NUTRITION OPTIMIZATION AND EDUCATIONAL TECHNOLOGIES IN THE SYSTEM OF PERSONALIZED PREVENTION OF OBESITY COMPLICATIONS: HYGIENIC ASPECTS

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Obesity is a global epidemic of the 21st century and a core component in the development of nutrition-related diseases. In the Russian Federation (RF), more than 60% of the adult population is overweight or obese, which necessitates designing and implementing new prevention strategies. This study aimed to provide a scientific basis for the role of personalized dietary interventions and educational technologies in preventing obesity-related complications. We reviewed papers from PubMed and eLIBRARY databases (2020–2026) found by keywords "obesity," "nutrition," "education," "prevention". The analysis showed that the effectiveness of the traditional approaches to diet therapy is insufficient. It was established that the key to successful prevention is extended diagnostics providing data on the individual metabolic phenotypes. Healthy Nutrition educational cluster and digital components of the NIAP system (research-based educational and analytical platform) are important tools in increasing obesity-related public awareness and professional training of medical specialists. Effective personalized prevention of obesity complications requires concurrent realization of three interrelated initiatives: diet correction based on instrumental diagnostics; adoption of educational technologies for doctors and patients; and reinforcement of sanitary and epidemiological surveillance measures. The proposed multilevel approach, which integrates hygiene-related measures and modern digital tools, enables a reduction in the prevalence of obesity and the achievement of strategic public health-saving goals in the Russian population.

Keywords: review, obesity, nutrition, prevention, education, health saving

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ОПТИМИЗАЦИЯ ПИТАНИЯ И ОБРАЗОВАТЕЛЬНЫЕ ТЕХНОЛОГИИ В СИСТЕМЕ ПЕРСОНАЛИЗИРОВАННОЙ ПРОФИЛАКТИКИ ОСЛОЖНЕНИЙ ОЖИРЕНИЯ: ГИГИЕНИЧЕСКИЕ АСПЕКТЫ

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Ожирение является пандемией XXI в. и ключевым звеном в развитии алиментарно-зависимых заболеваний. В Российской Федерации (РФ) более 60% взрослого населения имеют избыточную массу тела или ожирение, что требует внедрения новых стратегий профилактики. Целью работы было представить научное обоснование роли персонализированной коррекции рациона и образовательных технологий в системе профилактики осложнений ожирения. Выполнен обзор публикаций в базах данных PubMed и eLIBRARY (2020–2026) по ключевым словам: «ожирение», «питание», «образование», «профилактика». Анализ показал, что традиционные подходы к диетотерапии демонстрируют недостаточную эффективность. Установлено, что ключевым условием успешной профилактики является расширенная диагностика, направленная на идентификацию индивидуальных метаболических фенотипов. Важным инструментом повышения грамотности населения и профессиональной подготовки кадров выступает образовательный кластер «Здоровое питание» в совокупности с цифровыми возможностями платформы научно-информационного и аналитического просвещения (НИАП). Эффективная персонализированная профилактика осложнений ожирения требует одновременной реализации трех взаимосвязанных компонентов: коррекции рациона на основе инструментальной диагностики; внедрения образовательных технологий для врачей и пациентов; усиления мер санитарно-эпидемиологического надзора. Предложенный многоуровневый подход, интегрирующий гигиенические аспекты и современные цифровые инструменты, является необходимым условием для снижения распространенности ожирения и достижения стратегических задач здоровьесбережения населения РФ.

Ключевые слова: обзор, ожирение, питание, профилактика, образование, здоровьесбережение

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Obesity, which is a leading alimentary disease, is one of the priority problems of hygiene and practical healthcare. More than a billion people in the world are obese [1], and by 2050 the number of overweight and obese adults may increase significantly [2]. In the Russian Federation (RF), the prevalence of overweight and obesity among the adult population exceeds 60% [3]. The economic damage from obesity amounts to 3% of global gross domestic product [4]. The problem of obesity acquires particular urgency in the context of the effort to increase the length of life in RF, which is one of the national targets [5]. The portion of life expectancy lost to food quality and adverse nutritional factors offers a significant potential for preventive interventions [5]. Diet-related diseases account for the largest share of mortality in the Russian population and cause significant economic losses [6].

