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THE IMPACT OF IRON DEFICIENCY ON QUALITY OF LIFE, PHYSICAL PERFORMANCE, AND COGNITIVE FUNCTION AMONG WOMEN OF REPRODUCTIVE AGE: A REVIEW OF CURRENT LITERATURE

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ABSTRACT

Background: Iron deficiency is one of the most common nutritional deficiencies worldwide and represents a major public health concern, particularly among women of reproductive age. Although traditionally associated with anemia, increasing evidence indicates that iron deficiency may adversely affect health even in the absence of reduced hemoglobin concentrations.
Objective: This narrative review summarizes current evidence regarding the impact of iron deficiency on quality of life, physical performance, and cognitive function in women of reproductive age.
Methods: A literature review was conducted using PubMed/MEDLINE, Scopus, and Web of Science databases. Original studies, systematic reviews, and meta-analyses evaluating the clinical consequences of iron deficiency in women of reproductive age were included and qualitatively analyzed.
Results: Iron deficiency was consistently associated with reduced health-related quality of life, persistent fatigue, impaired psychological well-being, and poorer sleep quality. Evidence from systematic reviews and meta-analyses indicates that iron deficiency may impair physical performance by reducing aerobic capacity, exercise tolerance, and recovery after exertion, particularly among physically active women and athletes. Furthermore, inadequate iron availability may negatively affect cognitive function through its impact on neuronal metabolism and neurotransmitter synthesis, contributing to impaired attention, memory, and information processing. Importantly, many of these adverse effects may occur in women with iron deficiency without anemia. Iron supplementation has been shown to improve fatigue, selected cognitive outcomes, iron status, and physiological indicators of exercise capacity.
Conclusions: Iron deficiency should be recognized as a systemic condition affecting multiple dimensions of women's health beyond hematological parameters alone. Early diagnosis and appropriate management may improve quality of life, physical capacity, and cognitive functioning in women of reproductive age. Further research is required to establish standardized diagnostic criteria and optimal management strategies, particularly for iron deficiency without anemia.

KEYWORDS
Iron Deficiency, Women's Health, Fatigue, Cognitive Impairment, Exercise Performance

CITATION

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1. Introduction

Iron deficiency is one of the most prevalent nutritional deficiencies worldwide and remains a major public health challenge.[(Auerbach i in., 2025)] Women of reproductive age are particularly susceptible to iron deficiency due to menstrual blood loss, increased iron requirements during pregnancy, and, in some cases, inadequate dietary iron intake. In addition, physically active women constitute a population at increased risk, as intensive exercise may further affect iron metabolism [(Burns i in., 2025)]

Although iron deficiency is most commonly associated with anemia, accumulating evidence suggests that its clinical consequences may become apparent even before the onset of anemia. Insufficient iron availability adversely affects not only erythropoiesis and oxygen transport but also neurological function, cellular energy metabolism, and physical capacity. As a result, iron deficiency may contribute to chronic fatigue, reduced exercise tolerance, impaired concentration and memory, and diminished quality of life. [(Beatrix i in., 2022)]

The nonspecific nature of its clinical manifestations frequently leads to delayed diagnosis, which may adversely impact daily functioning, occupational performance, and participation in physical activity. Early recognition and appropriate management of iron deficiency may substantially reduce the burden of symptoms and limit the associated clinical consequences. [(Kumar i in., 2022a)]

The aim of this review is to present the current state of knowledge regarding the clinical consequences of iron deficiency in women of reproductive age, with particular emphasis on its impact on quality of life, physical performance, and cognitive function.

2. Materials and Methods

A narrative review of the literature was conducted to assess the impact of iron deficiency on quality of life, physical performance, and cognitive function in women of reproductive age. The literature search was performed using the PubMed/MEDLINE, Scopus, and Web of Science databases. The search strategy included the following keywords: "iron deficiency", "women of reproductive age", "quality of life", "physical performance", and "cognitive function".

Publications in English involving women of reproductive age and evaluating the clinical consequences of iron deficiency, including its effects on physical functioning, cognitive performance, and daily quality of life, were included in the analysis. Original studies, systematic reviews, and meta-analyses published in recent years were considered.

Based on the selected publications, a qualitative analysis of current evidence regarding the role of iron deficiency in women's health was performed.

