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DIETARY CORRECTION OF OBESITY IN CHILDREN AND ADOLESCENTS

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Abstract. Optimization of nutrition is one of the main components of obesity therapy in patients of all age groups. In children and adolescents, dietary correction of obesity is especially important due to the limitations of medical and surgical treatments. The goal of diet therapy for obesity in children is not only to reduce body weight, but also to provide the body with the nutrients necessary for further growth and development. Currently, the long-term use of hypocaloric diets is not recommended in outpatient practice for obese children due to their negative effect on nutritional status and quality of life. The method of choice is an individual isocaloric ration with sufficient protein content and control of carbohydrates and/or fats, compiled taking into account food tolerance and taste preferences of the child. It is necessary to educate patients to form a stereotype of healthy eating and adequate eating behavior in later age periods. A promising therapeutic strategy can be considered the supplementation of nutrients that are key to nutritional status. The article presents modern approaches to dietary therapy of obesity in children and adolescents, which make it possible to ensure long-term adherence to treatment for patients and their families.

Keywords: *obesity, children, nutrition, diet therapy*

ДИЕТИЧЕСКАЯ КОРРЕКЦИЯ ОЖИРЕНИЯ У ДЕТЕЙ И ПОДРОСТКОВ

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Резюме. Оптимизация питания является одним из ведущих компонентов терапии ожирения у пациентов всех возрастных групп. У детей и подростков диетическая коррекция ожирения имеет особое значение в связи с ограничениями медикаментозных и хирургических методов лечения. Целью диетотерапии ожирения у детей является не только снижение массы тела, но и обеспечение организма нутриентами, необходимыми для дальнейшего роста и развития. В настоящее время в амбулаторной практике для детей с ожирением не рекомендуется длительное использование гипокалорийных диет в связи с их негативным действием на пищевой статус и качество жизни. Методом выбора является индивидуальный нормокалорийный рацион с достаточным содержанием белка и контролем содержания углеводов и/или жиров, составленный с учетом переносимости пищевых продуктов и вкусовых предпочтений ребенка. Необходимо обучение пациентов для формирования стереотипа здорового питания и адекватного пищевого поведения.

ния в дальнейшие возрастные периоды. Перспективной терапевтической стратегией можно считать дотацию ключевых для пищевого статуса нутриентов. В статье представлены современные подходы к диетотерапии ожирения у детей и подростков, позволяющие обеспечить длительное сохранение приверженности к лечению пациентов и их семей.

Ключевые слова: ожирение, дети, питание, диетотерапия

INTRODUCTION

The main component of treatment strategy for obesity in children and adolescents is non-drug therapy aimed at lifestyle modification, including nutritional correction, increased physical activity and normalization of eating behavior [1]. Non-medication treatment has proven efficacy and safety, but requires strong motivation of each patient and his/her family for long-term, in many cases for many years, adherence to the recommendations in present obesogenic (obesity-promoting) environment. The goal of nutritional therapy for obesity is to reduce the excess energy value of food, which allows, in combination with adequate physical activity, to achieve a negative energy balance.

Since the beginning of the XXI century, the approach to the nutrition of obese children and adolescents has changed dramatically. In Russian and international medical practice, strict food restrictions have been replaced by healthy eating rules designed to form of new dietary habits in patients and their families [2, 3]. The Russian clinical guidelines for the treatment of obesity in children enshrine the leading role in the dietary therapy of obesity of a normocaloric diet that meets the age-sex requirements of each child in energy and nutrients [2]. Nowadays, all types of diets (hypocaloric, ketogenic, with a reduced glycemic index, etc.) are considered to be alternative options of diet therapy, which are used according to the indications, limited in time courses and often in hospital.

HYPOCALORIC DIET

The traditional approach in the treatment of obesity in children for many decades was the prescription of a hypocaloric diet with a reduction in energy value at the expense of fats and carbohydrates. This method was based on the classical diet no. 8 according to the system of M.I. Pevsner and was recommended for both inpatient and outpatient use [4]. Most researchers noted the low effectiveness of the hypocaloric diet in the long term for patients, who used it at home [5], but this

fact was often because of lack of discipline and willpower. However, long-term implementation of strict recommendations, including prohibition of a wide range of foods and dishes, calorie counting, regulated diet without taking into account individual food preferences, in the absence of professional psychological support was accompanied by a significant reduction in the quality of life as a result of hunger and impaired social functioning associated with food restrictions.