A key nutritional risk factor for obesity is a persistent deviation from healthy dietary patterns common in the population: insufficient consumption of vegetables, fruits, dairy products, and excessive amounts of fats, salt, and added sugar [7]. People in Russia eat less fruits and vegetables than is optimal for them, which significantly increases the risk of alimentary diseases [8]. At the same time, traditional approaches to obesity prevention based on standard dietary recommendations that do not factor in individual characteristics of body composition and metabolic profile have proven to be insufficiently effective: with standard diet therapy, a significant share of patients lose muscle mass, and the lost fat returns within a few years [9, 10]. These limitations of standard approaches necessitate finding new prevention strategies that integrate personalized diagnostics, modern educational technologies, and hygiene aspects.

This study aimed to systematize current data on the role of nutritional factors in the development of obesity and its complications, to substantiate the role of nutrition optimization and educational technologies in the personalized obesity prevention system based on digital technology, and to describe a multi-tier prevention framework emphasizing hygienic aspects of the public health-saving efforts.

Materials and methods

We conducted an analytical review of publications in the PubMed and eLIBRARY databases for the period 2020–2026 using the keywords "obesity," "nutrition," "education," and "prevention."

Nutritional risk factors for obesity

Obesity, resulting from a persistent imbalance between energy consumption and expenditure, is largely determined by modifiable nutritional and environmental factors. In Russia, nutritional disorders common in the population are some of the core factors of this kind (Fig. 1). One of the country's main diet-related problems is habitual dietary patterns: inadequate intake of fruits, vegetables, and dairy products, and excessive consumption of saturated fats, salt, and simple carbohydrates [7]. Such patterns are associated with an increased risk of obesity and its metabolic complications. A particularly alarming trend is the growing consumption of ultra-processed foods, which are high in calories, low in nutrients, and contain flavor enhancers and preservatives [4, 11].

Economic indicators support the significance of the problem: alimentary diseases cause a considerable proportion of deaths in Russia, they are are associated with significant economic damage [6]. At the same time, available data indicate that sanitary and epidemiological control measures have been effective: over the past 10 years, the prevalence of foodborne diseases and the frequency of food-quality violations have decreased significantly [5]. Nevertheless, the persisting unhealthy dietary patterns combined with insufficient physical activity and socio-economic determinants continue to support the growing prevalence of obesity and related damage to health and reduction of life expectancy.

Nutrition optimization as a priority area of prevention

Optimizing the nutrition of the population is one of the priorities of the state policy of the RF in the field of health saving. A personalized approach to obesity-related diet therapy based on comprehensive medical examination (including bioimpedance measurements, indirect calorimetry, laboratory diagnostics) should be implemented with the identified gender and age characteristics factored in. For obese men, whose rate of fat oxidation is reduced, the main goals are to limit saturated fats, increase the proportion of polyunsaturated fatty acids, and ensure adequate protein intake to preserve muscle mass. For obese women, whose rate of carbohydrate oxidation is reduced, the main recommendations are an even distribution of carbohydrates throughout the day, an emphasis on low glycemic index foods, sufficient fiber intake from vegetables and whole grains, and an adequate protein supply [12–15]. At the same time, individual nutrition optimization should be complemented by population-wide prevention measures. The level of fruit and vegetable consumption in Russia remains below suboptimal, and international experience shows that the most effective measures are information and communication campaigns, economic support mechanisms (subsidizing healthy eating), and legislative regulation of product labeling indicating the content of added sugars and saturated fats [8, 16]. The implementation of such measures can significantly reduce the incidence of alimentary diseases [8].

In the context of the development of population-based and personalized approaches, nutrition digital analysis tools are particularly interesting; they are considered as components of the strategy of development of the science of nutrition [17]. Digital technology gives rise to a fundamentally new ecosystem of nutrition management, integrating data from instrumental diagnostics (bioimpedance measurement, indirect calorimetry), laboratory monitoring, and actual diet analysis. Food diary applications, wearable devices monitoring physical activity, and telemedicine platforms are being integrated into preventive programs as a tool to increase patient adherence.