3. Iron Deficiency in Women of Reproductive Age – Clinical Aspects

Iron is an essential micronutrient required for the maintenance of normal hematological, metabolic, and neurological functions. Within the human body, iron is predominantly present in hemoglobin, myoglobin, and various heme-containing enzymes. It plays a central role in oxygen transport, oxygen storage within skeletal muscle, and the regulation of mitochondrial processes involved in adenosine triphosphate (ATP) synthesis. Consequently, iron deficiency results not only in impaired erythropoiesis but also in disruptions of cellular energy metabolism and dysfunction of tissues with high metabolic demands, particularly skeletal muscle and the central nervous system. [(Musallam & Taher, 2018)]

Iron homeostasis depends on a tightly regulated balance between iron absorption, transport, storage, and utilization. Transferrin, a plasma glycoprotein, serves as the principal iron transport protein by binding circulating iron and delivering it to tissues via transferrin receptors expressed on the cell surface. Transferrin saturation (TSAT) reflects the proportion of circulating iron readily available for erythropoiesis and metabolic processes, whereas total iron-binding capacity (TIBC) provides an indirect measure of the iron transport capacity of plasma. Ferritin is the primary intracellular iron-storage protein, and its serum concentration is the most widely used marker of body iron stores. In the setting of iron deficiency, serum ferritin concentrations decline, followed by a reduction in transferrin saturation and diminished iron availability for peripheral tissues. [(Ru i in., 2024)] However, because ferritin also functions as an acute-phase reactant, interpretation of ferritin values should take into account the presence of concomitant inflammation, ideally through assessment of inflammatory markers such as C-reactive protein (CRP). [(Rizo-Téllez i in., 2023)]

Iron deficiency may present either as iron deficiency without anemia (IDWA) or as iron deficiency anemia (IDA). IDWA is characterized by depleted iron stores despite preserved hemoglobin concentrations. Although anemia is absent, affected individuals may experience clinical manifestations related to impaired activity of iron-dependent enzymes, reduced cellular energy production, and alterations in neurobiological function. As iron depletion progresses, hemoglobin synthesis becomes compromised, ultimately leading to the development of microcytic hypochromic anemia and reduced oxygen-carrying capacity. [(Sevgi & Mehta, 2023)]

Women of reproductive age constitute a population particularly vulnerable to iron deficiency owing to regular menstrual blood loss. Heavy menstrual bleeding (HMB) is of particular clinical relevance, as it may result in chronic iron loss and gradual depletion of iron stores. [(Munro i in., 2023)] Pregnancy represents another physiological state associated with substantially increased iron requirements. Expansion of plasma volume and erythrocyte mass, placental growth, and the metabolic demands of the developing fetus collectively contribute to the increased need for iron during this period. [(Georgieff, 2020)]

Additional risk factors for iron deficiency include inadequate dietary iron intake, impaired gastrointestinal absorption, chronic blood loss, and the use of restrictive diets. Conditions such as celiac disease and inflammatory bowel disease may further compromise iron absorption and increase the risk of deficiency. [(Wiafe i in., 2023)] Particular attention should be paid to physically active women, in whom elevated metabolic demands may coexist with increased iron losses. Exercise can influence iron metabolism through several mechanisms, including exercise-induced hemolysis, sweat-related iron loss, gastrointestinal microbleeding, and transient increases in hepcidin concentrations following intensive training. These mechanisms are especially relevant in female endurance athletes, among whom iron deficiency frequently coexists with relative energy deficiency in sport (RED-S). [(Peinado i in., 2021)]

4. Impact of Iron Deficiency on Quality of Life

Iron deficiency may significantly impair quality of life, even in the absence of overt anemia. In addition to its established role in erythropoiesis and oxygen transport, iron is essential for cellular energy metabolism, mitochondrial function, and neurotransmitter synthesis. Consequently, depletion of iron stores may contribute to persistent fatigue, reduced vitality, impaired psychological well-being, and limitations in everyday functioning. Emerging evidence indicates that women of reproductive age with iron deficiency frequently report lower health-related quality of life (HRQoL), reduced work productivity, and decreased engagement in social and physical activities. A comprehensive understanding of the multidimensional effects of iron deficiency on quality of life is therefore important for timely diagnosis and appropriate clinical management.

A systematic review conducted by Greig et al. evaluated the impact of iron deficiency on women of childbearing age and demonstrated that iron deficiency was associated with greater fatigue and poorer mental health at baseline. Furthermore, several intervention studies included in the review reported improvements in fatigue and psychological well-being following iron supplementation. Although the available evidence was characterized by substantial methodological heterogeneity, the overall findings suggest that restoration of iron stores may reduce fatigue-related symptoms and improve patient-reported outcomes. These observations underscore the importance of early identification and treatment of iron deficiency, including cases in which anemia has not yet developed. [(Greig i in., 2013)]

Further evidence regarding the effects of iron deficiency on quality of life was provided by Avery et al. (2020) in a systematic review of 15 randomized controlled trials assessing the impact of iron supplementation on cognition, mood, well-being, and fatigue among women of reproductive age. The review demonstrated a consistent reduction in subjective fatigue following iron supplementation, with statistically significant improvements reported in five of seven studies. Improvements in mood and well-being were observed in seven of nine studies, supporting the hypothesis that iron deficiency adversely affects health-related quality of life. [(Avery i in., 2020)]

