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Tea Consumption and Iron Deficiency Risk in Physically Active Individuals: Mechanisms, Clinical Relevance and Dietary Strategies

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ABSTRACT

Background. Iron is essential for physical performance and overall functioning. In physically active individuals, iron balance may be compromised by exercise-induced iron losses, post-exercise increases in hepcidin, and dietary factors that reduce iron bioavailability, including tea polyphenols.

Aim of the study. The aim of this review was to analyze the relationship between tea consumption and the risk of iron deficiency in physically active individuals, with particular emphasis on the interaction between exercise, diet, and iron metabolism, as well as on practical nutritional implications for prevention and management.

Material and methods. This paper was prepared as a narrative literature review. PubMed was used as the primary source of literature. Studies relevant to iron metabolism, iron deficiency, tea consumption, polyphenols, and physically active populations were included and synthesized qualitatively.

Results. The reviewed literature suggests that iron deficiency in physically active individuals is a multifactorial problem. In addition to exercise-induced iron losses, intense exercise may increase hepcidin concentrations, with peak values typically observed several hours after training, which may transiently reduce iron absorption. Tea polyphenols markedly inhibit non-heme iron absorption and may further impair iron balance, particularly in individuals relying predominantly on plant-based iron sources. The greatest risk appears to concern premenopausal women, endurance athletes, individuals following plant-based diets, and athletes with low energy availability.

Conclusions. Tea consumption may represent a clinically relevant dietary factor contributing to difficulty in maintaining adequate iron stores in physically active individuals. Practical management should include individualized dietary counseling, attention to the timing of tea intake in relation to meals and iron supplementation, consideration of post-exercise changes in iron absorption, and targeted supplementation when clinically justified.

Keywords: tea consumption; iron deficiency; iron absorption; physically active individuals; hepcidin; tea polyphenols; endurance exercise; dietary strategies

1. Introduction

Iron is an essential micronutrient required for several fundamental biological processes necessary for human health and function [3][21]. Its best-recognized role concerns oxygen transport and storage, as iron forms the functional core of hemoglobin in erythrocytes and myoglobin in skeletal muscle [3][14]. Through these proteins, iron enables systemic oxygen delivery from the lungs to peripheral tissues and facilitates intracellular oxygen diffusion to mitochondria, thereby supporting aerobic metabolism [3][14].

The physiological significance of iron extends beyond oxygen handling. Iron is also an indispensable cofactor for enzymes of the mitochondrial electron transport chain, including cytochromes and iron–sulfur cluster proteins involved in oxidative ATP production [3][21]. In addition, adequate iron availability is important for immune function and central nervous system activity, including neurotransmitter synthesis, myelination, and cognitive performance [3][8].

Because of its broad biological role, insufficient iron availability may affect not only hematological status, but also energy production, muscular function, cognition, and general well-being [3][23]. Consequently, iron deficiency remains one of the most common micronutrient deficiencies worldwide and may have clinically relevant consequences even before overt anemia develops [11][23].

Given its central role in oxygen delivery and cellular energy metabolism, iron is an important determinant of physical performance and exercise adaptation [11][17][23]. In physically active individuals, adequate iron status supports maximal aerobic capacity, endurance, energetic efficiency, and tolerance of repeated training loads [5][17][23].

When iron deficiency progresses to iron deficiency anemia (IDA), reduced hemoglobin synthesis impairs the oxygen-carrying capacity of blood and has clear negative consequences for aerobic performance [14]. However, increasing evidence suggests that iron deficiency without anemia (IDNA) may also be functionally relevant. Even in the presence of normal hemoglobin concentrations, reduced iron stores may impair oxidative metabolism, increase fatigue, and compromise adaptation to training [5][11][20].

This issue is particularly relevant in active populations, as athletes may be exposed to an elevated risk of iron depletion due to exercise-related iron losses and exercise-induced regulatory changes affecting iron absorption [7][18][26]. As a result, impaired iron status may influence not only health, but also the ability to maintain training quality and achieve optimal performance outcomes.

In addition to physical and physiological determinants of iron balance, dietary factors may substantially modify iron status [15][21][25]. This may be particularly important in individuals whose diets rely predominantly on non-heme iron, including those following vegetarian or other plant-based dietary patterns [15][25]. Compared with heme iron, non-heme iron has lower bioavailability and is more susceptible to inhibition by other dietary components [21][25].

