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IODINE DEFICIENCY IN CHILDHOOD: THE CURRENT STATE OF THE ISSUE

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Abstract. The aim of the work was based on the results of a number of clinical studies to study the prevalence of iodine deficiency, its diagnosis and impact on the health of the child, as well as to consider possible ways to correct this condition. The geographical location of the Russian Federation, the peculiarities of the nature of nutrition of the majority of the child population at the present stage, the low level of use of iodized salt by the population causes a high prevalence of iodine deficiency among traditionally fed children. Compliance with restrictive types of nutrition by children without supervision of such a child by a pediatrician or a nutritionist may underlie the development of trace element imbalance and, as a consequence, the formation of iodine deficiency. The study of the prevalence of iodine provision in children who observe restrictive types of nutrition, as well as the study of modern possibilities for correcting the identified violations is an urgent issue of modern pediatrics, which is given little attention at the present stage.

Key words: *iodine; iodine deficiency; iodine deficiency diseases; supplementation; children.*

ЙОДНЫЙ ДЕФИЦИТ В ДЕТСКОМ ВОЗРАСТЕ: СОВРЕМЕННОЕ СОСТОЯНИЕ ВОПРОСА

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Резюме. Целью работы было на основании результатов ряда клинических исследований изучить распространенность йодного дефицита, его диагностику и влияние на здоровье ребенка, а также рассмотреть возможные способы коррекции данного состояния. Географическое расположение Российской Федерации, особенности характера питания большей части детского населения на современном этапе, низкий уровень использования йодированной соли населением обусловливает высокую распространенность йодного дефицита среди традиционно питающихся детей. Соблюдение ограничительных типов питания детьми без наблюдения за таким ребенком педиатра или диетолога может лежать в основе развития микроэлементного дисбаланса и как следствие — формирование йодного дефицита. Изучение распространенности йодной обеспеченности детей, соблюдающих ограничительные типы питания, а также изучение современных возможностей коррекции выявленных нарушений является актуальным вопросом современной педиатрии, которому уделяется достаточно мало внимания на современном этапе.

Ключевые слова: *йод; йодный дефицит; йоддефицитные заболевания; сапплементация; дети.*

Optimal supply of vitamins, essential macro- and microelements determines a child's normal growth, mental and physical development [1]. Iodine is an essential micronutrient. Ehe normal functioning of the human body is impossible without it. Regular iodine intake with food is a great importance for maintaining health, since the human body is unable to produce this trace element on its own [2]. Iodine is an obligatory structural component of thyroid hormones — thyroxine (T_4) and triiodothyronine (T_3), which determine the activity of most metabolic processes in our body. Physiological synthesis and secretion of thyroid hormones requires adequate intake of this trace element into the body.

The aim of the work was to study the prevalence of iodine deficiency (ID), its diagnosis and impact on child health, as well as to consider possible ways to correct this condition based on the results of a number of clinical studies.

The main natural sources of iodine for humans are products of plant and animal origin, drinking water. Most of the natural iodine reserves are located in sea water, where it was washed away during the formation of our planet from the soil surface by rains, glaciers, snow. At the same time, a significant part of land and fresh water is depleted of this trace element [3].

According to the results of epidemiological studies aimed at determining the prevalence of iodine deficiency diseases (IDD), it has been established that more than two billion inhabitants of our planet live in areas with IDD. At the same time, about one billion people have clinical manifestations of IDD: 740 million people have endemic goitre and 43 million suffer from mental retardation up to cretinism as a result of iodine deficiency [4]. According to the literature, about 50% of the European population has mild ID [5]. The most endemic regions for ID are considered to be mountainous areas, areas with frequent rainfall that washes iodine from the soil surface, and regions far from the ocean. Based on this information, a large part of the Russian Federation can be considered as endemic for ID.

According to the Iodine Global Network, the Russian Federation belongs to the areas with moderate ID. According to the literature it is known that this condition is detected practically on the entire territory of the post-Soviet states. In the Russian Federation, there are practically no territories whose population would not be at risk of developing IDD [6]. Thus, more than 50% of the territories of the subjects of our state are affected by naturally occurring IDD. About 60% of the population of our country lives in these territories [7]. Natural ID is aggravated by low consumption of food products that are sources of iodine (the fish, seafood and the algae). The most pronounced ID is observed among the inhabitants of foothill and mountainous areas (North Caucasus, Urals, Altai, Far East), in the territories of the Upper and Middle Volga region, Transbaikalia, in the population of Western and Eastern Siberia [8, 9, 10].