However, the effectiveness of digital interventions may decrease with time, which underscores the need to develop strategies to maintain long-term patient commitment to prevention programs. As a solution to this problem, and as a way to ensure seamless connection between individual dietary correction and population-wide educational efforts, Federal Research Center for Nutrition, Biotechnology and Food Safety has developed NIAP, a research-based educational and analytical platform usable through the Scientific Nutrition Analysis Tool program (Software State Registration Certificate No. 2023680849 of 05.10.2023). This software automatically evaluates patients' diets, enables compilation of personalized balanced menus in both manual and automated modes using machine learning algorithms, and generates individual recommendations for nutrition correction. The program accepts and stores personal data of the patients (anthropometric indicators, medical history, eating habits, food diary), and automatically processes and analyzes them. Based on the inputs, factoring in chemical composition of products and ready meals, the software designs balanced diets,

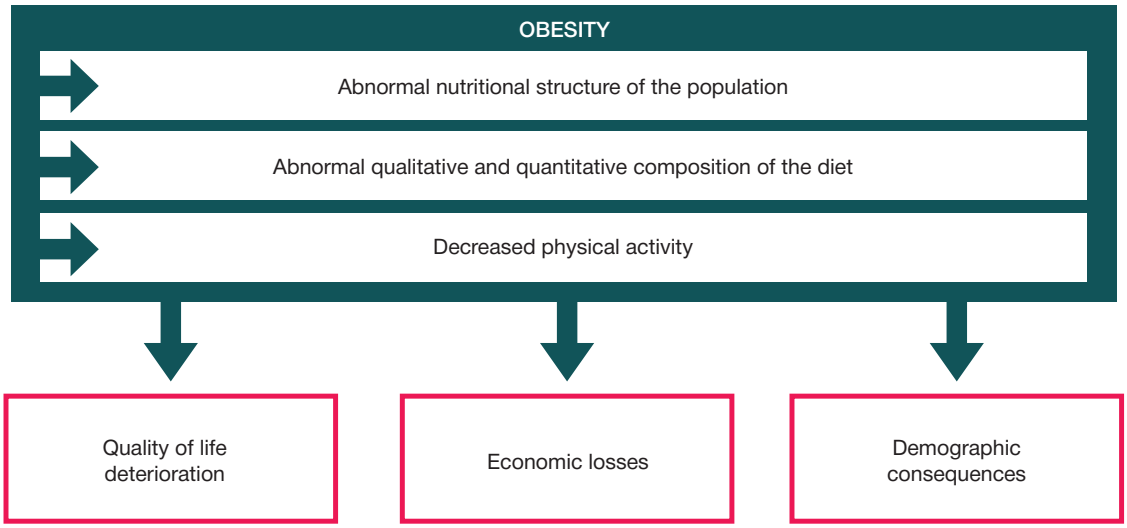

Fig. 1. Nutritional and environmental risk factors for obesity

individual recommendations, and generates reports. Integration of bioimpedance measurement, indirect calorimetry, laboratory monitoring and digital analysis of actual nutrition within NIAP platform creates the basis for personalized next-generation nutrition recommendations that can be used by doctors of various specialties, nutritionists and other specialists in the field of nutrition. An important prerequisite for the effective implementation of such recommendations is the availability of specialized food products that meet modern requirements for nutritional value and micronutrient composition. To this end, as part of the implementation of comprehensive scientific programs under the auspices of the Ministry of Science and Higher Education of the Russian Federation, the consortium "Health Preservation, Nutrition, Demography" coordinates development and deployment of innovative food technologies, including specialized products enriched with micronutrients. Together with digital tools, this work determines the current vector of development of preventive medicine.