Tea, one of the most widely consumed beverages worldwide, may therefore be a relevant dietary factor in the context of iron deficiency [16][24]. Tea contains substantial amounts of polyphenols, including tannins and catechins, which are recognized inhibitors of non-heme iron absorption [21][24]. These compounds bind iron in the gastrointestinal tract and reduce its bioavailability [6][21].

Experimental and isotope-based studies indicate that tea consumed with meals may markedly reduce the absorption of non-heme iron [6][12]. In physically active individuals, this issue may deserve particular attention because exercise itself may already compromise iron balance through increased losses and transient post-exercise reductions in absorption [2][7][26]. Under these conditions, habitual tea consumption may represent an additional factor contributing to difficulty in maintaining adequate iron stores, especially in high-risk groups.

The aim of this review was to analyze the relationship between tea consumption and the risk of iron deficiency in physically active individuals, with particular emphasis on the physiological role of iron, mechanisms of iron depletion, the inhibitory effects of tea polyphenols on iron absorption, groups at increased risk, and practical dietary implications for prevention and management.

2. Research materials and methods

2.1. Study design

This paper was prepared as a narrative literature review examining the relationship between tea consumption and the risk of iron deficiency in physically active individuals. The review was designed to assess the physiological role of iron, the importance of iron status for exercise performance, the mechanisms of iron depletion in physically active populations, the effects of tea polyphenols on iron absorption, groups at increased risk, and the practical dietary implications of these findings.

2.2. Data sources

The primary source of literature was the PubMed database. The literature search was conducted between February and March 2026 for the purpose of manuscript preparation in order to identify peer-reviewed scientific publications relevant to the aim of the study. Priority was given to original studies, review articles, and systematic reviews concerning iron metabolism, iron deficiency, exercise-induced iron losses, hepcidin regulation, tea consumption, polyphenols, and iron absorption.

2.3. Search strategy

The search strategy was based on combinations of keywords related to the scope of the study. The following terms were used, among others: iron, iron deficiency, iron deficiency without anemia, ferritin, hepcidin, athletes, physically active individuals, endurance exercise, female athletes, tea, tea consumption, polyphenols, tannins, iron absorption, low energy availability, vegetarian diets, and iron supplementation. These terms were combined using Boolean operators to identify the most thematically relevant publications.

2.4. Eligibility criteria

Publications were included in the review if they:

1. addressed iron physiology, iron deficiency, iron absorption, or factors affecting iron balance;
2. referred to physically active individuals, athletes, or mechanisms relevant to active populations;
3. evaluated the effects of tea, tea polyphenols, or related dietary inhibitors on iron absorption, or provided data relevant to practical dietary management;

4. were published in English;
5. were available in full text.

Experimental studies, observational studies, narrative reviews, and systematic reviews were eligible for inclusion. Publications not directly related to the aim of the review, duplicate records, and articles unavailable in full text were excluded.

2.5. Study selection and data synthesis

Publication selection was based on the analysis of titles and abstracts, followed by full-text assessment for relevance to the topic of the review. Particular attention was given to studies of high thematic relevance, especially those concerning athletes, female endurance populations, hepcidin regulation, iron absorption, and the effect of tea on non-heme iron bioavailability. Publications addressing plant-based diets, low energy availability, and practical nutritional strategies used in the prevention and management of iron deficiency were also considered.

The collected data was synthesized qualitatively. The material was organized according to the structure of the manuscript, including: the importance of iron in human physiology, the relationship between iron status and physical performance, mechanisms of iron deficiency in physically active individuals, the effect of tea and tea polyphenols on iron absorption, groups at increased risk, and practical dietary implications.

3. Research results

3.1. The importance of iron for performance and functioning in physically active individuals

Iron is an essential micronutrient involved in several physiological processes directly related to physical performance and overall functioning [3][11][23]. In humans, iron serves as the oxygen-binding ligand within porphyrin ring structures, forming the core of hemoglobin in erythrocytes and myoglobin in skeletal muscle [3][17]. Hemoglobin mediates oxygen transport from the lungs to peripheral tissues, whereas myoglobin facilitates oxygen diffusion from capillaries to mitochondria within muscle fibers [3][17]. Iron is also a critical component of the electron transport chain, where it is present in heme-containing cytochromes and iron–sulfur cluster enzymes involved in oxidative phosphorylation and ATP synthesis [3][17].