Recent studies have also highlighted a potential association between iron deficiency and impaired sleep quality among women of reproductive age. Al Hinai et al. (2024) conducted a cross-sectional analysis using data from the National Health and Nutrition Examination Survey (NHANES) collected between 2005 and 2018 to examine the relationship between iron deficiency and sleep-related outcomes in non-pregnant women aged 20–49 years. The study included 6,731 participants, and iron deficiency was defined based on serum ferritin, soluble transferrin receptor, and hemoglobin concentrations. Women with iron deficiency were found to have a significantly greater likelihood of reporting poor sleep quality (OR = 1.42; 95% CI: 1.02–2.00), whereas those with iron deficiency anemia exhibited more than a twofold increase in the odds of poor sleep quality (OR = 2.08; 95% CI: 1.29–3.38). No significant association was identified between iron deficiency and sleep latency. [(Al Hinai i in., 2024)]

The broader effects of iron deficiency on psychological well-being and everyday functioning have been comprehensively reviewed by Cappellini et al. (2022). The authors emphasized that iron deficiency influences not only hematological parameters but also multiple dimensions of physical, cognitive, and emotional health. Iron deficiency may adversely affect daily functioning by reducing the ability to perform routine activities, lowering work productivity, and restricting participation in social and family life. The review further highlighted that, despite the considerable burden associated with these symptoms, iron deficiency remains frequently underdiagnosed and undertreated among women of reproductive age. As a consequence, appropriate intervention is often delayed, prolonging its detrimental effects on psychological well-being and functional capacity. [(Cappellini i in., 2022)]

5. Impact of Iron Deficiency on Physical Performance

Adequate iron status is essential for maintaining optimal physical performance due to its central role in oxygen transport, mitochondrial energy production, and skeletal muscle function. Iron deficiency may impair exercise capacity even before the development of anemia by limiting aerobic metabolism and reducing the activity of iron-dependent enzymes involved in oxidative phosphorylation. Consequently, affected individuals may experience decreased exercise tolerance, earlier onset of fatigue, prolonged recovery, and diminished physical performance. These effects are particularly relevant in women of reproductive age, especially those engaged in regular physical activity or competitive sports, in whom increased iron requirements and exercise-related iron losses further elevate the risk of deficiency. Maintaining adequate iron stores is therefore critical for preserving physical capacity, facilitating training adaptations, and supporting overall health.

The effects of iron deficiency on physical performance in female athletes were recently evaluated in a systematic review by Pengelly et al. (2025). The authors analyzed 23 studies involving 669 elite and high-performance female athletes representing 16 different sports disciplines to investigate the relationship between iron deficiency, iron supplementation, and athletic performance. The review demonstrated that iron deficiency adversely affects endurance capacity, resulting in an estimated 3–4% reduction in endurance performance. Importantly, the authors noted that iron deficiency without anemia may also impair maximal aerobic capacity through reduced iron availability for hemoglobin synthesis and cellular oxidative metabolism. Among iron-deficient athletes, iron supplementation was associated with improvements in endurance performance ranging from 2% to 20% and increases in maximal oxygen uptake (VO_2max) of 6% to 15%. These findings suggest that restoration of adequate iron stores may enhance exercise capacity and support physiological adaptation to training. The authors further emphasized the importance of routine monitoring of iron status in female athletes, who are particularly susceptible to deficiency due to menstrual blood loss, intensive training loads, and increased physiological demands [(Pengelly i in., 2024)]

Additional evidence was provided by a recent systematic review and meta-analysis conducted by Nakamoto et al., which demonstrated that iron supplementation in women with iron deficiency, both with and without anemia, significantly improved iron status and was associated with enhanced maximal aerobic capacity (VO_2max/VO_2peak). However, the effects on exercise performance outcomes, including time-to-exhaustion and time-trial performance, were less consistent. These findings suggest that improvements in physiological capacity do not necessarily translate into measurable enhancements in athletic performance. Nevertheless, the results underscore the importance of early diagnosis and treatment of iron deficiency to optimize physical capacity and reduce exercise-related fatigue, particularly among physically active women. [(Nakamoto i in., 2026)]

Iron deficiency may also adversely affect post-exercise recovery and adaptation to training, particularly in endurance athletes. Kuwabara et al. (2022) reported that insufficient iron availability impairs several physiological processes essential for recovery following physical exertion, including mitochondrial energy production, oxidative metabolism, and oxygen delivery to active skeletal muscle. The authors emphasized that iron deficiency, even in the absence of anemia, may be associated with reduced exercise tolerance, impaired adaptation to training stimuli, and symptoms resembling functional overreaching or overtraining, including persistent fatigue and diminished performance capacity. Given their increased susceptibility to iron depletion resulting from menstrual blood loss, high training demands, and, in some cases, inadequate dietary intake, female athletes represent a population requiring particular attention. Maintaining adequate iron stores is essential for supporting optimal recovery, facilitating training progression, and preserving physical performance. [(Kuwabara i in., 2022)]

