# PREVALENCE OF IRON DEFICIENCY IN ADOLESCENT HIGH PERFORMANCE SPORTS

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In children, 90% of all anemia cases are due to iron deficiency. Iron is an essential element so iron metabolism disorders have negative consequences for health. Currently, there are no reliable statistical data on the prevalence of iron deficiency in elite young athletes in the Russian Federation (RF). The aim of this study was to evaluate the prevalence of iron deficiency anemia (IDA) and latent iron deficiency (LID) in young elite athletes. We retrospectively analyzed 802 outpatient records of members of the Russian national sport teams aged 13–18 (mean age is 15.4 ± 2.1 years; 434 (54.1%) girls, 368 (45.9%) boys) in 17 sports, who underwent in-depth medical examination including clinical blood tests and serum iron level assays. IDA was diagnosed in 43 young elite athletes (5.4% of all examined athletes). The prevalence of IDA in female adolescents was significantly higher than in male adolescents (8.9% and 1.1%, respectively; $p = 0.0001$). The prevalence of LID in game sports was significantly higher compared to the other sports. LID was recorded in 186 athletes (23.2%). LID was less common in cyclic sports and was not gender dependent. It can be concluded that young elite athletes have a moderate prevalence of IDA (> 5%). However, since LID was diagnosed in 20% of the athletes, it may be necessary to perform thorough examination for timely screening and correction of iron deficiency in adolescent high performance sports.

**Keywords:** children, iron deficiency anemia, latent iron deficiency, young athletes, sports medicine

**Author contribution:** Isaeva EP — development of the study protocol, collection of data, processing and interpretation of results, manuscript writing; Okorokov PL — collection of data, interpretation of results, manuscript editing; Zyabkin IV — approval of the study protocol, manuscript editing.

**Compliance with ethical standards:** the study was approved by the Ethical Committee of the Moscow Medico-Social Institute named after F.P. Gaaz (Protocol No. 4 dated October 04, 2021). Parents/guardians or legal representatives of athletes signed a voluntary consent to participate in the study.

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**Received:** 16.04.2024 **Accepted:** 31.05.2024 **Published online:** 27.06.2024

**DOI:** 10.47183/mes.2024.024

# РАСПРОСТРАНЕННОСТЬ ЖЕЛЕЗОДЕФИЦИТНЫХ СОСТОЯНИЙ В ДЕТСКО-ЮНОШЕСКОМ СПОРТЕ ВЫСШИХ ДОСТИЖЕНИЙ

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Железодефицитная анемия (ЖДА) составляет 90% от всех анемий в детском возрасте. Физиологическая значимость железа для организма человека высока, поэтому нарушения его обмена могут иметь негативные последствия. В настоящее время в Российской Федерации (РФ) отсутствуют достоверные статистические данные о распространенности железодефицитных состояний у элитных юных спортсменов. Целью работы было ценить распространенность ЖДА и латентного дефицита железа (ЛДЖ) у юных элитных спортсменов. Проведен ретроспективный анализ 802 амбулаторных карт членов сборных спортивных команд РФ в возрасте 13–18 лет (средний возраст — 15,4 ± 2,1 лет; 434 (54,1%) девочки, 368 (45,9%) — мальчиков) по 17 видам спорта, прошедших углубленное медицинское обследование, в том числе исследование общеклинического анализа крови и уровня сывороточного железа. ЖДА диагностирована у 43 юных элитных спортсменов, что составило 5,4% обследованных. Частота выявления ЖДА у девушек статистически значимо превышает таковую у юношей (8,9% и 1,1% соответственно; $p = 0,0001$). Распространенность ЖДА в игровых видах спорта статистически значимо выше по сравнению с другими группами спорта. ЛДЖ зафиксирован у 186 спортсменов (23,2%). ЛДЖ реже встречается у представителей циклических видов спорта и не имеет гендерных особенностей. Выводы: у юных элитных спортсменов отмечается умеренная распространенность ЖДА (> 5%). Однако у каждого пятого атлета выявляется ЛДЖ, что ставит вопрос о необходимости тщательного обследования для своевременного скрининга и коррекции железодефицитных состояний в детско-юношеском спорте высших достижений.