Because exercise performance depends on effective oxygen transport and mitochondrial energy production, adequate iron status is particularly important in physically active individuals [11][23]. In athletes and other active populations, sufficient iron availability supports maximal aerobic capacity ($\dot{V}O2max$), endurance, and tolerance of repeated training loads [11][23]. When iron depletion progresses to iron deficiency anemia (IDA), hemoglobin synthesis is impaired, reducing the oxygen-carrying capacity of the blood and limiting oxygen delivery to working muscles [3][23]. This condition is consistently associated with reduced aerobic power, lower V̇O2max, and diminished maximal work capacity [23].

Impaired exercise performance, however, may also occur in the absence of overt anemia. In iron deficiency without anemia (IDNA), hemoglobin concentrations may remain within the normal range, while depleted iron stores still adversely affect muscle oxidative metabolism and training adaptation [9][11]. Experimental and clinical studies indicate that tissue iron depletion reduces the concentration and activity of myoglobin, iron–sulfur enzymes, and respiratory chain cytochromes, thereby impairing mitochondrial function [3][9]. As a consequence, physically active individuals with IDNA may exhibit reduced energetic efficiency and a higher physiological cost of exercise at a given submaximal workload [4][5]. This may contribute to earlier fatigue and less efficient recovery following exercise.

The relevance of iron extends beyond skeletal muscle metabolism. Iron is also required for normal central nervous system function, including neurotransmitter synthesis and myelination [3][17]. Accordingly, iron deficiency has been associated with lethargy, reduced training tolerance, impaired concentration, negative mood states, and poorer cognitive performance [8][23]. In physically active individuals, such symptoms may reduce motivation, impair decision-making, and limit the ability to sustain demanding training programs.

3.2. Mechanisms of iron deficiency in physically active individuals

Iron deficiency in physically active individuals is multifactorial and results from the combined effects of exercise-induced iron losses, post-exercise inflammatory responses, and nutritional and energy-related factors [23][26]. In most cases, it develops gradually when repeated losses are not adequately compensated for by absorption and dietary intake.

One of the best-recognized mechanisms is exercise-induced hemolysis, particularly in endurance disciplines [13][18][26]. In runners, repetitive foot strikes may mechanically damage erythrocytes in the plantar capillaries, a phenomenon commonly referred to as foot-strike hemolysis [13][18]. However, this process is not limited to weight-bearing sports, as strong muscle contractions and vascular compression may also contribute to red blood cell damage in other forms of exercise [13][18].

Additional exercise-related routes of iron loss include gastrointestinal bleeding, hematuria, and sweat losses [14][18]. During intense exercise, blood flow is redistributed away from the gastrointestinal tract toward working muscles and skin, which may promote mucosal ischemia and, in some cases, occult gastrointestinal bleeding [18][26]. Hematuria may result from repeated mechanical stress or microtrauma involving the kidneys and urinary bladder [18]. Although sweat iron losses are relatively small during a single exercise session, they may become relevant in the setting of frequent and prolonged training, especially under hot environmental conditions [14][18].

A second major mechanism involves the post-exercise inflammatory response and the subsequent rise in hepcidin, the principal regulator of systemic iron homeostasis [7][19][26]. Intense and prolonged exercise stimulates the release of interleukin-6 (IL-6) from contracting skeletal muscle, which in turn increases hepatic hepcidin synthesis [18][26]. Hepcidin binds to ferroportin, the main cellular iron exporter expressed on enterocytes, macrophages, and hepatocytes, leading to its internalization and degradation [23][26]. As a result, intestinal iron absorption decreases, while the release of iron from body stores and erythrocyte recycling is temporarily restricted [7][26]. This mechanism is particularly relevant because it impairs the restoration of iron stores during the recovery period after exercise.

The magnitude of the hepcidin response is strongly influenced by nutritional status and energy availability. Training performed under conditions of low energy availability (LEA) or low carbohydrate availability amplifies the IL-6 response, especially when muscle glycogen stores are reduced [10][23]. This may prolong the post-exercise period during which iron absorption remains impaired and contribute to a chronic negative iron balance [10][26]. When such hormonal and inflammatory responses coexist with repeated mechanical losses and insufficient dietary intake, athletes may enter a cycle of progressive iron depletion that becomes difficult to reverse [23][26].

3.3. The effect of tea and tea polyphenols on iron absorption

Polyphenols are secondary plant metabolites widely present in foods and beverages, especially tea. Although they are often recognized for antioxidant and anti-inflammatory properties, they are also among the most potent dietary inhibitors of non-heme iron absorption [21][24]. Their inhibitory action is primarily related to the ability of phenolic compounds, including tannins and catechins, to bind iron within the gastrointestinal lumen [21]. This interaction leads to the formation of large, poorly soluble complexes that reduce the amount of iron available for intestinal uptake [6][12].