6. Impact of Iron Deficiency on Cognitive functioning.

Iron deficiency is increasingly recognized as a clinically relevant factor affecting cognitive function, even in the absence of overt anemia. Iron plays a fundamental role in maintaining normal brain activity through its involvement in oxygen transport, mitochondrial energy production, myelin formation, and the metabolism of neurotransmitters, including dopamine and serotonin. Consequently, insufficient iron availability may impair neuronal function and contribute to deficits in attention, memory, information processing, and overall cognitive performance. These effects are of particular relevance in women of reproductive age, who are at increased risk of iron depletion due to menstrual blood loss and elevated physiological requirements. Cognitive impairment associated with iron deficiency may adversely affect academic achievement, occupational performance, and daily functioning, thereby contributing to a substantial reduction in overall quality of life.

Iron deficiency may influence cognitive performance through multiple neurobiological pathways. Cappellini et al. (2022) emphasized the essential role of iron in maintaining normal brain function. Reduced iron availability may contribute to symptoms such as impaired concentration, decreased mental alertness, and reduced cognitive efficiency. These manifestations are particularly important in women of reproductive age, among whom iron deficiency is common and may remain undetected when hemoglobin concentrations are still within the normal range. As a result, cognitive dysfunction may adversely affect everyday functioning, work productivity, and the ability to perform educational and professional tasks. [(Cappellini i in., 2022)]

Additional evidence supporting the association between iron deficiency and impaired cognitive function has been provided by Sheema and Rawekar (2022). In their systematic review, the authors evaluated the effects of iron deficiency anemia on cognitive performance using the P300 event-related potential, an objective neurophysiological marker of attention, information processing, and working memory. The review demonstrated that women with iron deficiency anemia exhibited alterations in P300 parameters, indicating reduced cognitive efficiency and impaired central nervous system functioning. Improvements observed following iron supplementation suggest that correction of iron deficiency may partially restore cognitive performance. These findings indicate that iron deficiency may negatively affect attention, concentration, and information processing, potentially reducing effectiveness in both educational and occupational settings. [(Sheema & Rawekar, 2022)]

More recent evidence further supports the relationship between iron deficiency and impaired cognitive and psychological functioning. Fiani et al. (2025) conducted a systematic review and meta-analysis assessing the effects of iron supplementation on cognitive and psychiatric outcomes in non-anemic individuals, including menstruating adults. The authors reported that iron supplementation was associated with improvements in cognitive performance, particularly in measures of intelligence and short-term memory, as well as reductions in fatigue and improvements in physical well-being. These findings suggest that iron deficiency may adversely affect brain function even before the development of anemia, potentially contributing to reduced concentration, impaired learning capacity, and lower efficiency in daily and occupational activities. [(Fiani i in., 2025)]

7. Diagnosis, Treatment, and Prevention of Iron Deficiency in Women of Reproductive Age

7.1. Laboratory Diagnosis of Iron Deficiency

The diagnosis of iron deficiency relies on the assessment of hematological parameters and biomarkers of iron metabolism. The initial diagnostic evaluation typically includes a complete blood count, encompassing hemoglobin (Hb), hematocrit (Hct), and red blood cell indices such as mean corpuscular volume (MCV) and mean corpuscular hemoglobin (MCH). In established iron deficiency anemia, microcytic hypochromic anemia is commonly observed; however, hematological abnormalities generally develop at a relatively late stage of iron depletion. Consequently, normal hemoglobin concentrations do not exclude the presence of iron deficiency without anemia (IDWA). [(Rusch i in., 2023)]

Assessment of iron status requires measurement of serum ferritin, the primary biomarker of body iron stores. Reduced ferritin concentrations indicate depletion of iron reserves and may be detected before the onset of anemia. However, ferritin is also an acute-phase reactant, and its concentration may increase in the presence of infection or chronic inflammation. For this reason, interpretation of ferritin levels should be undertaken in conjunction with inflammatory markers, particularly C-reactive protein (CRP). [(Kernan & Carcillo, 2017)]

Further evaluation of iron metabolism includes the assessment of iron transport parameters, including transferrin concentration, transferrin saturation (TSAT), and total iron-binding capacity (TIBC). TSAT reflects the proportion of circulating iron available for erythropoiesis and other metabolic processes, and reduced values are a characteristic feature of iron deficiency. In contrast, TIBC provides an indirect measure of plasma iron-binding capacity and may increase in response to reduced iron availability. [(Åsberg i in., 2026)]