**Ключевые слова:** дети, железодефицитная анемия, латентный дефицит железа, юные спортсмены, спортивная медицина

**Вклад авторов:** Е. П. Исаева — разработка протокола исследования, сбор материала, обработка и интерпретация результатов, подготовка рукописи; П. Л. Окороков — сбор материала, интерпретация результатов, редактирование текста; И. В. Зябкин — утверждение протокола исследования, редактирование текста.

**Соблюдение этических стандартов:** исследование одобрено этическим комитетом при АНО ДПО «Московский медико-социальный институт имени Ф.П. Гааза» (протокол № 4 от 04 октября 2021 г.). Родители/опекуны или законные представители спортсменов подписали добровольное согласие на участие в исследовании.

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**Статья получена:** 16.04.2024 **Статья принята к печати:** 31.05.2024 **Опубликована онлайн:** 27.06.2024

**DOI:** 10.47183/mes.2024.024

Iron deficiency remains the most common nutrient deficiency in the world [1]. The occurrence of iron deficiency is associated with impaired intake and absorption or increased loss of iron, and is characterized by microcytosis and hypochromic anemia [2]. Iron is an essential trace element participating in enzymatic systems and providing redox homeostasis of the body, as well as an important component of proteins involved in aerobic metabolism [3]. In athletes, iron metabolism disorders can have negative consequences such as reduced physical performance, limited recovery opportunities, and decreased tone of skeletal muscles [4, 5]. Currently, there are no reliable statistical data on the prevalence of iron deficiency in young elite athletes in the Russian Federation (RF).

The aim of this study was to estimate the prevalence of iron deficiency anemia and latent iron deficiency in young highly qualified athletes in the Russian Federation.

## METHODS

A retrospective single-center uncontrolled study included young athletes of sports teams of the Russian Federation who underwent in-depth medical examination at the Federal Scientific and Clinical Center for Children and Adolescents of the Federal Medical and Biological Agency of Russia (Moscow, Russia) within 2019–2022 period.

Inclusion criteria: age up to 18 years; absence of therapy with iron preparations for three months before the study.

Exclusion criteria: presence of chronic blood diseases.

All young athletes were examined once for complete blood count and serum iron level. The complete blood count was performed using a Sysmex XN-350 hematology analyzer (Sysmex Corporaition; Japan) with determination of hemoglobin level. Blood biochemical analysis including serum iron level was performed using Indiko Plus Automatic Clinical Chemistry Analyzer (Thermo Fisher Scientific; USA). Iron deficiency anemia (IDA) was diagnosed when hemoglobin level decreased to values <120 g/L for female adolescents and 130 g/L for male adolescents in combination with a decrease in serum iron level to values <10.7 μmol/L [6]. Latent iron deficiency (LID) was diagnosed when serum iron levels dropped to <10.7 μmol/L [6].

Depending on main patterns of competitive and training activities, all the athlets were divided into six groups: game, cyclic, complex coordination, endurance, combat and multi sports.

## RESULTS

A total of 802 young athletes (368 male adolescents (45.9%), 434 female adolescents (54.1%)) aged 13–18 years (mean age 15.4 ± 2.1 years) in 17 sports were included in the study. IDA was diagnosed in 43 young elite athletes (5.4%) (see Table). In female adolescents, the prevalence of IDA was higher as compared to male adolescents (8.9% and 1.1%, respectively; $p = 0.0001$). The prevalence of IDA in game sports was statistically significantly higher compared to other sports groups (see Table).

LID was diagnosed in 186 athletes (23.1%). LID was observed to be less common in representatives of cyclic sports. No gender differences were found in the prevalence of LID in young highly qualified athletes (20.9% in male adolescents versus 25.2% in female adolescents; $p = 0.237$). No adverse events were recorded during the study.

