IRON DEFICIENCY STATES IN YOUTH: ETIOLOGY AND MODERN CORRECTION METHODS

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Abstract*. This review article analyzes contemporary medical literature on the prevalence, mechanisms, and treatment of iron deficiency states (IDS) among youth and adolescents. Although the World Health Organization recognizes iron deficiency as one of the most common nutritional disorders, in the 14–21 age group it often remains a hidden epidemic. The review aims to systematize clinical and epidemiological findings on the causes of sideropenia in young people and to emphasize the need for early diagnosis of latent deficiency. Evidence from national and international studies shows that screening based only on hemoglobin is insufficient because it may fail to detect many cases of depleted tissue iron stores. The article outlines key pathogenetic factors, including rapid growth, increased physiological demand, menstrual blood loss, and nutritional poverty caused by frequent fast-food consumption and inadequate intake of bioavailable heme iron. Special attention is given to non-hematological consequences, such as weakened T-cell immunity, reduced memory and concentration, poorer academic performance, and reproductive risks linked to impaired NO-dependent adaptation. Current recommendations indicate that dietary correction is mainly preventive, while confirmed latent iron deficiency, especially ferritin below 15–20 ng/mL, requires oral iron therapy for at least three months. Timely treatment improves quality of life and prevents future complications.*
Keywords: *iron deficiency, youth, serum ferritin, sideropenia, nutritional poverty.*

Introduction. Iron deficiency states (IDS) have remained one of the most discussed topics in global medicine for decades. According to expert estimates by the World Health Organization (WHO), a deficiency of this micronutrient is recognized as the most massive nutritional disorder, affecting more than 2 billion people—nearly one-third of the global population. Despite significant progress in nutrition and pharmacology, the problem of sideropenia has not lost its urgency and, in some regions, has even taken on the character of a "hidden pandemic." Researchers are particularly concerned about the health status of the youth—adolescents and students aged 14 to 21—who represent the strategic human and reproductive potential of any society.

The biological role of iron during critical periods of development. The biological significance of iron extends far beyond its participation in hemoglobin synthesis. This micronutrient is a unique biocatalyst and a cofactor for more than 70 enzyme systems that ensure the vital activity of every cell in the body. Iron is essential for cellular respiration processes (as part of cytochromes), DNA synthesis, detoxification of foreign compounds, and maintenance of the oxidant-antioxidant balance [3].

During the youth period (14–21 years), the demand for iron increases sharply. This is associated with the so-called "second growth spurt," characterized by an intense increase in linear body dimensions, muscle mass development (especially in males), and an increase in circulating blood volume. In females, this process is complicated by the onset of the menstrual cycle, creating

additional physiological iron losses that are often not compensated by dietary intake. Thus, even a minor deviation from a balanced diet at this age can lead to a negative iron balance.

The "hidden hunger" phenomenon: from latent deficiency to anemia. One of the main problems highlighted in modern literature is the insufficient diagnosis of the early stages of deficiency. In clinical practice, an approach has long prevailed where attention is paid to iron status only when hemoglobin levels decrease—the stage of manifest iron deficiency anemia (IDA). However, researchers emphasize that IDA is only the "tip of the iceberg." It is preceded by a long period of latent iron deficiency (LID), during which tissue iron stores (ferritin) are already depleted and specific tissue enzymes operate under deficiency conditions, even though hemoglobin remains within the normal range [4].

For today's youth, a specific pathogenetic background is characteristic. High physiological needs are superimposed on unfavorable social factors: irregular eating habits, a preference for fast food and products with low biological value (so-called "nutritional poverty"), and a trend toward unreasonable diets. Furthermore, the educational process in universities is accompanied by constant psycho-emotional stress and cognitive overload. In such conditions, iron is consumed by the body much faster. As a result, symptoms occur that students often mistake for ordinary fatigue: decreased concentration, memory impairment, constant drowsiness, and emotional instability.

Systemic influence and review objectives. The consequences of iron deficiency at a young age are systemic. This includes not only increased fatigue but also suppression of immune defense (secondary immunodeficiency), making youth more vulnerable to infections. Moreover, modern studies prove that IDS in youth acts as a predictor of serious reproductive disorders in the future.