The diagnosis of iron deficiency may be challenging because of the nonspecific nature of its clinical manifestations and the possibility of impaired iron status despite normal hematological findings. Symptoms such as chronic fatigue, reduced exercise capacity, impaired concentration, and delayed recovery are often attributed to stress, excessive workload, or intensive physical training, potentially delaying recognition of the underlying deficiency. This issue is particularly relevant among physically active women, in whom clinical symptoms may constitute the earliest manifestation of developing iron deficiency. [(Kovalev i in., 2024)]

7.2. Treatment of Iron Deficiency

Therapeutic management of iron deficiency should be tailored to the severity of iron depletion, the presence or absence of anemia, and the underlying etiology. A fundamental component of treatment is the identification and correction of factors contributing to iron loss, including heavy menstrual bleeding, impaired iron absorption, and inadequate dietary intake. [(Kumar i in., 2022b)]

Dietary modification represents an important element of management. Increasing the consumption of iron-rich foods, particularly sources of highly bioavailable heme iron, is generally recommended. In individuals following plant-based diets, careful nutritional planning and adequate intake of non-heme iron sources are essential. Iron absorption may be enhanced by concurrent vitamin C intake, whereas dietary components such as phytates, polyphenols, and calcium can reduce iron bioavailability when consumed simultaneously. [(Piskin i in., 2022)]

In most patients, oral iron supplementation remains the first-line therapeutic approach. Commonly prescribed formulations include ferrous sulfate, ferrous fumarate, and ferrous gluconate. Emerging evidence suggests that intermittent dosing regimens, including alternate-day administration, may enhance iron absorption by minimizing the regulatory effects of hepcidin while also reducing the frequency of gastrointestinal adverse events. [(Siebenthal i in., 2023)]

Intravenous iron therapy may be considered in patients who do not tolerate oral supplementation, demonstrate an inadequate response to treatment, have impaired gastrointestinal iron absorption, present with severe iron deficiency, or require rapid replenishment of iron stores. The choice of therapeutic strategy should be individualized and guided by the patient’s clinical status, underlying cause of deficiency, and treatment goals. [(Schaefer i in., 2020)]

7.3. Importance of Education and Prevention in High-Risk Groups

Prevention of iron deficiency should focus on the identification of women at increased risk and on raising awareness of the symptoms and potential consequences of this condition. Populations at particular risk include women with heavy menstrual bleeding, pregnant women, individuals following restrictive diets, patients with gastrointestinal disorders, and women engaged in intensive physical activity. [(Vinge i in., 2026)]

Particular attention should be given to physically active women, especially endurance athletes, in whom elevated metabolic demands, intensive training, and additional iron losses may contribute to the development of iron deficiency. Clinical manifestations such as persistent fatigue, reduced exercise capacity, impaired recovery, and declining athletic performance should prompt evaluation of iron status. [(Iolascon i in., 2024)]

Patient education regarding appropriate nutritional practices, regular laboratory monitoring, and early recognition of symptoms plays a key role in reducing the burden of iron deficiency and its associated consequences. Optimal management requires an interdisciplinary approach involving physicians, dietitians, and sports medicine specialists. Early diagnosis and appropriate treatment may contribute to improvements in quality of life, physical performance, and cognitive function among women of reproductive age. [(Skolmowska i in., 2022)].

8. Discussion

The findings presented in this review indicate that iron deficiency in women of reproductive age constitutes a clinically significant condition with consequences extending beyond the development of anemia. Current evidence suggests that reduced iron availability may adversely affect multiple physiological processes, including energy metabolism, skeletal muscle function, and central nervous system activity, resulting in diminished quality of life, impaired physical performance, and reduced cognitive function. Women of reproductive age are particularly vulnerable to iron deficiency due to menstrual blood loss, increased physiological demands during pregnancy, inadequate dietary intake, and conditions affecting iron absorption. Physically active women represent an additional high-risk population, as intensive exercise may exacerbate iron losses through mechanisms such as exercise-induced hemolysis, gastrointestinal microbleeding, and increased hepcidin activity. Consequently, regular assessment of iron status may be particularly important in individuals exposed to these risk factors. An important observation emerging from recent studies is the clinical relevance of iron deficiency without anemia (IDWA). Despite the presence of normal hemoglobin concentrations, depleted iron stores may adversely affect mitochondrial function, neurotransmitter synthesis, and skeletal muscle metabolism. As a result, women with IDWA may experience persistent fatigue, reduced exercise tolerance, impaired concentration, and limitations in daily functioning. These findings suggest that assessment of hemoglobin concentration alone may be insufficient to identify clinically meaningful iron deficiency.