The hypocaloric diet is currently considered to be the diet of choice for the treatment of obesity in hospital [3]. It can be used in courses to reduce body weight rapidly in case of morbid obesity and/or if a patient has severe complications that are not amenable to drug therapy (for example, obstructive sleep apnea syndrome). Rapid weight loss is also necessary in preparation for surgical treatment requiring general anesthesia.

This diet is characterized by a reduced content of simple carbohydrates and saturated fat. The amount of protein in the diet should correspond to the age norm or be slightly increased, and the reduction of energy value is achieved by reducing the content of carbohydrates and partially fats [1]. The example of hypocaloric menu for children in hospital is presented in Table 1.

The maximum weight loss using this method of diet therapy is noted in the first 3–5 days of inpatient treatment. It is associated with an increase in diuresis: during the transition from home food, which in most families is characterized by a high content of table salt, to a diet with normal sodium content.

In obese children, controlling protein intake requires special attention. Protein meals provide a sense of satiety, making dietary regimens easier to tolerate. Ensuring adequate protein intake in hospital settings can be difficult. Unfamiliar flavors of food, limited assortment of dishes, including meat and fish, often lead to children's refusal to eat, which causes a deficit in the intake of essential nutrients. Within the framework of a standard hypocaloric diet with regulated cooking technology, fish and egg dishes, vegetable side

Table 1. Sample menu of a hypocaloric diet for school-age children

Таблица 1. Примерное меню гипокалорийной диеты для детей школьного возраста

Наименование блюда / The course	Выход в г/мл / Quantity in gr/ml
<i>I Завтрак / I Breakfast</i>	
1. Омлет натуральный, фаршированный зеленым горошком / Natural omelette with green peas.	130
2. Салат из помидоров и огурцов с растительным маслом / Tomato and cucumber salad with vegetable oil.	115/5
3. Компот из сухофруктов / Dried fruit compote.	200
<i>II Завтрак / II Breakfast</i>	
1. Суфле из моркови с творогом / Carrot soufflé with cottage cheese.	215
2. Чай / Tea.	200
<i>Обед / Dinner</i>	
1. Суп рисовый с овощами вегетарианский, ½ порции / Vegetarian rice soup with vegetables, ½ portions.	250
2. Мясо отварное без соли / Boiled meat without salt.	55
3. Брокколи отварная с растительным маслом / Boiled broccoli with vegetable oil.	155/5
4. Сок фруктовый (абрикосовый) / Fruit juice (apricot).	200
<i>Полдник / Afternoon snack</i>	
1. Отвар шиповника / Rosehip decoction.	200
2. Яблоко печеное без сахара / Baked apple without sugar.	1 шт.
<i>Ужин / Supper</i>	
1. Рулет мясной запеченный / Baked meat roll.	105
2. Салат из свежей капусты и моркови с растительным маслом / Fresh cabbage and carrot salad with vegetable oil.	130/5
3. Чай / Tea.	200
<i>На ночь / For the night</i>	
1. Кефир 1% / Kefir 1%	200

Дополнительно: / Additionally:

Хлеб ржаной / Rye bread 100
 Энергетическая ценность: 1628 ккал / Energy value: 1628 kcal

dishes and salads are the least popular. Children with selective appetite and with established stereotypes of irrational nutrition may completely skip meals consisting of subjectively unacceptable for them foods and dishes. Insufficient adherence to nutritional therapy in such patients leads to a decrease in protein and dietary fiber intake [6].

It should be remembered that the use of a strict hypocaloric diet, especially in the absence of sufficient physical activity in the hospital, may lead to a decrease in the fat-free components of body composition and be the cause of lower resting energy expenditure in the long term [7–9].

There is a high risk of reducing fat-free components of body if patient uses a hypocaloric diet combined with hypodynamia. It limits the indications for long-term treatment of obesity in hospital [8, 10, 11]. Previously, it was believed

that treatment of obesity, regardless of its degree and the presence of complications, should be started in an inpatient clinic to "isolate" the child from the adverse effects of the family's dietary habits [12]. There was an opinion that in hospital a child is taught discipline and a proper dietary regimen. However, in practice, the low motivation to reduce body weight in children, especially preschoolers and younger schoolchildren, does not allow the formation of individual responsibility under conditions of strict food restrictions. It should be remembered that the use of a strict hypocaloric diet, especially in the absence of sufficient physical activity in hospital conditions, can lead to a decrease in fat-free components of the body and, in the long term, be the cause of a decrease in resting energy expenditure [7–9].