The food is the main source of iodine intake because the iodine content in drinking water is low (less than 2 μg/litre). Marine fish, seafood and seaweed are considered to be the main sources of iodine. Seaweed (kelp) is the richest product in terms of the content of this trace element (up to 1 % of dry weight). Eating 20–90 mg of dried seaweed provides its daily intake. However, this product is very rarely used in the nutrition of the child population in our country. In this case, the reaction of the child to the use of seaweed in food in most cases remains negative. Much less iodine is contained in the products on which the daily diet of most children is based — these are dairy products, cereals, potatoes and others. The iodine content in products of plant origin depends on its content in the soils on which they are grown, and in products of animal origin — on the content of the trace element in the animal feed used. It should be borne in mind that during heat treatment and storage of the product, the concentration of iodine in it decreases significantly, which significantly reduces the value of this product and dishes prepared from it as a source of iodine [11, 12].

Iodine enters the body in both inorganic and organic forms. After ingestion, it is almost completely absorbed in the small intestine, accumulating in the thyroid, which is the main depot of the trace element; kidneys; stomach; mammary and salivary glands. The concentration of iodine in breast milk, saliva and gastric juice is 30 times higher than its concentration in plasma. In the blood the trace element circulates as iodide and in the protein-bound state. The concentration of iodine in blood plasma at normal intake is about 10–15 μg/l. About 2/3 of iodine intake is excreted by kidneys (the iodine can also be excreted by mammary, salivary and sweat glands). Data on iodine concentration in the thyroid fluctuate widely. The human value is believed to be approximately 0.6 mg/l.

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The daily iodine requirement depends on age and physiological state. According to WHO data, for different population groups the daily dose of iodine differs and is: for children from birth to 6 years — 90 μg; for children from 6 to 12 years — 120 μg; for children from 12 years and adults — 150 μg; for pregnant and lactating women — 250 μg [13].

The chemical composition of food products and nutritional culture of the population of the Russian Federation indicate that it is impossible to ensure the recommended standards of iodine consumption using traditional products. To cover the need of the growing organism for this trace element, it is necessary to include a sufficiently large amount (about 100 g) of sea fish and seafood with high iodine content in the child's diet every day. Consequently, in modern conditions, a child's diet composed of natural products and quite adequate to the age-specific energy requirements is not able to provide the body with the necessary amount of iodine. This problem is especially acute among children who follow restrictive types of diet (includ vegetarianism) and don't like iodisation of food [13, 14].

Insufficient iodine intake into the body leads to the activation of successive adaptive processes aimed at maintaining normal synthesis and secretion of thyroid hormones. With a prolonged deficiency of this trace element occurs failure of adaptation mechanisms with the subsequent development of iodine deficiency.

It is known that the greatest danger is insufficient iodine intake into the body at the stage of intrauterine development and early childhood. Changes caused by iodine during these periods of life are manifested by irreversible defects in the intellectual and physical development of the child. Thyroid hormones play an important role in the formation of the brain during intrauterine development, and insufficient iodine supply in the pregnant woman can cause irreversible damage to the fetal brain [12, 15]. Among possible adverse effects of iodine deficiency in children are the development of hypothyroidism, goitre, mental retardation (up to cretinism), impaired cognitive function, lag in neuropsychiatric and physical development, and increased absorption of radioactive iodine in nuclear disasters.

Now control of iodine intake by the population, prevention of ID and IDD are urgent medical and social tasks. All IDD can be prevented, whereas the changes caused by iodine deficiency at the stage of intrauterine development and in early childhood are irreversible and practically cannot be treated and rehabilitated, leading to disability of the patient.

The severity of IDD is usually assessed by the level of excretion of iodine in the urine, which adequately reflects its intake, given that 90% of iodine consumed with food is excreted with urine. The urinary iodine level of an individual is known to vary throughout the day. Therefore, these measurements can only be used to estimate iodine availability in the general population in epidemiological researches.