The available evidence consistently demonstrates a substantial impact of iron deficiency on health-related quality of life. Fatigue, reduced vitality, impaired psychological well-being, and limitations in occupational and social activities are among the most commonly reported manifestations. Studies evaluating iron supplementation indicate that correction of iron depletion may improve fatigue and patient-reported measures of well-being, further supporting the importance of early diagnosis and appropriate treatment.

Iron deficiency also appears to adversely affect physical performance, particularly among physically active women and athletes. Reduced iron availability may impair oxygen utilization, mitochondrial energy production, and physiological adaptation to exercise, leading to decreased endurance capacity and delayed recovery following physical exertion. Although iron supplementation has been associated with improvements in physiological indicators such as maximal oxygen uptake, further research is needed to clarify its effects on specific measures of athletic performance.

In addition, iron deficiency may contribute to cognitive dysfunction through alterations in neuronal metabolism, neurotransmitter synthesis, and cerebral energy production. Available evidence suggests that reduced iron availability may impair attention, memory, and information processing, potentially affecting educational attainment, occupational performance, and everyday functioning. Observed improvements in cognitive outcomes following iron supplementation further indicate that timely recognition and management of iron deficiency may provide meaningful neurological benefits. Despite growing recognition of the consequences of iron deficiency, its diagnosis remains challenging because of nonspecific clinical manifestations and limitations associated with commonly used biomarkers. Although ferritin remains the principal marker of iron stores, its interpretation should account for inflammatory status and be complemented by additional parameters, including transferrin saturation. A comprehensive diagnostic approach is therefore particularly important in women presenting with symptoms suggestive of iron deficiency despite normal hemoglobin concentrations.

Taken together, the current evidence supports the view that iron deficiency should be considered a systemic condition affecting multiple dimensions of women's health. Early identification, appropriate laboratory assessment, and individualized management strategies may help prevent the functional consequences of iron depletion while improving quality of life, physical capacity, and cognitive performance in women of reproductive age. Further research is warranted to establish standardized diagnostic criteria and to optimize management strategies, particularly for individuals with iron deficiency without anemia.

9. Conclusions

Iron deficiency in women of reproductive age represents a clinically significant condition that extends beyond hematological abnormalities and may substantially affect multiple aspects of health and daily functioning. Current evidence indicates that inadequate iron availability is associated with reduced quality of life, persistent fatigue, impaired sleep quality, diminished physical performance, and altered cognitive function. Through its effects on oxygen transport, mitochondrial energy metabolism, and neurotransmitter synthesis, iron deficiency may contribute to reduced exercise tolerance, impaired recovery following physical activity, difficulties with concentration, and decreased cognitive efficiency. These consequences are particularly relevant in women of reproductive age, who are especially susceptible to iron depletion because of menstrual blood loss and increased physiological demands.

The available literature suggests that early identification and correction of iron deficiency may improve a range of functional outcomes, including fatigue, cognitive performance, physical capacity, and overall well-being. Nevertheless, further high-quality longitudinal and interventional studies are required to better characterize the clinical consequences of iron deficiency without anemia and to establish standardized approaches to diagnosis and management. Recognition of iron deficiency as a condition affecting not only laboratory parameters but also everyday functioning, occupational performance, and quality of life should constitute an integral component of women's healthcare. A broader clinical perspective may facilitate earlier diagnosis and more effective intervention, ultimately reducing the burden associated with iron deficiency and improving health outcomes in women of reproductive age.

REFERENCES

1. Al Hinai, M., Jansen, E. C., Song, P. X., Peterson, K. E., & Baylin, A. (2024). Iron deficiency and vitamin D deficiency are associated with sleep in females of reproductive age: An analysis of NHANES 2005–2018 data. The Journal of Nutrition, 154(2), 648–657. https://doi.org/10.1016/j.tjnut.2023.11.030

2. Åsberg, A., Åsberg, A. E., & Skadberg, Ø. (2026). Divide or subtract: Transferrin saturation versus unbound iron binding capacity (UIBC). Scandinavian Journal of Clinical and Laboratory Investigation, 86(2), 136–140. https://doi.org/10.1080/00365513.2026.2632315

3. Auerbach, M., DeLoughery, T. G., & Tirnauer, J. S. (2025). Iron deficiency in adults: A review. JAMA, 333(20), 1813–1823. https://doi.org/10.1001/jama.2025.0452

4. Avery, H., Jackson, P., & Haskell-Ramsay, C. (2020). The effect of iron supplementation on cognition, subjective mood, well-being and fatigue in women of reproductive age: A systematic review. Proceedings of the Nutrition Society, 79(OCE2), E330. https://doi.org/10.1017/S0029665120002785