The negative effect of tea on iron bioavailability is substantial and dose dependent. Studies have shown that consuming tea with a meal can markedly reduce the absorption of non-heme iron derived from food or supplements, and this effect appears to be dose-dependent [6][12][16][24].

This inhibitory effect has been observed across different forms of non-heme iron, including simple iron salts, fortificants, and iron naturally present in plant-based foods [6][12]. The addition of milk does not appear to eliminate this effect [6].

Interpretation of these findings requires a distinction between non-heme and heme iron. Tea polyphenols primarily inhibit non-heme iron absorption, whereas heme iron derived from animal-source foods is far less affected because it is absorbed through a different pathway [6][16]. This distinction is particularly relevant in individuals whose diets rely predominantly on plant-based iron sources. Vitamin C may partially counteract the inhibitory effect of polyphenols by improving the solubility and reduction of non-heme iron; however, this protective effect may be insufficient when tea is consumed in larger amounts together with iron-containing meals [6][16][21].

In physically active individuals, the effect of tea may be especially relevant because exercise itself already places considerable strain on iron balance. When regular tea consumption coexists with repeated exercise-related iron losses and transient post-exercise reductions in iron absorption, restoration of depleted iron stores may become even more difficult [2][16]. Tea consumption should therefore be regarded as an important dietary factor influencing iron status, particularly in active populations relying largely on non-heme iron sources.

3.4. Who is at greatest risk?

The risk of iron deficiency is not evenly distributed across all physically active individuals. It is highest in subgroups in whom physiological losses, training-related stress, dietary limitations, or increased iron requirements coexist.

Premenopausal women represent one of the most vulnerable groups. Regular menstrual blood loss contributes substantially to iron depletion, and the risk is even greater in those experiencing heavy menstrual bleeding [17][26]. Female athletes frequently present with additional risk factors, including dietary restriction, low energy availability, and high training volumes [1][26].

Elevated risk also applies to endurance athletes, particularly long-distance runners, race walkers, and triathletes [14][26]. This reflects the cumulative burden of repeated exercise-induced iron losses together with the inflammatory and hepcidin responses that follow prolonged training sessions [14][17][26]. In these athletes, even small but repeated disturbances in iron balance may gradually result in depleted iron stores.

Athletes following vegetarian or vegan diets constitute another high-risk group. Although plant-based diets may provide substantial total iron intake, they contain only non-heme iron, which has lower bioavailability and is more susceptible to inhibition by dietary factors such as phytates, fiber, and polyphenols [15][25]. As a result, athletes adhering to plant-based diets are more often present with reduced ferritin concentrations, particularly when dietary planning is inadequate or when tea and other inhibitors are regularly consumed with meals [15][17][25][26]. Increased risk also concerns athletes with low energy availability (LEA), including those affected by Relative Energy Deficiency in Sport (RED-S) [10][15]. In this group, insufficient energy intake not only limits the intake of iron and other nutrients, but may also worsen iron regulation through altered metabolic and inflammatory responses [10][26].

Finally, athletes training at altitude may experience a rapid increase in iron requirements due to accelerated erythropoiesis stimulated by hypoxia [17][26]. In the absence of adequate baseline iron stores or appropriate nutritional support, altitude exposure may therefore trigger or aggravate iron deficiency.

3.5. Practical implications: tea timing, diet and nutritional counseling

Effective management of iron status in physically active individuals requires an integrated approach that combines appropriate food choices, careful planning of meals and beverages, and individualized nutritional counseling. The primary dietary objective should be to maximize iron bioavailability. Heme iron derived from animal-source foods is absorbed more efficiently and is less susceptible to dietary inhibitors, whereas non-heme iron from plant-based foods requires more deliberate planning [21][26].

One of the most important practical recommendations concerns the timing of tea consumption. Because tea polyphenols strongly inhibit non-heme iron absorption, tea should not be consumed together with main meals or with oral iron supplements [17][24]. Nutritional counseling should therefore emphasize clear temporal separation between tea intake and iron-rich meals, particularly in athletes with low ferritin, a history of deficiency, or diets based predominantly on non-heme iron sources [24].

Athletes should also be encouraged to combine non-heme iron sources with enhancers of absorption, particularly vitamin C [14][21][26]. At the same time, other inhibitors, such as calcium-rich foods, may need to be separated from iron-rich meals in individuals with compromised iron status [17][21][26].

