxidative stress also causes diseases of the cardiovascular system and a low concentration of the coenzyme antioxidant system (antioxidant enzymes) weakens, leading, for example, to atherosclerosis.

The decrease in the concentration of the coenzyme can be exogenous or endogenous in nature. In the first case, the intake of the coenzymes themselves, as well as their vitamins, is reduced. This may be due to hunger, a disturbed diet, and an unfavorable environment. In the second case, this is due to the organs of the gastrointestinal tract, which are involved in the absorption of nutrients, genetic diseases, biosynthesis disorders due to aging of the body, and others.

Of all of them, the most important at the moment are the violation of the diet, as well as changes in the environment. This is due to the preference of young people to eat fast food, environmental degradation due to industry and transport, all this leads to various kinds of diseases due to a lack of substances necessary for the body.

To prevent deficiency of enzymes and coenzymes, it is worth normalizing nutrition by eating healthy foods. But in cases of genetic dysregulation, the intake

of coenzymes from outside is preferable, the toxicity of synthetic Q10 has not been identified. Various studies report the results of studies on different dosages depending on the disease. Preparations based on ubiquinone are effectively used in various fields of clinical medicine. For example, in cardiology, treatment of chronic heart failure, endocrinology, nephrology and even cosmetology, as well as in the following cases:

- Genetic disorders of synthesis.
- Taking statins (in this case, the goal of Q10 is to reduce their negative effect on the muscles);
- Some forms of infertility. There is such a condition - ostenozoospermia, when the percentage of actively motile spermatozoa in the semen drops;
- Dystrophy of muscle tissue;
- Metabolic disorders;
- Correction of immunity;

The oxidized form of Q10 (ubiquinone) is optimal for people under 30, as the body is still able to convert it to ubiquinol. But with a deficiency of selenium and zinc in the diet, this process slows down. A reconstituted (ubiquinol) more bioavailable form for people over 30. coenzyme Q10 is much better absorbed with fat-soluble vitamins (A, E, D, K) or foods rich in fats.

Rapid depletion of Q10 reserves is observed during intense physical or psycho-emotional stress, serious illnesses and operations, taking cardiotoxic drugs. Cytostatics (doxorubicin, adriamycin), as well as when taking drugs widely used in the clinic, such as statins. The content of Q10 in tissues decreases with aging. In cardiac patients, the content of Q10 in the body is 25% below normal. After 60 years, the content of Q10 in the myocardium is only half the level recorded at 20 years. Inhibitors of the liver enzyme KoA - reductase, or statins, which are widely used in the world for atherosclerosis, also inhibit the body's ability to produce Q10 by affecting the mevalonate biosynthesis pathway common to Q10 and cholesterol. After the use of statins , the content of Q10 in plasma may decrease. The positive effect of Q10 on the myocardium has been best studied. The heart muscle, which has been working non-stop throughout human life, is extremely sensitive to ATP deficiency. Over the years, as the disease progresses, the proportion of functionally active cardiomyocytes decreases. The content of Q10 in the heart decreases proportionally. A number of animal experiments and clinical studies have shown that taking Q10 increases myocardial contractility, reduces the length of stay in the hospital after heart surgery, accelerates rehabilitation after myocardial infarction, improves the endurance of cardiac patients, especially the elderly. In the retina, as in many other tissues, the content of Q10 decreases with age. When comparing Q10 concentrations in the retina of people younger than 30 and older than 80 years, a significant decrease in Q10 levels by 40% was shown in older people. In the

literature, there are indications of a protective effect of Q10 in relation to retinal neurons with an increase in intraocular pressure.

The contribution of Q10 to the health and youth of the body is manifested in the following:

- In order for ATP energy to form in the mitochondria and cellular respiration to take place, it needs hydrogen ions, the "donor" of which is Q10. In more detail, it carries out in mitochondria the transfer of electrons from membrane dehydrogenases to cytochromes. ATP, in turn, is a source for the synthesis of nucleic acids, regulates the activity of various enzymes, and controls appetite. Accordingly, the lower the Q10 concentration , the worse these processes occur.
- Participates in the oxidation of fatty acids in mitochondria. This also leads to an increase in the energy supply of the cell.
- Provides powerful antioxidant protection. coenzyme Q10 "catches" free radicals and reactive oxygen compounds inside mitochondria, protecting them from damage, thereby preventing the appearance of oxidative stress. The coenzyme also protects low-density lipoproteins, phospholipids and mitochondrial DNA from free radicals.
- Reduces the level of gamma - glutamyltransferase, which is a marker of metabolic stress. A high level of this enzyme in the blood may indicate the presence of cirrhosis of the liver, cancer of the prostate, pancreas, breast, infectious mononucleosis.
- It promotes the activation of another important antioxidant - vitamin E. This is an important function, since free radicals oxidize, change the structure, destroy cells and DNA chains, which leads to the appearance of neurological, oncological diseases, heart disease, diabetes, Alzheimer's and Parkinson's.
- Regulates the growth and division of cells on cell membranes. Stimulates the production of lymphocytes, increases both their total number and specific subpopulations - NK cells (a subspecies of lymphocytes that fight viral and cancer cells).
- Reduces the ability of monocytes to stick to the walls of blood vessels. And the first stages of the development of atherosclerotic changes are precisely in the fact that monocytes begin to adhere to the damaged endothelium, then turning into macrophages and accumulating modified lipoproteins.
- Increases the synthesis of nitric oxide. It is needed so that the vessels relax, and their lumen expands. This is how the regulation of blood flow to the organs and the stabilization of blood pressure occurs.
- Improves female and male reproductive function. A high level of Q10 improves the quality of eggs and sperm, protecting them from oxidation.

The totality of data indicates a decrease in the content of Q10 with age, which reduces the potential of the endogenous antioxidant system of the body. At the same time, with age, free radicals are formed more intensively, which is the mechanism for the development of many pathological manifestations in elderly patients. Preventing oxidative damage to cell membranes slows down the aging process. Coenzyme Q10 is indicated for the prevention of the development of a number of diseases, of which diseases of the cardiovascular system are of the greatest importance in the structure of mortality. Thanks to the functions and properties of Q10 , myocardial contractility increases, blood flow improves, the level of natural energy and cognitive functions is maintained, exercise tolerance increases, the harmful effects of free radicals are reduced, and the aging process and apoptosis slow down.

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