Healthy Nutrition educational cluster as a tool in population-wide prevention programs

The effectiveness of preventive measures is largely determined by the level of training of medical personnel and the literacy of the population in matters of healthy nutrition. For this purpose, the Healthy Nutrition educational cluster has been created and is successfully operating on the basis of the Federal Research Center for Nutrition, Biotechnology and Food Safety. It combines the potential of a leading research center and the educational capabilities of specialized departments of medical universities [18]. The Healthy Nutrition cluster is an integrated system of educational and regulatory initiatives aimed at reducing the prevalence of obesity and alimentary diseases in the Russian population. The concept of the cluster is based on a three-vector approach: professional training of specialists, hygienic education of the population, and conducting information and educational campaigns. Professional training of specialists involves the acquisition of competencies in the field of nutritional diagnostics, personalized diets, clinical application of bioimpedance and indirect calorimetry methods, as well as interpretation of biochemical indicators of nutritional status. The lack of nutritional training for doctors is recognized as a key systemic problem in modern healthcare. According to an international review, a significant proportion of clinicians lack sufficient practical skills in dietary counseling, which substantially reduces the effectiveness of preventing diet-related diseases [19]. The inclusion of courses on the principles of nutritional science, vitamins, minerals, and bioactive food components in professional educational programs provides the necessary evidence base for clinically sound dietary recommendations [20]. Hygienic education of the population is aimed at learning the standards and rules of rational nutrition, development of healthy lifestyle skills, and limiting the consumption of saturated fats, ultra-processed foods, and simple sugars. The results of the analysis of randomized controlled trials demonstrate that preventive interventions at school, including dietary adjustments, increased physical activity, and general organizational changes, significantly reduce body mass index in children and adolescents [21].

The cluster actively uses digital technologies, mobile applications, and telemedicine, which enables wide audience coverage, personalized recommendations, and continuous monitoring of dietary patterns [22]. Information and educational campaigns are aimed at increasing the nutritional literacy of the population as a key predictor of healthy eating behavior. Studies show that comprehensive education for obese patients, combining dietary counseling and self-control exercises, significantly reduces body weight, waist circumference, and glycated hemoglobin levels compared with standard medical care [23]. The work of the educational cluster relies on systemic mechanisms, sanitary and epidemiological monitoring, and legislative regulation of food labeling, which enables creation of a conducive food environment and ensure the consistency of educational and regulatory interventions. Thus, Healthy Nutrition is a multi-level system integrating professional training of doctors, hygienic education of the population, and information and educational campaigns. The implementation of a three-vector approach, combined with digital technologies and regulatory mechanisms, creates the basis for sustainable healthy eating skills and reducing the prevalence of alimentary diseases. Further development of the cluster should be aimed at standardizing nutritional education programs, expanding population coverage with preventive measures, and deepening interagency cooperation in the field of health care.

Multi-tier system of prevention of obesity complications

The modern paradigm of obesity prevention is based on the principle of several tiers, involving the integration

