

Prevalence of Iron Deficiency with Or Without Anemia In Female Athletes- A Review

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Abstract

Background: Iron deficiency is the most prevalent form of malnutrition and the most common cause of iron deficiency anemia in female athletes across worldwide. It has been shown to impact overall health as well as the physical performance of female athletes.

Objective: To provide a literature review on the prevalence of iron deficiency with or without anemia in female athletes and to understand its effects on health and sports performance.

Methods: International databases Google Scholar, PubMed and MEDLINE were searched using combinations of the keywords: 'iron deficiency', 'iron status', 'iron-deficiency anemia', 'female athletes', 'sports performance', 'causes', 'health consequences'. Studies were conducted only on female athletes from 2000 to 2020 and published in English included in the present study. The present study included varied study designs like cross-sectional studies or surveys, controlled clinical trial studies, descriptive studies, comparative studies, retrospective, and correlational studies.

Results: A total of 11 studies have been included in this review based on inclusion and exclusion criteria. Most of the studies had reported low hemoglobin levels and low iron status in female athletes (15 to 35 years) of different sports. It has been found that there was a high prevalence of iron deficiency with or without anemia in female athletes.

Conclusion: It concluded that female athletes are at higher prevalence of developing iron-deficiency and anemia. Iron deficiency (with or without anemia) may severely affect an athlete's ability to perform at an optimal level. Proper health education to increase knowledge about anemia, as well as its causative factors, iron store screening, appropriate nutritional education and iron supplementation are warranted.

Keywords: iron status, causes, oral iron, sports performance, iron deficiency anemia

INTRODUCTION

Iron deficiency is considered to be one of the most prevalent forms of malnutrition throughout the world, yet there has been a lack of consensus about the health consequences of iron deficiency in the female athlete population yet. Simply, iron deficiency can be defined as depletion in the body's iron stores, and a restricted supply of iron to various tissues becomes apparent [1]. Iron deficiency (ID) is a state in which there is insufficient iron to maintain the normal physiological function of tissues [2]. Iron deficiency is the

most frequent cause of anemia worldwide and is a widespread disorder in daily medical practice [3]. It is recognized as the world's most widespread nutritional disorder, affecting 1.6 billion people that constitute about 25% of the global population [4]. Iron deficiency anemia is the most common nutritional disorder seen more in the developing countries, affecting young children, adolescents, women of reproductive age group, and pregnant/ lactating women [5-7]. Most research suggests that the prevalence of IDA and iron deficiency is higher in athletes than in non-athletes and more common in female athletes, with risk specifically increasing in exercising and menstruating women. The end-stage of iron deficiency is iron deficiency anemia (IDA). There was a clear and significant gender difference in the previous studies that ID is the most common among women [8,9]. In sports, the rate of iron deficiency was found to be higher (52%) in female adolescent athletes [10] and occurs more often in endurance sports and in disciplines with a high prevalence of eating disorders [11,12]. Globally, 50% of the anemia is assumed to be attributable to iron deficiency [13]. Iron deficiency anemia was defined as the $Hb < 120 \text{ g L}^{-1}$ and ferritin concentration $< 12 \text{ microgram L}^{-1}$ [14]. Decreased hemoglobin production leads to anemia (Hemoglobin $< 120 \text{ gL}$, Hematocrit $< 0.36\%$) [15]. Iron equilibrium in the body regulated carefully to compensate for body losses of iron by the absorption. Body loss of iron quantitatively is as important as absorption and helps in maintaining iron equilibrium. Constant and steady errors in maintaining this equilibrium lead to either iron deficiency or iron overload [16]. Symptoms of IDA are headache, pallor, irritability, fatigue, lack of energy, tachycardia (increase heart rate), and pica (desire to eat dirt or ice) [17].