## DISCUSSION

Iron deficiency ranks first among 38 most common human disorders [7]. In children, the main reasons of iron deficiency are nutritional iron deficiency, increased body demand for this trace element due to weight gain and rapid growth, reduced absorption, helminth infections, iron loss exceeding physiological levels (blood loss due to bleeding, etc.) [2]. Appearence of iron deficiency in athletes results from intense physical activity accompanied by increasing iron losses with urine and through the gastrointestinal tract, as well as dietary patterns (vegetarian diets, overall reduction in caloric intake in order to reduce weight, with existing eating disorders) [8].

Iron is a component of certain proteins and enzymes involved in cellular and systemic aerobic metabolism and redox homeostasis of the organism [4]. In particular, iron is involved in transport of cytochromes, iron-seroproteins and oxygen, and is a component of active centers of redox enzymes [9]. In the human body, vital cellular functions and elimination of possible cellular damage is maintained by regulation of iron metabolism including its absorption, transport and deposition in a nontoxic form [10]. As a catalyst of oxygenation and hydroxylation reactions, iron is involved in production and removal of free radicals, in the processes of tissue proliferation and immune defense as well as development and normal functions of the brain. [11]. As part of hemoglobin, iron is involved in oxygen transport; as part of myoglobin it helps to provide oxygen reserves in muscles; as part of the cytochromes of the respiratory chain, iron is invoilved in the processes of aerobic energy formation. Iron metabolism disorders therefore adversely affect the athletes' professional performance. [5].

Iron deficiency develops in two stages: LID characterized by a progressive decrease of storage iron and appearance of iron-deficient erythropoiesis, and IDA characterized by a combination of sideropenic and anemic syndromes.

Currently, there are no reliable statistical data on the prevalence of iron deficiency in elite young athletes in the Russian Federation. According to foreign studies, the prevalence of iron deficiency in female athletes varies from 15 to 35%, with 3 to

**Table.** Prevalence of iron deficiency anemia (IDA) and latent iron deficiency (LID) in highly skilled athletes depending on the type of sports activity

| Sports | LID | IDA |
|---|---|---|
| Combat sports ($n = 332$) | 22.9% (76) | 3.6% (12) |
| Game sports ($n = 183$) | 21.9% (40) | 8.2% (15) |
| Multi-sport athletic events ($n = 14$) | 35.7% (5) | – |
| Endurance sports ($n = 1$) | – | – |
| Complex coordination sports ($n = 237$) | 25.3% (60) | 5.9%(14) |
| Cyclic sports ($n = 35$) | 14.3% (5) | 5.7%(2) |
| $p$ | $p_{1-6} = 0.032$<br>$p_{2-6} = 0.028$<br>$p_{3-6} = 0.123$<br>$p_{5-6} = 0.037$ | $p_{1-2} = 0.012$<br>$p_{5-2} = 0.034$<br>$p_{6-2} = 0.043$ |
| Total: | 23.1% (186) | 5.4% (43) |

11% in male athletes [4]. Based on our results, IDA in young highly qualified athletes is observed in 5.4% of cases, and it is more frequent in female adolescents than in male adolescents. The obtained data well correlate with general population studies demonstrating gender differences in the prevalence of anemic conditions in children [6].

LID is considered to be a functional disorder and accounts for 70% of all cases of iron deficiency [12]. The analysis of epidemiological data revealed that the prevalence of LID in children varies significantly depending on living conditions, age, nutrition, socioeconomic conditions as well as criteria for diagnosing iron deficiency. According to epidemiologic studies, the prevalence of LID in Russia reaches 7.9–31% and is much more common in girls compared to boys. The most significant causes of LID are nutritional disorders and bleeding of various localizations [13]. Our results show that the prevalence of LID in young athletes is the same as in population on the whole however, without gender differences. Reduced iron in the body may be accompanied by a decrease in physical performance, impaired adaptation to regular increased loads on cardiovascular, respiratory and central nervous system as well as occurrence of immune deficiency in athletes [14]. Such physiological changes severely limit the professional capabilities of athletes and reduce their chances of achieving high performance.

## CONCLUSIONS

The study results reveal a high prevalence of latent iron deficiency in young highly qualified athletes regardless of gender. Timely correction of iron deficiency is very important under intense training and competitive pressure. Further research is needed to develop methods for correcting sideropenic states in young athletes.

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