The high risk of reducing fat-free components of body composition in children using a hypocaloric diet combined with hypodynamia limits the indications for long-term inpatient treatment of obesity [8, 10, 11]. Previously, it was believed that treatment of obesity, regardless of its degree and the presence of complications, should be started in an inpatient setting to "isolate" the child from the adverse effects of the family's dietary habits [12]. There was an opinion that inpatient hospitalization the child is taught discipline and a proper dietary regimen. However, in practice, the low motivation to reduce body weight in children, especially preschoolers and younger schoolchildren, does not allow to form individual responsibility in the conditions of strict food restrictions. In the past, so called fasting days were considered

a mandatory component of treatment of obesity in both children and adults [4, 13]. In essence, it was a mono-diet used for one day. Both protein (kefir, cottage cheese, boiled meat) and carbohydrate (fruits, vegetables) models of nutrition were used to reduce energy intake. There was an opinion about the usefulness of "cucumber" and "watermelon" fasting days. Such one-day restrictions were recommended to be practiced at least once a week. At present, this approach to dietary therapy of obesity cannot be recognized as acceptable due to its nonphysiologic nature, lack of evidence, and negative impact on metabolism. Despite significant restriction of energy intake, nutrient imbalance leads to abnormalities in body composition. Therefore, the ostensible effectiveness of fasting days has often been attributed to dehyd-

Table 2. Sample menu of an isocaloric diet for school-age children

Таблица 2. Примерное меню нормокалорийной диеты для детей школьного возраста

Наименование блюда / The course	Выход в г/мл / Quantity in gr/ml
<i>I Завтрак / I Breakfast</i>	
1. Язык отварной / Boiled tongue.	75
2. Каша гречневая рассыпчатая с растительным маслом / Buckwheat porridge with vegetable oil.	170/10
3. Кофе с молоком / Coffee with milk.	130/50
<i>II Завтрак / II Breakfast</i>	
1. Творог свежеприготовленный / Freshly prepared cottage cheese.	100
2. Яблоко печеное с ягодами без сахара / Baked apple with berries without sugar.	1 шт.
<i>Обед / Dinner</i>	
1. Борщ вегетарианский со сметаной / Vegetarian borsch with sour cream.	500/10
2. Бефстроганов из отварного мяса / Boiled beef stroganoff.	55/60
3. Картофельное пюре с растительным маслом / Mashed potatoes with vegetable oil.	200/10
4. Маслины / Olives.	30
5. Компот из ягод с сахаром / Berry compote with sugar.	200
<i>Полдник / Afternoon snack</i>	
1. Отвар шиповника без сахара / Rosehip decoction.	200
2. Фрукты свежие / Fresh fruits.	200
<i>Ужин / Supper</i>	
1. Рулет мясной, фаршированный омлетом / Meat roll stuffed with scrambled eggs.	125/5
2. Винегрет овощной с растительным маслом / Vegetable vinaigrette with vegetable oil.	150/10
3. Биточки морковно-яблочные / Carrot and apple cutlets.	180
4. Чай / Tea	180
<i>На ночь / For the night</i>	
1. Йогурт / Yoghurt.	125
2. Курага размоченная / Soaked dried apricots	60

Дополнительно: / Additionally:

1. Хлеб ржаной / Rye bread 100
2. Хлеб пшеничный / Wheat Bread 120

Энергетическая ценность: 2630 ккал / Energy value: 2630 kcal

ration of the body [14]. Exclusion of protein from the diet is particularly dangerous because it promotes mobilization of protein from depots, which are primarily skeletal muscles. Current knowledge about the high frequency of sarcopenic obesity in all age categories and its role in the development of comorbid pathology proves the danger of protein exclusion from the diet even for a short period of time [7, 8, 15, 16]. In addition, excessive fructose consumption when using popular "apple" and "fruit" fasting days is an important etiologic factor in the development of nonalcoholic fatty liver disease [17].

NORMOCALORIC DIET

Prolonged treatment of obesity in pediatric patients is accompanied by certain difficulties, because it requires not only creating an energy deficit, but also providing the body with nutrients necessary for further growth and development. For example, in children, you cannot sharply limit the fat component of the diet due to the need for it to form an adequate hormonal background in puberty. And the restriction of meat products can increase the risk of anemia in adolescent girls. The safest and most effective method of dietary therapy of obesity in children at the outpatient stage is a normocaloric diet corresponding to the patient's age-specific needs for energy and nutrients [18].

It should be noted, that the diet used to correct obesity is not a short-term diet, at the end of which the patient can return to the usual style of eating. Due to the need for long-term compliance with the new nutritional rules in outpatient clinics, it requires individualization of recommendations, taking into account the food preferences of a particular patient while maintaining the norm of energy and nutrient intake. This approach allows maintaining normal growth and development rates, as well as maintaining high physical and intellectual activity [1]. An example of a normocaloric menu for children is shown in Table 2.