Impact on health and sports performance

Poor iron status is detrimental to overall health as well as the physical performance of female athletes [18]. It is not surprising that a significant loss of iron commonly occurs with exercise. Consumption of cereal-based diets provide non-haem iron of poor bioavailability, the main cause of iron deficiency [19], the prolonged negative imbalance between dietary intake of iron and body's physiological demand [20,21] and deficiency of other nutrients like vitamins A, C, B2, B12, and folic acid may also cause anemia [22]. Although the exact mechanism is unknown, there are following factors which lead to iron deficiency in women: hemolysis due to foot strike [23,24], increased iron loss due to the gastrointestinal tract, hematuria, sweat [15], inadequate dietary iron intake [25-28] or altered intestinal iron absorption, including the effects of inflammation resulting from training [24, 29-31]. The exercise-induced iron loss are mainly due to gastrointestinal bleeding, haematuria, sweating, and hemolysis [32-34], with inflammation and hormone activity also being relevant [35]. During exercise, visceral blood flow can be reduced by more than 50%, due to increased sympathetic nervous system activity, in the function of exercise intensity [36], with possible necrosis and mucosal bleeding of the gastrointestinal tract [37,38]. Repeated episodes of training and competition induced blood loss through the gastrointestinal tract may, therefore, contribute to iron deficiency and anemia within athletes [39]. Sweating, which is mainly a mechanism of thermoregulation, is also a mechanism by which the body may lose iron, and athletes exercising for prolonged periods in multiple training sessions in the heat may incur a cumulative debt, which could ultimately affect the body iron status [40]. McInnis and colleagues [33] suggested that the intensity of exercise is the causal mechanism to cause haematuria since renal blood flow is decreased proportionally to exercise intensity, resulting in an increased filtration fraction and glomerular filtration rate. Haemolysis induces iron loss as a consequence of the destruction of the red blood cell membrane and consequent release of both hemoglobin (Hb) and iron (act as poison) into the surrounding plasma. When the free Hb concentration in plasma rises, there is a decline in serum haptoglobin levels. This blood profile is typical in runners [41] as runners usually have reduced iron status [42]. Premenopausal women

and adolescent athletes are of particular concern because of the blood loss associated with menses in the former and the extra demand with increasing blood volume and lean muscle mass in the latter. Iron depletion has been reported in up to 50% of adolescent female athletes and 17% of male runners [43]. It has been shown that the activity of iron-dependent enzymes and cytochromes needed for oxidative metabolism is decreased in humans [44] with IDNA (Iron Deficiency without Anemia), which leads to impaired endurance performance.

The loss of iron can be divided into three stages (as shown in the fig 1.) according to their impact on red cell synthesis. 'Iron depletion' is Stage 1 in which a fall in the level of serum ferritin is observed. 'Iron deficient erythropoiesis' is the second stage in which serum ferritin levels are low (<10 to 20%), reduced transferrin saturation (<16%), and increased total iron-binding capacity (>390 µg/100ml). Iron deficiency without anemia (stage 2) caused muscle and hormonal dysfunction and altered resistance to infection [1]. Stage 3 is 'iron-deficient anemia', in which hemoglobin levels are subnormal [1]. The anemia (stage 3) is the functional consequence of iron depletion or deficiency in which blood gas transport (O₂ and CO₂) is impaired and work capacity reduced. It may be responsible for fatigue, weakness, dizziness, and sensitivity to cold. As it is known that during exercise, the energy demand of the body increases, so, the first symptom of anemia is a drop in performance or a plateau in the athletes. Performance and hemoglobin are directly proportional to each other. Reduced performance is proportional to the hemoglobin loss. It had been observed that even a small decrease of 1 to 2 g/100ml causes a 20% decrease in performance [45]. The lack of hemoglobin could also lead to decreases in mental performance [46].

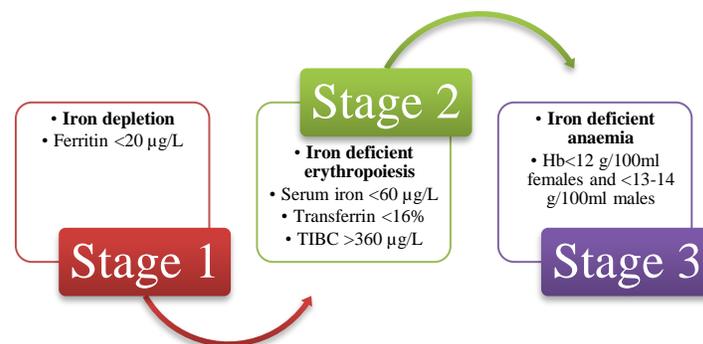


Fig. 1. Iron deficiency stages (TIBC= Total Iron Binding Capacity)