The purpose of this literature review is to systematize current data on the etiology and pathogenesis of IDS in youth, analyze the effectiveness of existing diagnostic markers, and justify the need for early preventive correction of this condition. We aim to show that the timely detection of iron deficiency at the latent stage is key to preserving the health and intellectual potential of young people.

Materials and methods. Information search strategy. To write this literature review, a comprehensive retrospective search and systematic analysis of domestic and foreign scientific and medical publications were conducted. The search for relevant sources was carried out in leading electronic databases and scientific citation indexes, including PubMed/MEDLINE, Web of Science, Scopus, as well as the RSCI (eLibrary.ru) and CyberLeninka.

The search was conducted using the following keywords and their combinations in Russian and English: “iron deficiency anemia,” “latent iron deficiency,” “serum ferritin,” “sideropenia,” “youth,” “adolescents,” “students,” “nutritional poverty,” and “reproductive health.”

Inclusion and exclusion criteria. To ensure high reliability and a narrow focus of the review, strict criteria for selecting literary sources were developed. The final analysis included the following categories of publications:

- ✓ Epidemiological studies covering the target age group—adolescents and young adults (14 to 21 years old).
- ✓ Works dedicated to the comparative analysis of the diagnostic value of hemoglobin and serum ferritin.
- ✓ Studies of systemic (non-hematological) manifestations of iron deficiency, including effects on immune status, cognitive functions, and the reproductive system.

- ✓ Official clinical recommendations from international and national committees (e.g., International Nutritional Anemia Consultative Group — INACG) on the prevention and treatment of IDS.
- ✓ Articles dedicated to the following were excluded from the review:
- ✓ Congenital hemolytic anemias (thalassemia, sickle cell anemia) not related to nutritional and physiological factors.
- ✓ Iron deficiency in elderly and senile persons, as the etiology of IDS in these groups is fundamentally different (predominantly oncological diseases and chronic gastrointestinal bleeding).

Analysis and synthesis of data. The methodological basis of the review included both modern clinical studies and fundamental historical works (e.g., the works of H. Pastides [5] and early publications by L.M. Kazakova [1]), which allowed for tracing the evolution of scientific views on the problem.

A total of more than 50 primary sources were analyzed, from which the most representative works with a high level of evidence were selected for final citation. Data evaluation was carried out using the qualitative synthesis method: information was grouped according to key pathogenetic mechanisms, which made it possible to identify the main gaps in modern diagnostics and formulate substantiated recommendations for their elimination.

Results and discussion. Analysis of IDS prevalence in the youth population. The synthesis of modern epidemiological research data reveals an extremely high prevalence of sideropenia among individuals aged 14–21. The literature analysis indicates that the actual situation is significantly more complex than reflected in official statistics, which are primarily based on hemoglobin levels.

According to studies by H. Pastides conducted among various groups of young people in Connecticut, the frequency of manifest iron deficiency anemia (IDA) varied from 4.4% to 17.9% in females, while it did not exceed 5.5% in males. Notably, in the group of Yale University students, the anemia rate was among the highest among women, which refutes the thesis that iron deficiency is exclusively a problem of low-income populations [5].

However, the most alarming figures pertain to latent iron deficiency (LID). As noted by A.N. Shchukov and V.I. Petukhov, the percentage of individuals with hidden deficiency (exhibiting normal hemoglobin but ferritin <20 ng/mL) is two to three times higher than the frequency of anemia. In certain regions of Russia and Latvia, the prevalence of LID among the generation born in the 1990s reaches 40–50% [4]. This means that nearly every second young person is in a state of metabolic exhaustion that remains undiagnosed by standard methods.