Another important consideration is the timing of iron intake relative to exercise. Because iron absorption is reduced in the post-exercise period due to exercise-induced hepcidin elevation, iron-rich meals and supplements should be planned outside the period of greatest inhibition [2][26]. In practice, this may involve consuming iron before training, as soon as feasible after exercise, or during recovery days, depending on the athlete’s training schedule [2][17].

In individuals at increased risk, particularly female athletes, endurance athletes, and athletes with low energy availability, regular dietary assessment and monitoring of iron-related parameters are advisable [17][26]. Counseling should include not only recommendations regarding iron-rich foods, but also guidance on energy availability, meal distribution, and avoidance of repeated dietary patterns that may reduce iron absorption.

When dietary measures prove insufficient, targeted iron supplementation may be required [22]. Such decisions should be individualized and based on laboratory findings, clinical symptoms, and training demands [20][26]. Supplementation may support restoration of ferritin stores and improve selected performance-related outcomes in iron-deficient athletes; however, it should be implemented under appropriate supervision and accompanied by follow-up assessment [20][22][26].

4. Discussion

Clinical relevance of the findings

The findings synthesized in this review indicate that impaired iron status in physically active individuals should not be viewed solely through the lens of overt iron deficiency anemia (IDA). The available evidence suggests that iron deficiency without anemia (IDNA) may also be functionally relevant, particularly in endurance-oriented populations, because reduced iron stores can adversely affect oxidative metabolism, energetic efficiency, and selected markers of exercise performance even when hemoglobin concentrations remain within the normal range [4][5][20].

This issue is clinically important because reliance on hemoglobin alone may underestimate the significance of low iron stores in active populations. In female athletes, iron deficiency has been associated with reduced endurance performance, while iron supplementation has been reported to improve selected performance-related outcomes, particularly in athletes with clearer evidence of deficiency [17][20]. The clinical implications of these findings extend beyond exercise capacity alone, as low iron availability may also contribute to fatigue, impaired recovery, and reduced training tolerance, thereby affecting both performance and general well-being.

The clinical management of iron status is further complicated by exercise-induced changes in iron regulation. Prolonged or intense exercise is associated with an increase in hepcidin concentration, typically peaking 3–6 hours post-exercise, which transiently reduces iron absorption and iron release from stores [7][26]. This post-exercise response may be especially relevant in athletes exposed to frequent training sessions, low energy availability, or repeated endurance loads, because it may limit the restoration of iron balance over time [7][26].

Tea consumption may represent an additional clinically relevant dietary factor. Mechanistic and isotope-based studies show that tea polyphenols markedly inhibit non-heme iron absorption, and this inhibitory effect may persist even in women with iron deficiency anemia, in whom iron absorption is otherwise physiologically upregulated [12][16][24]. Although most of these data are not derived from athlete-specific cohorts, they suggest that habitual tea intake may contribute to the persistence of low iron status, particularly in individuals whose diets depend predominantly on non-heme iron sources.

Practical importance for athletes and physically active individuals

From a practical perspective, the reviewed evidence suggests that optimizing iron status in athletes requires a broader strategy than simply increasing total dietary iron intake. The first step should be the identification of individuals at elevated risk, particularly premenopausal women, endurance athletes, athletes with low energy availability, and those relying heavily on plant-based diets [17][26]. In these groups, routine attention to symptoms, diet, training characteristics, and iron-related biomarkers may be justified.

The findings also support the importance of dietary patterning and nutrient timing. Because non-heme iron is particularly susceptible to inhibition by tea polyphenols and other dietary components, athletes at risk of deficiency may benefit from consuming tea separately from iron-rich meals and oral iron supplements [16][24]. Observational review evidence suggests that, in groups at risk of iron deficiency, consuming tea between meals and waiting at least one hour after eating may be a prudent approach [16]. At the same time, non-heme iron sources may be better utilized when combined with enhancers of absorption such as vitamin C [17].

Practical planning should also account for the post-exercise hepcidin response. Since iron absorption appears to be reduced during the hours following strenuous exercise, meal timing and supplement timing may influence the effectiveness of iron repletion strategies [2][7][26]. This does not imply that a single universal schedule is appropriate for all athletes; rather, it supports an individualized approach based on training schedule, exercise frequency, and overall dietary pattern.

