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The value of iodine as a trace element in sports

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Abstract
The high physical activity inherent in modern sport, determines the special requirements for the energy supply system of the athlete's body, different from those presented to ordinary people. A sports result depends on how efficiently an athlete’s body can mobilize its energy resources. First of all, this concerns the thyroid glands, the extremely important role of which in the regulation of energy metabolism in the body is not in doubt. The high correlation between the levels of iodine in the urine and blood lactate before and after exercise, recommend ioduria as a reliable biochemical marker for assessing both the iodine status of athletes and the effectiveness of the body's energy supply systems during muscle activity and during recovery processes.

Keywords: Sports, athlete, iodine, iodine deficiency, hormone, energy, disease

Introduction
The high physical loads inherent in modern sport make special demands on the energy-supplying system of the athlete's body. The sports result depends on how efficiently the athlete’s body can mobilize and use energy substrates and how completely a regulation system for these processes will be formed. Of particular interest in this regard is the physical work in the submaximal power zone (middle-distance running, cycling, swimming short distances, etc.), in which all types of energy supply are realized, with the primary glycolytic mechanism of ATP resynthesis, characterized by a high rate of lactic acid accumulation, which reduces the activity of key enzymes of glycolysis and the respiratory complex of mitochondria and thereby reduces the effectiveness of both anaerobic and aerobic mechanisms of energy generation. In the adaptation of athletes to physical activity, including submaximal power, the priority is given to the pituitary - adrenal cortex system, with this, the role of other hormonal systems in the processes of adaptation to such loads is not well understood. First of all, this concerns the thyroid gland, whose extremely important role in the regulation of energy metabolism in the body is not in doubt. At the same time, an adequate provision of the body with iodine is a prerequisite for the normal functioning of the thyroid gland, the deficiency of which is one of the most common nutritional deficiencies in the world; Exercise under unfavorable conditions caused by insufficient supply of iodine to the body, as well as insufficient coenzyme forms of enzymes and a complete protein, is accompanied by intense thyroid status and causes a significant decrease in the synthesis of mitochondrial enzymes and the energy-producing function of the cell. At the same time, an analysis of the results of scientific research shows that for athletes, comprehensive studies of iodine status, as well as the effect of iodine deficiency on physical performance and recovery processes after muscle work, including anaerobic - glycolytic orientation, were not conducted. In this regard, the study of the physiological mechanisms of the influence of the iodine status of athletes on adaptation to physical loads of submaximal power seems to be a timely and urgent problem. Despite certain successes in the development of physiological and biochemical control in port, the expansion of the analytical, scientific and methodological base for assessing the iodine status of athletes and the effectiveness of energy supply systems of the body during muscle activity using modern physiological and biochemical research methods also remains relevant. The above list of questions served as the basis for the work, defined its goals and objectives.

Objectives of the study: To determine the value of iodine as a key trace element as a reliable biochemical marker for assessing the effectiveness of the body's energy supply systems during muscle activity and during recovery processes after physical exertion of submaximal power.

Methods and Discussion

The high physical activity inherent in modern sport, determine the special requirements for the energy supply system of the athlete's body, different from those presented to ordinary people. The sports result depends on how efficiently the athlete's body can mobilize its energy resources and how perfectly the system of regulation of these processes works (A.G. Samborsky, 1991; P.C. Suzdalnitsky *et al*., 2000).

Of particular interest in this regard is the physical work in the submaximal power zone (middle-distance running, cycling, short-distance swimming, etc.), which implements all types of energy supply, with a predominant glycolytic resynthesis mechanism [4, 5], characterized high intensity of accumulation of lactic acid, which reduces the activity of key glycolysis enzymes and the respiratory complex of mitochondria and, thereby, reduces the effectiveness of both anaerobic and aerobic mechanisms of energy generation [4, 6, 16, 17]. In the adaptation of athletes to physical exertion, including submaximal power, traditionally priority is given to the pituitary-adrenal cortex system, while the role of other hormonal systems in the processes of adaptation to this kind of exertion is not well understood. This primarily concerns the thyroid gland [1, 2], the extremely important role of which in the regulation of energy metabolism in the body is beyond doubt [6]. High correlation between urine iodine and blood lactate levels before and after exercise, recommend ioduria as a reliable biochemical marker for assessing both the iodine status of athletes and the effectiveness of the body's energy supply systems during muscle activity and during recovery processes after physical exertion submaximal power.