5. Beatrix, J., Piales, C., Berland, P., Marchiset, E., Gerbaud, L., & Ruivard, M. (2022). Non-anemic iron deficiency: Correlations between symptoms and iron status parameters. European Journal of Clinical Nutrition, 76(6), 835–840. https://doi.org/10.1038/s41430-021-01047-5

6. Burns, J. L., Miller, C. H., Fontaine-Bisson, B., & Connor, K. L. (2025). Iron deficiency and iron deficiency anaemia in women of reproductive age: Sex- and gender-based risk factors and inequities. Journal of Trace Elements in Medicine and Biology, 90, 127684. https://doi.org/10.1016/j.jtemb.2025.127684

7. Cappellini, M. D., Santini, V., Braxs, C., & Shander, A. (2022). Iron metabolism and iron deficiency anemia in women. Fertility and Sterility, 118(4), 607–614. https://doi.org/10.1016/j.fertnstert.2022.08.014

8. Fiani, D., Chahine, S., Zaboube, M., Solmi, M., Powers, J. M., & Calarge, C. (2025). Psychiatric and cognitive outcomes of iron supplementation in non-anemic children, adolescents, and menstruating adults: A meta-analysis and systematic review. Neuroscience & Biobehavioral Reviews, 178, 106372. https://doi.org/10.1016/j.neubiorev.2025.106372

9. Georgieff, M. K. (2020). Iron deficiency in pregnancy. American Journal of Obstetrics & Gynecology, 223(4), 516–524. https://doi.org/10.1016/j.ajog.2020.03.006

10. Greig, A. J., Patterson, A. J., Collins, C. E., & Chalmers, K. A. (2013). Iron deficiency, cognition, mental health and fatigue in women of childbearing age: A systematic review. Journal of Nutritional Science, 2, e14. https://doi.org/10.1017/jns.2013.7

11. Iolascon, A., Andolfo, I., Russo, R., Sanchez, M., Busti, F., Swinkels, D., Aguilar Martinez, P., Bou-Fakhredin, R., Muckenthaler, M. U., Unal, S., Porto, G., Ganz, T., Kattamis, A., De Franceschi, L., Cappellini, M. D., Munro, M. G., Taher, A., & from EHA-SWG Red Cell and Iron. (2024). Recommendations for diagnosis, treatment, and prevention of iron deficiency and iron deficiency anemia. HemaSphere, 8(7), e108. https://doi.org/10.1002/hem3.108

12. Kernan, K. F., & Carcillo, J. A. (2017). Hyperferritinemia and inflammation. International Immunology, 29(9), 401–409. https://doi.org/10.1093/intimm/dxx031

13. Kovalev, A. V., Викторович, К. А., Kovalev, A. V., Tishko, V. V., Владимирович, Т. В., Tishko, V. V., Polyakov, A. S., Сергеевич, П. А., Polyakov, A. S., Glavinskaya, A. M., Михайловна, Г. А., Glavinskaya, A. M., Egorova, E. N., Николаевна, Е. Е., Egorova, E. N., Bulankov, Y. I., Иванович, Б. Ю., & Bulankov, Y. I. (2024). Iron deficiency and daily physical activity in female military personnel. Bulletin of the Russian Military Medical Academy, 26(3), 411–420. https://doi.org/10.17816/brmma623700

14. Kumar, A., Sharma, E., Marley, A., Samaan, M. A., & Brookes, M. J. (2022a). Iron deficiency anaemia: Pathophysiology, assessment, practical management. BMJ Open Gastroenterology, 9(1). https://doi.org/10.1136/bmjgast-2021-000759

15. Kumar, A., Sharma, E., Marley, A., Samaan, M. A., & Brookes, M. J. (2022b). Iron deficiency anaemia: Pathophysiology, assessment, practical management. BMJ Open Gastroenterology, 9(1). https://doi.org/10.1136/bmjgast-2021-000759

16. Kuwabara, A. M., Tenforde, A. S., Finnoff, J. T., & Fredericson, M. (2022). Iron deficiency in athletes: A narrative review. PM & R: The Journal of Injury, Function, and Rehabilitation, 14(5), 620–642. https://doi.org/10.1002/pmrj.12779

17. Munro, M. G., Mast, A. E., Powers, J. M., Kouides, P. A., O'Brien, S. H., Richards, T., Lavin, M., & Levy, B. S. (2023). The relationship between heavy menstrual bleeding, iron deficiency, and iron deficiency anemia. American Journal of Obstetrics & Gynecology, 229(1), 1–9. https://doi.org/10.1016/j.ajog.2023.01.017

18. Musallam, K. M., & Taher, A. T. (2018). Iron deficiency beyond erythropoiesis: Should we be concerned? Current Medical Research and Opinion, 34(1), 81–93. https://doi.org/10.1080/03007995.2017.1394833