When dietary measures are insufficient, targeted iron supplementation may be considered. The strongest support appears to concern iron-deficient female athletes, particularly those engaged in endurance training. In this context, the available review evidence suggests that supplementation with approximately 100 mg of elemental iron per day, or on a bi-daily basis in selected protocols, may improve selected endurance-related outcomes, although responses are not uniform across studies and may depend on baseline iron status, compliance, and the form of iron administered [5][17][20]. Therefore, supplementation is best viewed as part of a broader management plan rather than as a stand-alone solution.

A further practical consideration concerns female-specific physiology. Preliminary literature suggests that menstrual status and possibly menstrual cycle phase may influence iron regulation and hepcidin dynamics, but current evidence remains insufficient to support strong cycle-based recommendations for clinical practice [7][17][26]. At present, awareness of menstrual blood loss and individualized monitoring appear more robustly supported than prescriptive cycle-phase protocols.

Evidence gaps and limitations of current literature

Despite growing interest in iron metabolism in athletes, several important limitations remain. One of the most persistent issues is the lack of consensus regarding the diagnostic thresholds used to define iron deficiency in athletic populations. Differences in serum ferritin cut-offs and in the interpretation of non-anemic iron deficiency complicate comparisons across studies and may partly explain inconsistent conclusions regarding performance outcomes and treatment responses [17][20][26].

A second limitation is the relative scarcity of athlete-specific evidence on the long-term impact of tea consumption on iron status. While the inhibitory effects of tea polyphenols on iron absorption are well documented in controlled settings, there are limited longitudinal data assessing how habitual tea intake affects iron stores and performance in athletic populations over time [12][16][24]. In addition, experimental studies often use standardized servings of tea or defined polyphenol doses, which may not fully reflect real-life brewing methods and intake patterns.

The literature is also limited by underrepresentation or insufficient physiological stratification of female athletes. Many studies do not adequately control for menstrual cycle phase, heavy menstrual bleeding, hormonal contraception, or sex-specific differences in baseline hepcidin responses [7][17][26]. As a result, the interaction between exercise, hormonal status, and iron regulation remains incompletely understood.

Finally, much of the evidence base is characterized by moderate study quality, small sample sizes, and methodological heterogeneity. The recent systematic review by Pengelly et al. found that most included studies had group sizes of 20 athletes or fewer, which limits statistical power and may contribute to inconsistent findings across performance domains [20]. Future research should therefore prioritize larger athlete-specific cohorts, more consistent diagnostic criteria, and intervention studies that jointly consider hepcidin dynamics, dietary timing, menstrual factors, and sport-specific performance outcomes.

5. Conclusions

Iron is an important micronutrient for physical performance and overall functioning, while physically active individuals may be particularly susceptible to its depletion due to exercise-induced iron losses and post-exercise changes in iron regulation [7][18]. The reviewed literature also suggests that habitual tea consumption may further aggravate this vulnerability, as tea polyphenols substantially inhibit non-heme iron absorption and may reduce iron bioavailability even in individuals with increased physiological demand or established deficiency [6][12].

The risk of iron depletion appears to increase when intense training, dietary factors, and physiological predisposition coexist. Premenopausal female athletes, endurance athletes, individuals relying predominantly on non-heme iron sources, and athletes with low energy availability seem to represent groups at particularly high risk [10][25][26].

The available evidence indicates that practical management of iron status should include individualized, hepcidin-aware dietary strategies. Tea consumption should be separated from main meals and oral iron supplementation, especially in individuals at risk of deficiency [16][24]. Likewise, the timing of iron-rich meals and supplements may need to account for the post-exercise period, during which iron absorption may be transiently reduced [2][7][26]. Although female-specific physiological factors may influence iron regulation, current evidence remains insufficient to support strong cycle-phase-based recommendations in routine practice [17][26].

Regular monitoring of iron-related parameters, combined with appropriate nutritional counseling and targeted oral supplementation when clinically justified, may help maintain or restore adequate iron status in physically active individuals [20]. Overall, the findings of this review support an individualized approach that integrates dietary quality, nutrient timing, training context, and clinical monitoring to protect long-term health and support athletic performance.

Disclosure

Supplementary Materials

Not applicable.

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The authors declare no conflict of interest regarding the publication of this paper.

AI Declaration

Declaration of the use of generative AI and AI-assisted technologies in the writing process. In preparing this work, the authors used ChatGPT for the purpose of assisting with grammar and readability. After using this tool, the authors reviewed and edited the content as needed and accept full responsibility for the substantive content of the publication.

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