Thyroid hormones perform many key functions in the human body, including regulating body temperature and metabolism. Thyroid hormones bind to receptors on the membrane surface of each cell and in mitochondria. This process activates the energy and metabolic functions of the cell.

For more than a century, thyroid hormones have been recognized in clinical observations and experimental studies as the main regulator of the metabolic rate of the whole organism [15]. In fact, thyroid hormones deeply affect the key metabolic pathways that control energy [10, 17]. Thus, it becomes apparent that the dysregulation of thyroid hormone levels significantly affects body weight and metabolic homeostasis in humans [7, 9]. Reduced energy consumption, leading to weight gain, is observed in patients with hypothyroidism. Conversely, hyperthyroidism (an excess of thyroid hormones) contributes to a hypermetabolic state characterized by increased energy expenditure and weight loss [14].

Iodine is a key trace element that is stored mainly in the thyroid gland. The thyroid gland produces thyroid hormones thyroxine (T4) and triiodothyronine (T3), using iodine and other elements such as selenium and tyrosine. Sufficient levels of magnesium, iron, vitamin C and zinc are also needed.

The ingestion of iodine is associated with proteins in the blood, especially with albumin. Approximately 30% of the iodine enters the thyroid gland, and the rest is excreted in the urine. A person has an average of 15 - 20 mg of iodine in the body with the highest concentration in the thyroid gland (about 70% - 80%). The rest is in the muscles, skin, bones and blood.

Iodine is mostly lost with sweat, although some are also excreted in the urine. Some studies show that athletes can lose more iodine due to sweat during an hour of vigorous training than in their daily urine. High sweating during exercise can lead to depletion of iodine levels and lead to dehydration and decreased activity. The recommended iodine intake is 150 mcg / day, but some studies show that on average, athletes can lose almost 50% of this need only in sweat. Athletes living in humid climates (even without exercise) may have more sweat than those who live in cooler conditions. Exercise under unfavorable conditions caused by insufficient supply of iodine to the body, as well as insufficient coenzyme forms of enzymes and a complete protein, is accompanied by intense thyroid status and causes a significant decrease in the synthesis of mitochondrial enzymes and energy-producing cell function [6, 8, 11, 12, 13, 16, 17, 18]. Athletes performing with high intensity for extended periods of time, especially in a humid environment, significantly increase the risk of iodine deficiency.

It is important to remember that in addition to training, the thyroid gland is affected by many other factors: chronic physical or emotional stress and high levels of cortisol will lead to an increase in the level of another thyroid hormone called reverse T3 (rT3). Heavy metals and chemicals, a low-carb diet, starvation, and selenium deficiency can also lower T3 levels. There are many chemicals and metals in the environment, known as "endocrine disruptions," which interfere with the healthy function of the thyroid gland. Polychlorinated biphenyls (PCBs) and polybrominated diphenyl ethers (PBDEs) are widespread in our environments (in soil and food products grown in this soil, including meat, electronics, electrical cables, paints, plastics, furniture), which can interfere with hormone signaling thyroid gland at receptor levels. Perchlorate in foods and water inhibits the thyroid gland's ability to absorb iodine from the bloodstream, while prolonged consumption of fluorinated drinking water is associated with hypothyroidism (low thyroid function). Others, such as dioxins, BPA (found in sticky films, drinking bottles, and plastic) or bisphenols in canned foods, plastic containers, and plastic packaging, are also endocrine disruptors.

Regarding women's sports, when an athlete has an excess of estrogen, this can reduce the effectiveness of thyroid hormones by 25%. In athletes with high testosterone or insulin resistance, thyroid effectiveness may also be reduced due to the reduction in globulin, which carries thyroid hormone throughout the body. Low thyroid function due to the low content of iodine or other nutrients can also cause receptor sensitivity problems for other female hormones, such as progesterone, causing PMS symptoms, irregular periods and fertility problems. Cortisol increases estrogen levels, and high estrogen levels also increase cortisol, which increases T4 binding by 3 times, which leads to a decrease in the activity of thyroid hormones, a decrease in metabolism and weight gain.