Therapy for iron deficiency in sports

Therapy for iron deficiency has shown in Fig 2. Correction of the nutritional iron intake is the first step for its management. Haem iron and free iron as Fe²⁺ or Fe³⁺ exist in meat. Oral uptake studies show that the uptake of haem iron is much better than the uptake of free iron [1]. Heme iron is an essential dietary source of iron because it is more effectively absorbed than is non-heme iron. Thus, vegetarians can be at a relatively higher risk for iron deficiency [30]. 14mg/day is the nutritional intake of iron. Optimal dietary iron intake in sports includes an adequate energy intake, especially for athletes with low body mass index because they suffer more frequently from iron deficiency [47]. Daily consumption of meat, poultry, or fish, at least five times per week, and citrus fruit juice is advised as vitamin C enhances iron uptake [48,49]. For vegetarians, the goal is to reach a high load of iron through their vegetable diet (legumes and

green vegetables). Oral iron therapy is the second step for the management of iron deficiency. There is further evidence that oral iron loading increases circulating hepcidin [50]. A previous study reported that 100 mg of FeSO₄ was shown to be effective in inactive women [51]. Therefore, supplementation of 40 to 60 mg of elemental iron once daily is recommended as oral iron is well tolerated and efficient [52].

Intravenous (I.V.) therapy, the last step, should be recommended if oral therapy fails. The dosage is dependent on the severity of iron deficiency. The main advantage of i.v. therapy is the immediate correction of their iron deficiency. Usually, 200 mg Fe-saccharose, 500 to 100 mg Fe-carboxymaltose is given for its management. Physician should respect the WADA (World Anti-Doping Agency) anti-doping regulations while administering infusion in elite sports players. According to WADA, intravenous infusions >50 ml per 6 hours are prohibited (except for those legitimately received in the course of hospital admissions) [53,54].

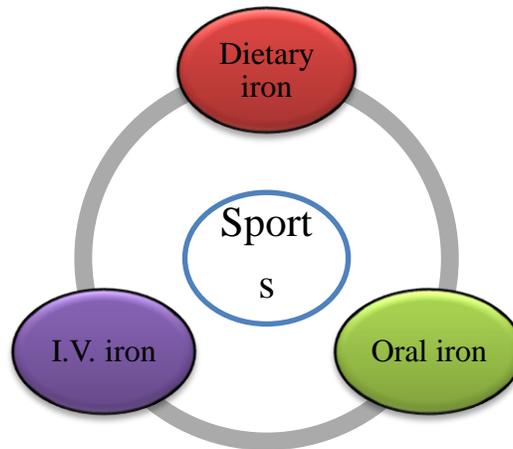


Fig.2. Therapy for iron deficiency in sports (I.V.= Intravenous)

OBJECTIVE

The main objective of this study is to provide a literature review on prevalence of iron deficiency in female athletes and to understand the effects on health and sports performance.

METHODOLOGY

Literature Search Strategy

An electronic search was conducted in the international databases PubMed, Google Scholar and MEDLINE using combinations of the keywords: 'iron deficiency', 'iron status', 'iron-deficiency anemia', 'female athletes', 'sports performance', 'causes', 'health consequences'. A subsequent search was conducted using these databases to ensure that all recently published articles meeting the inclusion criteria were identified.

Inclusion and Exclusion criteria

The included studies were required to meet the following inclusion criteria:

- Studies conducting only on female athletes and iron deficiency were included.
- Studies published in the English language included in this review.
- Articles published after the year 2000 till 2020 included in this review.

Review studies and studies with abstract only were excluded from the present study.

Data extraction and Analysis

The eligibility of each retrieved record was assessed first based on the title and abstract. If the information was unclear, the full-text article was screened. Secondly, all included studies were subsequently re-screened by reading the full-text articles. A total of 11 studies were included in this review after the double screening. The (Fig. 3) gives an idea about the selection process of included studies. The present study included varied study designs like cross-sectional studies or surveys, controlled clinical trial studies, descriptive studies, comparative studies, retrospective, and correlational studies.