To ensure maximum individualization of nutritional therapy, it is recommended to make a diet on the base of nutritional status of each patient. The energy value of the diet should correspond to the actual energy expenditure of the child. "The gold standard" for determining individual values of basic energy metabolism and oxidation rate of macronutrients is indirect calorimetry [19]. Amount of nutrients is established depending on the individual metabologram values. The importance of determining metabolic requirements is

determined by the high frequency of violations of their values in children. Thus, about half of obese children have an increased rate of fat oxidation associated with its excessive amount in the usual diet. This feature indicates that there is no need for a sharp restriction of fats, especially unsaturated fats, in the diet of an obese child.

Indirect calorimetry is not a commonly available method. Therefore, calculated formulas can be used to determine the daily energy value of the diet. In obese children, it is recommended to estimate the level of basal metabolism using the Shoefild formula, taking into account age and sex [18]. When calculating the daily energy value of the diet, it is necessary to focus on the level of physical activity of the patient. To determine the daily energy requirement of individuals with a low level of physical activity, the index of resting energy expenditure is multiplied by a coefficient of 1.4, with an average level — by 1.6, with a high level of physical activity — by 1.9.

In children with a low obesity class in the absence of complications, general age-sex norms of energy and nutrient intake can be used, as given in the guideline "Norms of physiologic needs in energy and nutrients for different population groups of the Russian Federation" (2021) [18].

The daily ration of a child should be distributed in such way, that the main part of it falls on the first half of the day, i.e. the hours of greatest motor activity. The last meal should be at least two hours before bedtime.

In formulating diets for obese children, a number of basic rules should be adhered to in order to achieve optimal nutrient intake without severe restriction or prohibition of any foods and meals that do not allow long-term adherence to the recommendations. A complete ban may be appropriate only for the group of sweet soft drinks with added sugar, which includes not only carbonated beverages, but also commercially prepared juices/nectars, bottled tea, morsels, and kvass [20, 21].

A child's daily menu should contain lean meat (beef, veal, rabbit, chicken, turkey), fish (cod, hake, pink salmon, etc.), eggs, and low-fat milk and dairy products, including in the form of fermented milk drinks. However, milk and dairy products with a high fat content (milk with a fat content of more than 3.2%, cream, sour cream with a fat content of 20% or more, cottage cheese with a fat content of more than 5%, cottage cheese desserts, glazed cottage cheese, cottage cheese mass, cheese varieties with a fat content of more than 40%)

should be limited in the diet of obese children and used no more than 1–2 times a month.

In the diet should be sharply limited the use of any sausages, wieners, refractory animal fats (beef, mutton, pork), trans fats (margarine). The amount of butter can remain within the age-appropriate range.

Vegetable oil intake should be in line with age-related needs. A diet containing adequate amounts of vegetable fats helps to reduce hunger. Vegetable oil should be used in its natural form: for salad dressing, vinaigrettes. It can be added to dishes cooked without fat.

Modification of the carbohydrate component of the diet in obese children requires special attention. The quota of simple carbohydrates is reduced by significantly limiting foods with a high glycemic index in the diet: added sugar, confectionery, bread, primarily made of refined flour. According to current Russian norms, the daily intake of added sugar should not exceed 10% of the energy value of the diet, and for overweight and obese persons it is recommended to reduce the intake of added sugar to $\leq 5\%$ of the daily energy intake. Thus, obese children should limit added sugar to 2–3 teaspoons per day.

Vegetables and fruits form an important part of the diet. Dietary fibers in fruits and vegetables stimulate intestinal peristalsis, contribute to the regulation of lipid metabolism, and are a substrate for normal gut microbiota. Foods rich in dietary fiber create a feeling of satiety. Fruits and vegetables provide the child's body with minerals and vitamins, have a diuretic effect, removing excess fluid from the body. In this regard, the diet should include cucumbers, cabbage (white, cauliflower, Brussels, kohlrabi), zucchini, tomatoes, pumpkin, radishes, carrots, turnips, asparagus, leafy salads, unsweetened fruits and berries. It is advisable to include in the diet several times a day dishes of raw and cooked vegetables (salads, vinaigrettes with vegetable oil, boiled and stewed vegetables, etc.). The amount of potatoes should be limited to 1/2–1/3 of the recommended rate, replacing it with other vegetables. Potatoes are cooked in baked or boiled form. Fried potatoes and mashed potatoes with butter are not included in the diet.