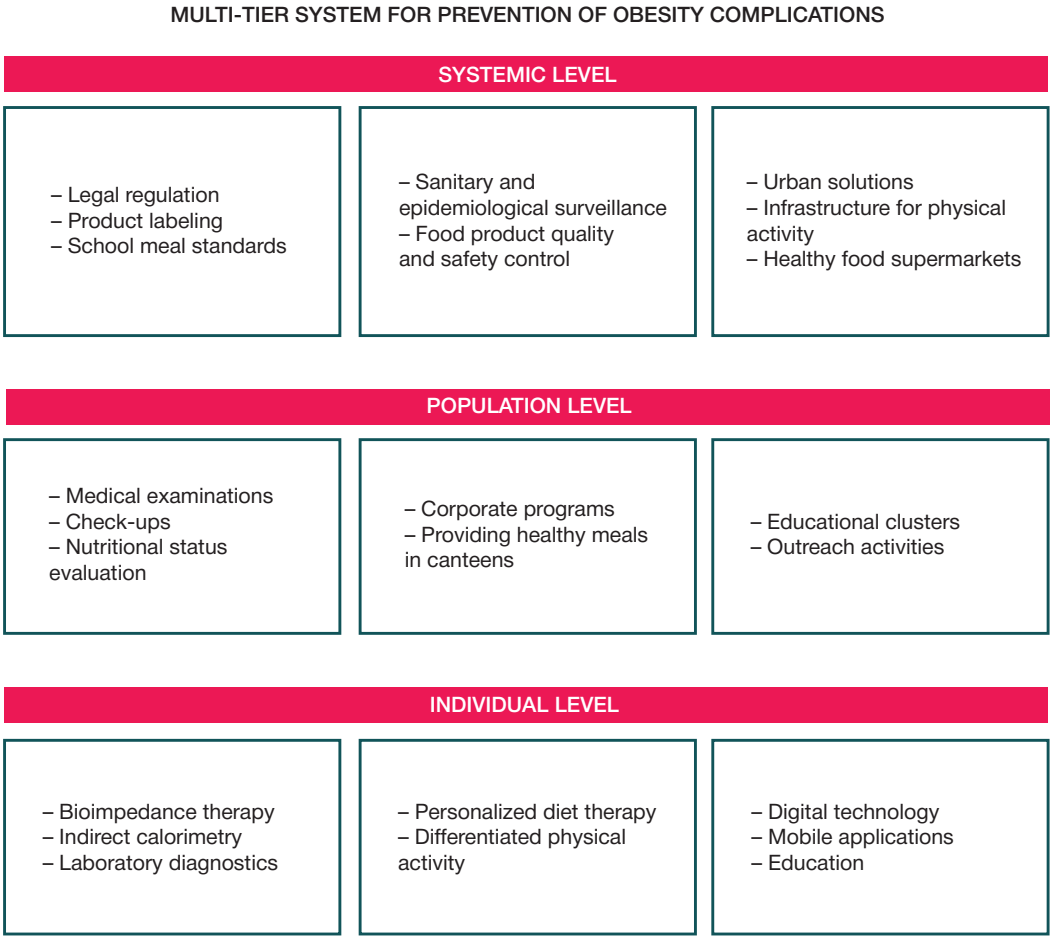

Fig. 2. Multi-tier system for prevention of obesity complications in the context of population's health preservation efforts

of individual, population, and systemic interventions to achieve a positive effect (Fig. 2). Long-term studies show that single interventions aimed at only one patient or one risk group do not achieve a sustainable reduction in the population-wide burden of the disease. In this regard, the development of multi-tier prevention systems working on the systemic, population, and individual levels is a methodologically sound approach [24–26].

At the systemic level, the efforts are aimed at legislative regulation, food labeling, school nutrition standards, sanitary and epidemiological supervision, food quality and safety control, urban planning solutions and deployment of infrastructure for physical activity, and launching healthy food supermarkets. Experts recognize structural changes in the environment that create conditions for healthy behavior as more effective than isolated educational programs, since they affect risk factors before they are realized at the level of a single person [26].

At the population level, the work revolves around general medical and preventive examinations, assessment of nutritional status, corporate health programs, provision of healthy meals in canteens, as well as the development of educational clusters and awareness-raising activities. The level of an individual involves digital technologies and mobile applications, educational programs for patients, personalized diet therapy, differentiated physical activity, as well as diagnostic methods for metabolic disorders (bioimpedance, indirect calorimetry, laboratory diagnostics).

A personalized approach that accounts for individual metabolic, genetic, and behavioral characteristics of the patient, ensures higher adherence to treatment and long-term control of body weight [27–29]. Personalized obesity therapy is based on the identification of the patient's metabolic phenotypes. The indirect calorimetry method allows determining the respiratory coefficient and calculating the rate of oxidation of carbohydrates and fats, which enables prediction of the effectiveness of diet therapy and tailored selection of the ratio of macronutrients [12]. Bioimpedance measurements show the total volume of fat and its distribution, and reveal the musculoskeletal mass and phase angle that reflect the integrity of cell membranes and the quality of nutrition of the patient [30, 31]. An additional method that increases the accuracy of personalization is the analysis of biochemical markers of nutritional status (carbohydrate and lipid profiles, vitamins, minerals, hormonal status) and genetic polymorphisms (FTO, MC4R, PPARG, ADRB2, ADRB3) associated with the risk of obesity and the rate of metabolic processes [32, 33]. Consequently, the multi-tier system of prevention of obesity complications is a complex model in which systemic, population-based, and individual interventions mutually reinforce each other. At the same time, it is at the individual level that the data of bioimpedance measurements, indirect calorimetry, and molecular genetic analysis are integrated for personalization of therapeutic and preventive measures, which is critically important for the formation of a stable commitment of patients and the prevention of relapses of the disease.