Since thyroid hormones affect the processes in the gastrointestinal tract, athletes with low iodine and thyroid glands can also suffer from problems such as bloating, diarrhea or constipation, food intolerance, reflux, heartburn and dysbiosis, and digestive infections.

Thyroid hormones also affect the basis of our immune system in the digestive tract, called intestinal lymphoid tissue (GALT). GALT consists of several types of lymphoid tissues that store immune cells, such as T and B lymphocytes. Most infectious agents that enter the human body get access through the intestines, and GALT protects us from these pathogens.

Consequently, an athlete may be more susceptible to infections if thyroid hormone levels are low or iodine deficiency exists.

Other nutrients and elements affect iodine and thyroid function. Many athletes suffer from anemia or low iron levels and believe that their fatigue and poor performance may be related to iron. The situation is a double-edged sword, as iron deficiency disrupts the synthesis of thyroid hormones, and low thyroid function disrupts gastric secretion, which reduces the absorption of iron from food.

There is a definite relationship between zinc, copper and thyroid function. Zinc is necessary for the production of T4 and T3, so zinc deficiency can lead to a decrease in gastric secretion and a decrease in iron content. Zinc and copper also counteract each other, so a low zinc content can lead to a high copper content. Excess copper slows down the thyroid gland and depletes zinc.

The concentration of iodine in food varies depending on the concentration in the soil and the amount of fertilizer used in agricultural methods. Thus, the iodine content in food also varies greatly in grain, meat and vegetables. Although the daily recommended iodine intake is 150 mcg, it can be difficult even with iodine sources of food due to such variability.

Metabolic acidosis is a condition where the body's pH is too acidic (pH 7.35 or lower). This can occur in athletes after lengthy exercises with high intensity, leading to the accumulation of lactic acid. Chronic metabolic acidosis can decrease T4 and T3 and increase TSH concentrations and can lead to subclinical conditions of hypothyroidism.

Conclusion and scientific advice

To prevent iodine deficiency, athletes should:

1. Track basal (morning) body temperature. Anything less than 36.4 C0 requires immediate observation with a qualified doctor.

2. Athletes should regularly consume enough iodine. Good food sources include seafood (wild sea fish contains more iodine than freshwater fish), seaweed and other seaweeds (wakame, kombu, nori), kelp noodles, sushi are a rich source of iodine. Other reasonable sources include milk and yogurt, sea beans, eggs, cranberries, strawberries and some meat.

3. Since 2009, iodine has been added to packaged bread in Australia, although freshly baked bread may not reveal the added amount. Iodized salt is also available, but keep in mind that too much salt can affect blood pressure.

4. With caution, eat gobogenic vegetables. The high food content of plants of the cabbage family, including cabbage, cabbage, broccoli, cauliflower, Brussels sprouts, radish, turnips, watercress, spinach, contains isothiocyanates, which can block the absorption and utilization of iodine in the thyroid gland. Cooking these vegetables and consuming just 1–2 servings per day can reduce their exposure.

5. Check your vitamin D level. Vitamin D is associated with hypothyroidism and autoimmune thyroid diseases.

6. Check the level of hormones, cortisol, iron, zinc, copper and iodine.

9. Reduce the impact of external factors by drinking filtered water, installing filters on shower heads, choosing natural sources of bathing water, and not in chlorinated pools, consuming no pesticides or perfectly environmentally friendly products, choosing organic personal hygiene products, cosmetics and detergents, avoiding storing food in plastic, use a wax wrap, etc. instead.

10. Foods rich in iodine are fish (especially cod and haddock), shellfish, seaweed, seaweed, egg yolk, soy nuts, beans, milk, yogurt and cottage cheese. Iodized salt contains about 76 micrograms of iodine per gram of salt or 380 micrograms per teaspoon.

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