In the diet of obese children should not be used soups, canned compotes, fruit purees, including homemade. Preference should be given to natural fresh fruits and berries without added sugar. In the absence of fresh seasonal vegetables, berries and fruits should be used frozen products.

Food is cooked in boiled, steamed, grilled, baked ways. In the diet of obese children, we do not use dishes fried in oil, deep-fried. Surface frying on a dry pan or with a minimum of vegetable oil is allowed (it is recommended to use spray oil).

First meals should be predominantly vegetarian. Meat, chicken, mushroom and fish broths are limited in the diet of an obese child. Meat and fish dishes are given in the form of boiled portioned pieces or in the form of steamed cutlets, beaters, meatballs. As garnishes for second courses it is recommended to use a variety of vegetables or crumbly porridge: buckwheat, pearl, oatmeal and millet. Rice, potatoes, pasta from durum wheat varieties are included in the menu no more than once a week.

Eggs (for chicken eggs — no more than 1 per day, 3 per week) should be hard-boiled or used for cooking [22].

According to current national clinical guidelines, the necessary conditions for effective treatment include:

- restriction of sweet drinks: prohibition (consumption of no more than 1 portion and no more than once a week) not only of sparkling sweet drinks, but also of juices, compotes, morsels with permission to take drinking water at the child's request;
- limit in sweet fruits — up to 1 serving (100 g) per day;
- at least 4 meals a day, breakfast is compulsory;
- prohibition of sweet dairy products;
- control of portion size/number of servings; "food plates" are now widely used to show the desired portion size. If a child wants to eat a second portion of lunch/dinner allow it 20 minutes from the first, provided it is eaten regularly (at least 4 meals a day);
- enriching the diet with vegetables (300 g for young children and 400 g per day for adolescents, limiting the use of potatoes as the only vegetable in such quantities), dietary fiber, whole-grain products;
- teaching children to eat slowly without computer/TV/mobile phone [2].

Forcing a child to consume certain foods that are considered healthy but have ambiguous organoleptic characteristics depending on the method of cooking (fish, lean meat, cruciferous vegetables, etc.) can lead to negative attitudes toward these foods. If a food is strictly prohibited, it is more likely to be consumed in excess in the absence of control.

ALTERNATIVE DIET THERAPIES

These diets are used for short-term prescription to accelerate weight loss and increase patients' motivation. Currently authorized approaches in children include hypocaloric diets, ketogenic diets, and reduced glycemic load diets.

Ketogenic diet

The main objective of the ketogenic diet is to reduce the carbohydrate component of the diet. The mechanism of action of this diet is ketosis resulting from reduced carbohydrate intake. ESPGHAN is authorized to use the ketogenic diet as an alternative approach to diet therapy for obesity in pediatric practice [23]. The indications for prescribing this diet in children and adolescents are morbid obesity, as well as the presence of complications of obesity (obstructive sleep apnea syndrome, metabolic syndrome, etc.), in which rapid weight loss at the initial stage of treatment is recommended. The duration of the ketogenic diet in children and adolescents should not exceed 10 weeks. The maximum rate of weight loss is noted during the first 2 weeks, and then ranges from 0.5 to 1 kg per week. Patients need regular medical follow-up to monitor adherence to the diet and identify potential side effects. Adherence to the ketogenic diet is accompanied by a high risk of electrolyte imbalance, especially hypokalemia. Possible complications include weakness, orthostatic hypotension, diarrhea or constipation, and cholelithiasis. An adequate drinking regimen is necessary to prevent dehydration. Due to the restriction of fruits, vegetables and dairy products, additional multivitamin intake is recommended, providing 100% of the recommended intake rate [13]. The complete blood count, liver function parameters, serum amylase and albumin levels, and the concentration of ketones in urine should be examined at least once a month [24].

After the end of the diet, carbohydrates are introducing into the diet for several weeks. A number of studies have shown good tolerance for the diet, absence of a pronounced hunger, preservation of a high quality of life. With short-term use, this diet appears to be more effective than the standard hypocaloric diet, which is confirmed by a more significant reduction in body weight, adipose tissue, as well as a decrease in insulin resistance indices [23].

Despite the above advantages of the ketogenic diet, it should be noted that the main indica-

tion for its use is pharmacoresistant epilepsy. The number of randomized controlled trials on its isolated efficacy in obese children is currently small. Exclusion from the diet of most fruits, vegetables and cereals, due to the need to sharply limit carbohydrate intake, leads to a deficiency of dietary fiber. It has a negative impact on the gut microbiota and determines the limitation of the duration of use of the diet [6].