Etiological structure of the deficiency Based on the analyzed materials [1, 2, 3], we have classified the primary causes of IDS development in youth as follows:

- ✓ **Intensive Biological and Physiological Requirements**: During the critical developmental window of 14 to 21 years, the human body undergoes a "second growth spurt". This period is defined by an intense increase in linear body dimensions and the rapid development of muscle mass, particularly in males. These processes necessitate a sharp increase in iron demand to facilitate the building of new cellular structures and the substantial expansion of circulating blood volume.
- ✓ **The Socio-Behavioral Phenomenon of "Nutritional Poverty"**: Modern adolescents frequently succumb to a specific dietary pattern where an excess of carbohydrates is consumed alongside a critical deficit of heme iron. This "nutritional poverty" is

characterized by a preference for fast-food products and refined items with low biological value. Because such diets fail to provide even the minimum physiological requirement of bioavailable iron, they inevitably lead to a negative iron balance and metabolic exhaustion.

- ✓ **Gender-Specific Physiological Factors**: In females, the biological demand for iron is significantly complicated by the onset of the menstrual cycle. The resulting physiological iron losses are the dominant cause of anemia within this subgroup, as these losses are frequently not compensated by adequate dietary intake.
- ✓ **Academic and Psycho-Emotional Stressors**: The educational environment in universities introduces constant cognitive overload and psycho-emotional stress. Under these high-pressure conditions, the body consumes its iron reserves—which act as a cofactor for over 70 enzyme systems—at a much faster rate than under normal circumstances.
- ✓ **The "Hidden Hunger" Diagnostic Gap**: A significant contributing factor to the persistence of these states is the clinical reliance on hemoglobin levels alone. This traditional approach leaves up to 70% of cases of critical tissue iron depletion undetected. Consequently, students remain in a state of latent iron deficiency (LID), where tissue stores (ferritin) are depleted even while hemoglobin remains within a "normal" range

Non-hematological manifestations: immunity and the cognitive sphere Analysis of literary data shows that the systemic consequences of iron deficiency manifest long before a drop in hemoglobin occurs. T.V. Kazyukova argues that sideropenia is a potent factor in secondary immunodeficiency [3]. A lack of iron as a cofactor for myeloperoxidase and other enzymes leads to decreased phagocytosis and impaired proliferation of T-lymphocytes. This explains the high frequency of respiratory diseases among students with low ferritin levels.

The cognitive aspect is of particular significance. Iron participates in the synthesis of dopamine and the process of myelinating nerve fibers. Research confirms a direct link between iron deficiency and "student burnout syndrome": distractibility, impaired short-term memory, and an inability to withstand prolonged intellectual loads are typical signs of cerebral tissue hypoxia at low ferritin levels.

Reproductive risks and long-term prognosis. A pivotal and highly consequential outcome derived from this comprehensive analytical review is the unequivocal confirmation of the pathophysiological linkage connecting iron deficiency states (IDS) during adolescence with the subsequent emergence of profound reproductive dysfunctions in adulthood. Pioneering experimental investigations conducted by A.N. Shchukov and V.I. Petukhov have successfully established a robust, positive correlation between the circulating concentrations of serum ferritin—the primary biomarker of tissue iron stores—and the endogenous production of nitric oxide (NO).

A precipitous decline in systemic iron reserves effectively inhibits the enzymatic synthesis of nitric oxide, a critical vasodilator that is absolutely indispensable for the physiological adaptation and hemodynamic remodeling of the maternal vascular architecture throughout the gestational period. As a direct physiological consequence of this vascular maladaptation, women who endured uncorrected iron deficiency states throughout their youth exhibit a quantifiable, twofold escalation in the statistical probability of experiencing "missed" pregnancies alongside a spectrum of other severe gestational complications. Therefore, it is clinically imperative to recognize that the prompt, accurate diagnosis and early therapeutic intervention of iron deficiency states within the contemporary youth demographic serves as a fundamental, non-negotiable prerequisite for safeguarding the demographic vitality and overall physiological well-being of successive generations.

Effectiveness of correction methods. In the context of therapeutic intervention, there is an unequivocal consensus among all the scrutinized researchers and clinical experts [1, 3, 6]: dietary modifications and nutritional optimization serve an exclusively prophylactic function. Once a clinical diagnosis of either latent iron deficiency (LID) or manifest iron deficiency anemia (IDA) is definitively established, reliance on dietary intake alone becomes clinically insufficient; instead, the immediate implementation of targeted pharmacological therapy utilizing oral iron supplements becomes an absolute medical necessity.