Currently, the median urinary iodine concentration and the proportion of urine samples with iodine levels less than 50 μg/litre are the two main statistical indicators needed to assess iodine status worldwide. The main indicator of the degree of iodine stress in the population is ioduria — the level of urinary iodine excretion in a representative group of the population living in a particular region. The representative group is usually considered to be children of primary school age (6–12 years old), as this age period excludes the influence of occupation and working conditions, as well as hormonal shifts and other changes characteristic of puberty. The collection of the material itself is carried out directly in schools, which ensures the necessary random of selection. After determining the levels of iodine excretion in individual urine portions, an integral indicator is calculated — the median concentration of iodine in urine, according to which the level of iodine supply of the whole population is determined. With optimal iodine supply, no more than 20% of urine samples should have an iodine level of less than 50 μg/l [16].

For school students normal iodine availability in the region where the study is conducted is considered to be at a median ioduria of 100–200 μg/day. In mild ID, the median ioduria is 50–99 μg/day, in moderate ID it is 20–49 μg/day, and in severe ID it is less than 20 μg/day [4].

All measures to prevent IDD are based on the norms of physiological iodine intake. Today world experts have formed the main strategy for overcoming ID based on three main types of iodine prophylaxis: mass, individual and group. Mass prophylaxis is considered to be the most effective. The preference in mass iodine prophylaxis is given to iodisation of food salt, despite the fact that there is an experience in iodisation of other products (milk, butter, bread).

The salt iodisation is recommended by WHO as a universal, highly effective method of mass iodine prophylaxis, according to which all salt for human consumption (i.e. the salt sold in shops and used in food processing) should be iodised [13]. To achieve optimal iodine intake (150 μg/day), WHO and the International Council for the Control of IDD recommend the addition of an average of 20–40 mg iodine per 1 kg of salt. Potassium iodate has been recommended as an iodising supplement [15]. The choice of salt as an iodine "carrier" is also due to the fact that it is used by the population regardless of social and economic characteristics. The average daily dose of salt consumption is 5–10 g and may vary depending on age, sex, and season. Unlike other foodstuffs, iodine from which isn't fully assimilated (10–50%), it is assimilated almost completely (85–90%) from iodised salt. Modern salt iodisation technologies are reliable and low-cost. At the same time, it has been found that mass iodine prophylaxis methods are effective if more than 90% of the participants in the process use iodised salt at home. Iodine overdose is practically impossible with proper salt iodisation. All of the above has led more than 120 countries around the world to choose this method of iodine prophylaxis as a national strategy for overcoming ID and preventing IDD.

It is estimated that the average daily iodine intake with iodised salt is about 150 μg, which corresponds to the daily norm and is safe for humans. Even if this amount of iodine (150 μg) is added to the average daily amount in the diet (40–80 μg), it will be only 20–25% of the maximum safe amount of iodine intake, which for a school-age child is 500 μg/day.

In the 1980s, the prevention of ID in the USSR was discontinued, resulting in a gradual increase in the prevalence and severity of ID among the population in the post-Soviet countries. In the Russian Federation, the use of iodised salt as the main method of mass prevention of IDD was introduced by the Russian government in 1999. However, in contrast to a number of near and far abroad countries (USA, Australia, Armenia, Belarus), where the law on universal salt iodisation was adopted and IDD was practically eliminated. In our country the use of iodised salt is voluntary, and only about 30–40% of families use it [12].

Control is quite important in the prevention of ID, which is organised by continuous monitoring of iodine supply to the population. The effectiveness of iodine prophylaxis is also assessed by the level of median ioduria, use of iodised salt and compliance of its samples with state standards. Iodine prophylaxis is considered effective when the median ioduria in the population ranges from 100–199 μg/l, and in pregnant women — 150–249 μg/l; prophylaxis is also considered effective when iodised salt is used in 90% of households (when 95% of salt samples comply with state standards for iodine content GOST R 51575–2000 «Iodised table salt. Methods of determination of iodine and sodium thiosulphate».) [15].

However, in certain periods of life (children under two years of age, pregnant and lactating women) physiological need for iodine increases, and the body needs additional amounts of this element. In such cases, individual and group iodine prophylaxis is carried out by taking pharmacological products containing a physiological (standardised) dose of potassium iodide. In these population groups, the prevalence of IDD is particularly high, and therefore the administration of medicines with an accurate dose of potassium iodide has not only preventive but also therapeutic value. The use of pharmacological preparations of iodine with its specific level allows to individually select the necessary dose of iodine and to control the effectiveness of the conducted prophylaxis [6].