CONCLUSION

The analysis confirms that obesity is a multifactorial disease based not only on individual metabolic characteristics, but also on structural features of the food environment that form patterns of poor nutrition at the population level [7, 8]. Our findings

are consistent with the results of global epidemiological studies demonstrating a stable relationship between the availability of ultra-processed foods, low physical activity, and an increase in the prevalence of obesity [4, 11]. Traditional approaches to prevention, limited to dietary counseling not taking into account the metabolic phenotype, show low effectiveness in the long term, which is confirmed by high rates of repeated weight gain after the end of diet therapy [9, 10].

The key result of this work is the justification of the need to move from unified dietary recommendations to a personalized strategy that integrates instrumental diagnostic data. The use of bioimpedance allows not only to quantify fat and musculoskeletal mass, but also to determine the phase angle, which is considered as an integral marker of nutritional status and cellular health [30, 31]. In turn, indirect calorimetry enables calculation of the respiratory coefficient and the individual rate of oxidation of substrates, which is critically important for predicting the effectiveness of diet therapy and preventing a slowdown of basal metabolism in response to caloric restriction [12]. An additional predictor that increases the accuracy of personalization is the analysis of genetic polymorphisms associated with the risk of obesity and the rate of metabolic processes [33]. The integration of these methods into clinical practice is in line with current trends in the development of personalized medicine; it enables realization of the individual approach to nutritional support, taking into account the patient's metabolic, genetic characteristics and eating behavior. The three-level prevention model presented in the review, combining systemic, population-based, and individual interventions, deserves special attention. Literature data indicate that structural changes in the food environment have greater population effectiveness compared to isolated educational programs, since they affect risk factors before they are realized at the individual level [34].

However, the success of systemic measures directly depends on the level of nutritional literacy of doctors and the population, which underscores the important role of the Healthy Nutrition educational cluster. The insufficient level of dietary competence among clinicians, confirmed by international reviews [19, 20], limits the implementation of personalized prevention. In this regard, the development of a system of continuing medical education in the field of nutrition, as well as the implementation of school hygiene education programs that have proven effective in reducing body mass index in children [21, 22], should be considered as public health policy priorities. An important practical result of the work is the description of the NIAP software that integrates bioimpedance measurement, indirect calorimetry, and laboratory tests data to generate personalized nutrition recommendations. According to modern research, digital platforms of this type can increase patient adherence to treatment by visualizing progress, automating diet control, and providing real-time feedback [17]. Thus, the results of the analysis allow formulating key provisions that are important for the scientifically based organization of obesity prevention: firstly, the assessment of the metabolic phenotype using bioimpedance and indirect calorimetry is a prerequisite for the personalization of diet therapy; secondly, a multi-tier prevention system should simultaneously be implemented at the systemic, population, and individual levels, prioritizing structural changes; thirdly, the training of qualified personnel and increasing the awareness of the population with the help of the Healthy Nutrition educational cluster are necessary to ensure effectiveness of preventive programs. The implementation of such a system requires coordination of efforts at all stages — from the formation of a health-saving environment and population screening to personalized diet therapy based on advanced diagnostics. The introduction of these methods into general medical and preventive examination programs will allow identifying high-risk metabolic phenotypes and developing individual nutrition recommendations, which aligns with the strategic objectives of health preservation of the population of the Russian Federation. However, their effective deployment is impossible without the proper level of training of medical personnel and literacy of the population. The development of the Healthy Nutrition educational cluster and the introduction of digital tools, including the NIAP platform, create an infrastructure for improving the competencies of specialists and educating the population, which, together with sanitary and epidemiological monitoring measures, forms the basis for long-term body weight control and reducing the prevalence of alimentary diseases. In order to implement these tasks in real clinical practice, further research should aim to evaluate the clinical and economic effectiveness of the proposed educational and diagnostic technologies in primary health care, as well to develop national clinical recommendations for personalized prevention of obesity that factor in the hygienic aspects of nutrition.

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