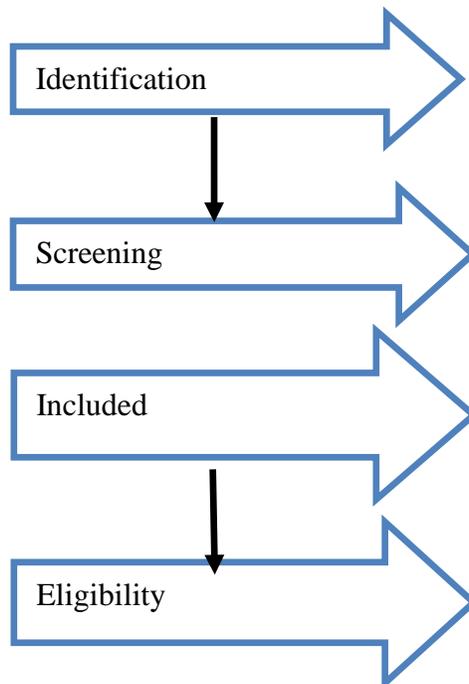


Fig-3. The process of selection of studies

RESULTS

Description of included studies

A total 11 studies were included in this review as a summary of the included articles showed in Table 1. The studies included in our study examined athletes from individual sports like swimming or running and team-based sports like soccer, volleyball and rowing. There were also studies on elite athletes that are mixed (rowing, runners, track field, soccer, golf, skating, wrestling, skating, basketball, volleyball, tennis, ice hockey, swimming, softball, martial arts)The sample size ranged from lowest 14 to highest 5201. The ranged age of the female athletes was 15 to 35 years. Most of the included studies were cross-sectional survey. Most of the studies reported a high prevalence of iron deficiency and iron-deficiency anemia in female athletes [55, 58-62].Only one study had reported no significant differences in hemoglobin level [10],and two studies [56,63] reported no significant differences in the iron status of female athletes when compared to the control group.

DISCUSSION

The present study found that there was a high prevalence of iron deficiency and iron-deficiency anemia in female athletes of different sports. It has been found that the prevalence of iron deficiency anemia in soccer players was 57% [57]. Gropper et al. found that non-anemic iron depletion was present among female collegiate athletes involved in many different sports like cross-country track, tennis, softball, swimming, soccer, basketball, and gymnastics [62]. That is why the study analyzed food records of 55 collegiate female athletes and found that cross-country runners had a significantly higher intake of iron than athletes from other sports because 55% were using iron supplements. Parks et al.[55] found the prevalence of anemia at PPE (Pre Participation Examination) was 5.7% and found that only 2.2% of female athletes indicated iron deficiency anemia and 30.9% indicated iron deficiency without anemia. A similar study reported which reported a prevalence of anemia for females at PPE in 1067 collegiate athletes was 3.6%, which is slightly lower [64]. Females tend to have lower concentrations of iron status biomarkers than males [65-68]. Ahmadi et al. concluded that the intake of iron and calories were low in female athletes in team ball sports [60],.

In contrast, Bozo found that female players are in the borderline of the iron-dependent anemic state [58] because they tend to have lower hemoglobin concentrations, RBC counts, hematocrit level. However, iron deficiency does not seem to be the only underlying factor for anemia in the player's groups. A decrease in performance time in iron-depleted rowers were reported compared with those with normal iron stores [59]. Natural of athletics and the distance type could effect the iron status in females as it had reported that exercise (running) was found to be significant in causing iron expense [69] because ,more extended performance needs the anaerobic ability of the body [56]. Previous studies found that habitual runners, as compared with inactive women, are at increased risk for iron-deficient states as habitual running was associated with lower body's iron store [61,70].

In contrast to these studies, Braun et al. found no significant differences in iron status in both swimmers group and untrained inactive females group [63]. Furthermore, supported by another study, which also found no difference between athletes and non- athletes regarding hemoglobin value and iron status, which are the common markers of iron status [10]. However, the mean levels of serum iron and TIBC (total iron-binding capacity) were significantly lower in the athlete group. Di Santolo et al. reported that female athletes had lower serum iron but no difference in transferrin and ferritin [8]. More studies are needed to understand the impact of iron deficiency on sports performance in different sports.

CONCLUSION

It concluded that there is a high prevalence of iron deficiency with or without anemia in female athletes. Studies had found that female athletes are more prone to develop iron deficiency and anemia, which could further lead to a decrease in the performance level and impact physical health. The issue of increased iron losses during exercise, especially in younger individuals, needs immediate attention because a negative iron balance could easily be generated. Proper health education to increase knowledge about anemia, as well as its causative factors, iron store screening, appropriate nutritional education and iron supplementation are warranted.

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