19. Nakamoto, F. P., de Almeida, K. M., Gonçalves, L. C., & dos Santos Quaresma, M. V. L. (2026). Effect of iron supplementation on exercise performance of women with non-anemic iron deficiency or iron deficiency anemia—A systematic review and meta-analysis. Journal of Trace Elements and Minerals, 15, 100275. https://doi.org/10.1016/j.jtemin.2025.100275

20. Peinado, A. B., Alfaro-Magallanes, V. M., Romero-Parra, N., Barba-Moreno, L., Rael, B., Maestre-Cascales, C., Rojo-Tirado, M. A., Castro, E. A., Benito, P. J., Ortega-Santos, C. P., Santiago, E., Butragueño, J., García-de-Alcaraz, A., Rojo, J. J., Calderón, F. J., García-Bataller, A., & Cupeiro, R. (2021). Methodological approach of the iron and muscular damage: Female metabolism and menstrual cycle during exercise project (IronFEMME study). International Journal of Environmental Research and Public Health, 18(2), 735. https://doi.org/10.3390/ijerph18020735

21. Pengelly, M., Pumpa, K., Pyne, D. B., & Etxebarria, N. (2024). Iron deficiency, supplementation, and sports performance in female athletes: A systematic review. Journal of Sport and Health Science, 14, 101009. https://doi.org/10.1016/j.jshs.2024.101009

22. Piskin, E., Cianciosi, D., Gulec, S., Tomas, M., & Capanoglu, E. (2022). Iron absorption: Factors, limitations, and improvement methods. ACS Omega, 7(24), 20441–20456. https://doi.org/10.1021/acsomega.2c01833

23. Rizo-Téllez, S. A., Sekheri, M., & Filep, J. G. (2023). C-reactive protein: A target for therapy to reduce inflammation. Frontiers in Immunology, 14. https://doi.org/10.3389/fimmu.2023.1237729

24. Ru, Q., Li, Y., Chen, L., Wu, Y., Min, J., & Wang, F. (2024). Iron homeostasis and ferroptosis in human diseases: Mechanisms and therapeutic prospects. Signal Transduction and Targeted Therapy, 9(1), 271. https://doi.org/10.1038/s41392-024-01969-z

25. Rusch, J. A., van der Westhuizen, D. J., Gill, R. S., & Louw, V. J. (2023). Diagnosing iron deficiency: Controversies and novel metrics. Best Practice & Research Clinical Anaesthesiology, 37(4), 451–467. https://doi.org/10.1016/j.bpa.2023.11.001

26. Schaefer, B., Meindl, E., Wagner, S., Tilg, H., & Zoller, H. (2020). Intravenous iron supplementation therapy. Molecular Aspects of Medicine, Iron in Health and Diseases, 75, 100862. https://doi.org/10.1016/j.mam.2020.100862

27. Sevgi, M., & Mehta, R. P. (2023). Symptomatic iron deficiency without anemia: An underrecognized phenomenon. Blood, 142(Supplement 1), 1092. https://doi.org/10.1182/blood-2023-173737

28. Sheema, U. K., & Rawekar, A. (2022). P300, a tool for cognitive assessment in women with iron deficiency anemia: A systematic review. Journal of Family Medicine and Primary Care, 11(6), 2320–2326. https://doi.org/10.4103/jfmpc.jfmpc_1151_21

29. Siebenthal, H. K. von, Gessler, S., Vallelian, F., Steinwendner, J., Kuenzi, U.-M., Moretti, D., Zimmermann, M. B., & Stoffel, N. U. (2023). Alternate day versus consecutive day oral iron supplementation in iron-depleted women: A randomized double-blind placebo-controlled study. eClinicalMedicine, 65. https://doi.org/10.1016/j.eclinm.2023.102286

30. Skolmowska, D., Głąbska, D., Kołota, A., & Guzek, D. (2022). Effectiveness of dietary interventions to treat iron-deficiency anemia in women: A systematic review of randomized controlled trials. Nutrients, 14(13), 2724. https://doi.org/10.3390/nu14132724

31. Vinge, F., Stubbendorff, A., Bolmsjö, B. B., Jakobsson, U., Milos Nymberg, V., & Wolff, M. (2026). Screening for iron deficiency in young women: The predictive validity of a five-item screening instrument (IRON-5). Scandinavian Journal of Primary Health Care, 44(1), 2649329. https://doi.org/10.1080/02813432.2026.2649329

32. Wiafe, M. A., Ayenu, J., & Eli-Cophie, D. (2023). A review of the risk factors for iron deficiency anaemia among adolescents in developing countries. Anemia, 2023(1), 6406286. https://doi.org/10.1155/2023/6406286