Diet with reduced glycemic load

Carbohydrate metabolism disorder with the formation of insulin resistance develops in most obese children. A differentiated approach to the selection of foods containing carbohydrates, taking into account glycemic index, can reduce the load on the insular apparatus and thus improve the clinical course of obesity. This approach categorizes foods into high (≥ 70), medium (56–69), and low (≤ 55) glycemic index groups. Reduction of body weight in this variant of the diet is slower than in the ketogenic diet, but is not accompanied by negative effects. A sufficient amount of unsweetened fruits and vegetables determines the feeling of satiety and contributes to a longer adherence to the recommendations [5]. It has been shown that children lose more fat mass on a low glycemic load diet than on a fat-reducing diet. In children aged 6–12 years, the use of such diet results in loss of body weight in a short time. In adolescents 13–18 years of age, a reduced glycemic load diet, in addition to body weight loss and optimizing body composition in the short term, contributes to the maintenance of the achieved values after 1 year [25].

"Food traffic light"

The "traffic light" diet does not fully qualify as an alternative nutritional therapy for obesity in children, as it is intended for long-term use. This approach is part of a program designed for elementary school children and their families that includes family counseling, increased physical activity, and regular counseling by a psychologist. The goal is to preferentially consume foods with low energy value. Products are divided into 3 categories: "green", "yellow" and "red" (Table 3). Low calorie foods (most fruits and vegetables) are considered "green" and recommended for frequent consumption. Moderate energy foods (e.g., cereals) are considered "yellow" and restricted. "Red" high calorie foods are to be severely restricted. The program involves educating the family about

grocery shopping and individual psychological training to support the child's motivation to lose weight [26]. The target group for this nutrition program is obese children aged 6–12 years.

It is shown that the use of the "food traffic light" diet leads to a decrease in body weight in obese children with preservation of the achieved results in the long term (5–10 years follow-up). The effectiveness of the "food traffic light" program depends on the implementation of additional recommendations and family participation in lifestyle changes. In modern foreign recommendations, this approach to nutrition has proven effectiveness and is one of the behavioral strategies for forming a healthy lifestyle in obese children [21].

A universal component of obesity treatment programs is the monitoring of food eaten in the form of a food diary. The diary is kept by the child or parents. Daily physical activity is also noted. Analysis of the food diary is performed both by the pediatrician/nutritionist and parents or patient, especially when the child is adolescence [1].

Despite the availability of various nutritional approaches to the treatment of obesity in children, it is often impossible to follow them for many years. In this regard, the formation of a correct stereotype (pattern) of nutrition, which is widely used in foreign practice, seems relevant. The aim

of this approach is to consolidate the stereotype of healthy eating in children and adolescents to ensure optimal eating behavior in further age periods. Recommendations for the formation of a healthy eating pattern as a component of therapy, proposed by the European Society of Pediatric Endocrinologists, include:

- reducing the consumption of fast food;
- reducing the use of added sugars and eliminating sugary drinks;
- reducing the consumption of foods rich in fat, sodium and deeply processed foods;
- consuming whole fruits instead of fruit juice;
- teaching to control portion size;
- reducing saturated fat intake;
- consuming dietary fiber, vegetables and fruits according to national recommendations;
- eating regular meals at specific times;
- identifying situations that encourage overeating [20].

KEY NUTRIENTS IN PEDIATRIC OBESITY

An important aspect of the modern nutritional approach for the treatment of obesity in children is the search for key nutrients, which supplementation allows to control nutritional and metabolic status in this category of patients. Polyunsaturated fatty acids, L-arginine and polyphenols are promising nutrients for inclusion in the diet.

Table 3. Nutritional Recommendations for the Traffic Light Diet

Таблица 3. Рекомендации по питанию для диеты «пищевого светофора»