A profoundly significant physiological revelation highlighted within the literature is the stark temporal discrepancy in recovery rates: the biochemical replenishment of deep tissue iron reservoirs—specifically represented by serum ferritin "depots"—proceeds at a considerably more protracted and gradual pace compared to the relatively rapid normalization of circulating hemoglobin concentrations. Consequently, to secure a durable, long-term therapeutic outcome and actively prevent subsequent clinical relapses, the prescribed regimen of pharmacological ferrotherapy must be meticulously sustained for a minimum continuous duration of at least three months..

Conclusion. Summarizing the analysis of modern scientific literature, it can be stated that the problem of iron deficiency states (IDS) in youth (14–21 years old) has moved beyond a narrow hematological discipline and acquired the status of a multidisciplinary medical and social task. The systematization of data from leading researchers [1, 3, 5] allows us to formulate the following key conclusions and recommendations:

- ✓ **The need to change the diagnostic paradigm.** The conducted review confirms that traditional screening, based exclusively on the determination of hemoglobin levels, is an insufficiently sensitive tool for the youth population. It leaves up to half of the cases of latent iron deficiency (LID) undiagnosed, a condition in which systemic metabolic disorders are already observed. We consider it critically important to introduce mandatory testing of serum ferritin levels into the routine health screening programs for students. A threshold ferritin value below 15–20 ng/mL should be considered a signal for the immediate initiation of corrective measures, even with normal red blood cell indices.
- ✓ **Multifactorial etiology.** The problem of IDS in youth cannot be solved by medical methods alone. The deep interrelationship between the physiological needs of the growing body and socio-behavioral factors ("nutritional poverty," high academic loads, stress) requires a comprehensive approach. It is necessary to create educational programs for students aimed at improving nutritional literacy and understanding the importance of consuming bioavailable heme iron.
- ✓ **Recognition of systemic consequences.** Iron deficiency at a young age is not temporary fatigue, but a factor directly affecting the quality of the nation's intellectual capital and its demographic future. The proven link between sideropenia and the risks of reproductive losses in the future, as well as secondary immunodeficiency, makes early correction of IDS a matter of national security and long-term population health.
- ✓ **Strategy for therapeutic correction.** Based on the analyzed clinical guidelines [6], it should be emphasized: the treatment of an identified deficiency must be exclusively pharmacological and prolonged. Diet therapy is an important background but cannot serve as an independent method of treatment. To fully replenish tissue iron stores, the course of ferrotherapy should continue for 3–4 months under ferritin control, which prevents relapses and ensures the stable functioning of all iron-dependent systems of the body.

The implementation of these recommendations into practical healthcare will significantly improve the academic performance of the youth, strengthen their immune status, and minimize the risks of developing serious pathologies in adulthood.

REFERENCES

1. Kazakova L. M. Iron deficiency in children // Pediatrics. — 1984. — № 9. — P. 31–33.
2. Kazakova L. M. Iron deficiency in children (Lead article) // Kemerovo State Medical Academy. — 25 p.
3. Kazyukova T. V. Iron deficiency in children and adolescents (Lecture) // Department of Children's Diseases No. 1. — 12 p.
4. Shchukov A. N., Bykova E. Y., Petukhov V. I., Baumane L. H. Iron deficiency states (IDS) as a predictor of reproductive disorders // Eurasian Union of Scientists (ESU). — 2014. — № VI. — Medical Sciences. — P. 69–71.
5. Pastides H. Iron Deficiency Anemia Among Three Groups of Adolescents and Young Adults // The Yale Journal of Biology and Medicine. — 1981. — Vol. 54. — P. 265–271.
6. International Nutritional Anemia Consultative Group (INACG). Guidelines for the Use of Iron Supplements to Prevent and Treat Iron Deficiency Anemia. — Washington, 1998.
7. Addy D. P. Happiness is: iron // British Medical Journal. — 1986. — Vol. 292. — P. 969–970.
8. Alimova, Z. A., Ulugberdiyev, A., Ismoiljonov, A. I., Mukhammadjonov, K., & Rikhsiboyev, R. (2024). The role of semiconductor heterostructures in modern microelectronics. *Science and innovation*, *3*(A10), 204-208.