For group and individual iodine prophylaxis, it is customary to use potassium iodide preparations in accordance with age norms. For the region of mild iodine deficiency it is recommended to use: for young children — 50–100 μg/day; for children of primary school age (6–12 years) — 100 μg/day; for adolescents — 200 μg/day; for pregnant and lactating women — 250 μg/day.

Iodine metabolism directly depends not only on the amount of iodine supplied to the body, but also on the supply of other micronutrients from which cofactors involved in iodine metabolism are synthesised. Thus, for the synthesis of thyroid hormones it is important to get enough tyrosine amino acid in the body, in this regard, the level of consumption of protein products (meat, fish, dairy products) is of particular importance. The structure of thyroperoxidase includes iron, and the activity of the enzyme depends on the level of cobalt and copper. Selenium is part of the deiodinases that convert T_4 to T_3. The synthesis of thyroid hormones is impossible without superoxide dismutase, which is possessed by manganese, copper and zinc. That is why trace element imbalance is the basis for the decrease in the activity of metalloenzymes, aggravates iodine metabolism disorder, reduces the synthesis of thyroid hormones, increases its sensitivity to the stimulating effect of thyroid-stimulating hormone, increases the level of autocrine growth factors, activates apoptosis and autoimmune processes, which causes the development of goitre [7, 17, 18]. Probably, one of the reasons for the development of such trace element imbalance in a child may be the observance of vegetarian type of diet without medical supervision and without supplementation with trace elements and vitamins [19]. In this connection, the study of iodine supply in children following restrictive types of diet, as well as the functional state of the thyroid gland, is an urgent issue of modern paediatrics, especially in areas endemic for ID [20].

Thus, in a research conducted in Norway — a country with a high level of marine fish consumption, the iodine supply of adult vegans, vegetarians and pascetarians was studied. It was found that the median ioduria in vegans corresponded to mild-to-moderate ID, and in vegetarians and pascetarians to mild ID [21].

Low dietary iodine intake among vegans and vegetarians relative to traditionally eating people was also found in a study conducted in the Great Britain. The authors also point to the fact that people who follow restrictive diets, in most cases, do not control the level of micronutrient intake and do not perform their supplementation [22].

Along with inadequate iodine supply, a number of substances capable of impairing thyroid function — disruptors — have recently received increasing attention. These substances include thiocinates found in the cabbage, radish, rapeseed, horseradish, beans, potatoes and maize. Thiocinates inhibit the capture of iodine by the thyroid and stimulate its excretion from the body. Some flavonoids found in plant extracts and millet are also considered disruptors. They affect the binding of thyroid hormones by transport proteins. The qualitative and quantitative composition of anthropogenic disruptors in the modern environment is continuously changing and increasing. Road transport is an important source of such substances in the environment. These disruptors weaken the function of oxidases, which take part in the oxidation of iodide to elemental iodine. In addition, detergents and cleaning agents, dyes, degradation products of polymeric materials, the use of which in modern society is very common, have a negative impact on the thyroid gland.

Thus, the problem of studying the iodine supply of the child population of our country and further prevention of ID and development of IDD are urgent issues of modern paediatrics. The geographical location of the Russian Federation, the iodine content of foodstuffs for the majority of the child population at the present stage, and the low level of iodised salt use by the population cause a high prevalence of ID among traditionally nourished children. The absence in Russia of a state strategy aimed at the elimination of ID continues to have a negative impact on the health of the entire population of the country. In this regard, it is of current importance to popularise preventive measures using iodised salt, as well as group and individual prophylaxis with potassium iodide preparations in the most vulnerable population groups, which include pregnant women, lactating women and infants. Observance of restrictive types of nutrition by children without supervision of such a child by a paediatrician or nutritionist may underlie the development of microelement imbalance and, as a consequence, the formation of ID. Children living in our country who follow restrictive diets, including vegetarianism, should probably be considered as a risk group for ID and further development of IDD. The study of the prevalence of iodine availability in children following restrictive types of diet, as well as the study of modern possibilities of correction of the revealed disorders, is currently relevant and requires more attention.

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