«Красный» цвет / "Red" color	«Желтый» цвет / "Yellow" color	«Зеленый» цвет / "Green" color
<ul style="list-style-type: none"> • Фастфуд / Fast food. • Майонез / Mayonnaise. • Плавленный сыр / Process cheese. • Жирная сметана / Full-fat sour cream. • Жирное мясо (свинина, жирная птица) / Fatty meats (pork, fatty poultry). • Копчености / Smoked meats. • Торты и пирожные с кремом / Cakes and pastries with cream. • Дрожжевая выпечка / Yeast baked goods. • Белый хлеб / White bread. • Газированные и сладкие напитки / Carbonated and sugary drinks 	<ul style="list-style-type: none"> • Макароны из твердых сортов пшеницы / Durum wheat pasta. • Каши на воде (кроме манной) / Porridge with water (except semolina). • Выпечка из несладкого слоеного теста / Unsweetened puff pastry. • Отварной картофель / Boiled potatoes. • Нежирное мясо / Lean meat. • Вареная колбаса / Boiled sausage. • Горький шоколад / Dark chocolate. • Пастила, мармелад, зефир / Pastilla, marmelade, zephyr. • Твердый сыр / Hard cheese. • Творог / Cottage cheese. • Сладкие фрукты и сухофрукты / Sweet fruits and dried fruits. • Пряности / Spices. • Кетчуп и соления / Ketchup and pickles 	<ul style="list-style-type: none"> • Капуста / Cabbage. • Зеленые салаты / Green salads. • Огурцы / Cucumbers. • Томаты / Tomatoes. • Патиссоны / Squash. • Баклажаны / Eggplant. • Морковь / Carrot. • Зелень / Greens. • Яблоки / Apples. • Цитрусовые / Citrus. • Клубника и смородина / Strawberries and currants. • Оливковое масло / Olive oil. • Морепродукты / Seafood. • Отварная рыба / Boiled fish. • Нежирные йогурты / Low-fat yogurts. • Кефир, простокваша / Kefir, curdled milk. • Яйца вкрутую (до 2 штук) / Hard-boiled eggs (up to 2 pieces)

Polyunsaturated fatty acids

Low-fat diet is not recommended in pediatric practice due to the danger of fat deficiency in the body and disruption of normal development and health. At the same time, taking into account the heterogeneity of the fat component, certain positive effects in obesity can be achieved by changing the qualitative composition of fat, in particular, by reducing the level of saturated and increasing unsaturated and polyunsaturated fatty acids (PUFAs).

PUFAs are fatty acids containing at least two double bonds. According to the position of the first double bond relative to the methyl end, PUFA molecules belong to the families ω -3, ω -6, ω -9 and others. The ancestors of PUFA families, ω -3 and ω -6, are essential α -linolenic and linoleic fatty acids, which cannot be synthesized in the human body and must be supplied with food [27].

The main prerequisites for the use of PUFAs to enrich the diets of obese children are: influence on the expression of genes-regulators of carbohydrate and lipid metabolism, regulation of inflammation, regulation of the formation of endocannabinoids (regulators of appetite and energy homeostasis). Dietary enrichment with PUFAs, especially PUFAs of ω -3 family, leads to a decrease in triglyceride synthesis by the liver and release of LDL from the liver into the bloodstream and reduces fat deposition in depots. Reduction of triglyceridaemia and improvement of blood lipoprotein profile serves as a factor in the prevention of cardiovascular complications of obesity. In addition, ω -3 PUFAs inhibit the expression of genes associated with the development of chronic subclinical inflammation accompanying obesity [28].

Actual nutritional studies show that the diet of modern human is dominated by saturated fatty acids to the detriment of PUFAs, and the ratio of ω -6/ ω -3 PUFAs is shifted towards the predominance of ω -6 and is 20–30:1 instead of the recommended 5–10:1. It leads to the fact that all metabolic processes in the body occur against the background of inflammation due to the predominance of metabolites of ω -6 PUFAs, which have the most pronounced pro-inflammatory properties [29]. It was noted in the literature, that ω -6 PUFA, namely arachidonic acid, has adipogenic properties associated with the formation of prostacyclin. It stimulates the synthesis of substances necessary for the final stage of adipogenesis, and 2-arachidonoyl-glycerol, the

main endogenous cannabinoid, which, binding to the appropriate receptors of the brain, stimulates food intake and fat synthesis. Consequently, excess ω -6 PUFA and high ω -6/ ω -3 PUFA ratio in the diet may lead to adipogenic effects [30]. Reduction of adipogenesis can be achieved by reducing the proportion of saturated fatty acids in the diet (no more than 10% of the daily fat requirement) and reducing the ratio of ω -6/ ω -3 PUFAs in the diet to the norm of 5–10:1 [31]. The richest source of ω -3 PUFAs is fish and seafood. It is estimated that consumption of fish or seafood 1–2 times a week provides an average daily intake of ω -3 PUFAs at the level of physiologic need for these compounds. The source of ω -6 PUFAs are vegetable oils: sunflower, corn, etc., the content of these compounds is 40–60% of the sum of fatty acids in the product.

L-arginine

Arginine may be considered as one of the key nutrients in obese children. As a precursor to the nitric oxide, amino acid arginine regulates many metabolic processes including fatty acid, glucose, amino acid and protein metabolism by activating signaling pathways and gene expression. Arginine's effects include stimulation of lipolysis and expression of key genes responsible for activating the oxidation of fatty acids to CO₂ and water. In addition, arginine regulates the interaction between adipocytes and muscle cells during energy metabolism by acting on cytokine and hormone secretion [32]. Arginine action in skeletal muscles restores insulin sensitivity [33].

There is a lot of researches showing that arginine supplementation may be a new approach to the treatment of obesity and metabolic syndrome. Meta-analysis of randomized placebo-controlled studies (12 studies: 492 participants) showed that short-term (3 to 180 days) arginine administration at a dose of 3 to 24 g/day improves endothelial function and promotes endothelial recovery in case of endothelial dysfunction, including against the background of hyperlipidemia due to high fat intake [34].

At the beginning of the XXI century, it was suggested that arginine promotes the preservation of fat-free mass in the process of body weight loss. Arginine has been shown to be effective in the treatment of abdominal obesity in adults [35].

Nowadays, there are few studies that have examined the effects of arginine in children. However, they confirmed good tolerability of arginine

administration in the pediatric population [36]. Dietary supplementation with L-arginine at a dose of 9 g/day in combination with nutritional therapy and aerobic physical activity in obese adolescents has been shown to be accompanied by stabilization of body muscle mass [37].

A recent study of an arginine product for obese children [38, 39] in addition to a hypocaloric diet found a statistically significant reduction in internal organ fat area and preservation of skeletal muscle mass and active cell mass.

Polyphenols

Polyphenols are minor biologically active compounds of plant origin. They are found in various food products: fruits, vegetables, cereals, nuts, coffee, cocoa, spices, seeds. Depending on the structure of the molecule among them are phenolic acids, stilbenes, flavonoids, lignans. In the literature, there are numerous data on the effect of the consumption of polyphenolic compounds, mainly flavonoids and their subclasses: lignans, on the reduction of excess body weight [40].

The use of polyphenols both in the form of dietary supplements and as part of foods of plant origin can modulate the pathogenetic factors of obesity. Biological effects of polyphenols include inhibition of adipocyte differentiation and transformation of white adipocytes into brown adipocytes, regulation of lipid metabolism, appetite suppression, increase in energy expenditure, and modulation of gut microbiota composition. Polyphenolic compounds (especially resveratrol and quercetin) can affect adenosine monophosphate-activated protein kinase, which triggers the inhibition of fat accumulation, reduces cholesterol synthesis, and modulates inflammatory cytokines [41, 42].

It was shown that the use of catechin contained in green tea extract was accompanied by a decrease in lipid accumulation in the body due to inhibition of differentiation of 3T3-L1 preadipocytes into adipocytes. And administration of epigallocatechin gallate at a dose of 583 mg of catechins per day for 12 weeks caused a decrease in adipose tissue mass and serum levels of cholesterol, low-density lipoproteins [43]. In another study, curcumin was demonstrated to promote the conversion of white adipocytes to brown adipocytes [44]. Green tea polyphenols at a daily dose of 400–600 mg increase antioxidant levels and decrease serum leptin levels, reduce fatty acid absorption and decrease IL-6 and TNF gene expression levels. The

ability of polyphenols to reduce high blood pressure has also been proven in clinical studies [45].

CONCLUSION

Thus, nutritional optimization is one of the leading aspects of non-drug therapy of obesity in all age groups. The particular importance of nutrition in children and adolescents is related to the limited options for medical and surgical treatment of obesity at this age. The development of an effective approach to nutritional therapy is complicated by the need to provide children with the energy and nutrients necessary to maintain normal growth and development. The method of choice is an individualized normocaloric diet with sufficient protein content and control of carbohydrate and/or fat content, tailored to the child's food tolerance and taste preferences. Supplementation of key nutrients for nutritional status may be considered a promising therapeutic strategy.

Despite the crucial role of diet therapy in obese patients, it should be taken into account that it is only part of a comprehensive treatment approach that includes a spectrum of non-drug, pharmacologic, and surgical methods. The isolated use of diet for the treatment of obesity is not effective in the long term and should not be recommended to patients as the only method of weight loss.

ADDITIONAL INFORMATION

Author contribution. Thereby, all authors made a substantial contribution to the conception of the study, acquisition, analysis, interpretation of data for the work, drafting and revising the article, final approval of the version to be published and agree to be accountable for all aspects of the study.

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