Prevalence and Risk Factors of Iron Deficiency Among Female Athletes in Sulaymaniyah District, Kurdistan Region of Iraq

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Abstract- Iron deficiency is frequent in female athletes due to greater turnover of red blood cells during exercise. Also, female athletes are considered to be at a greater risk of iron disturbance, which may lead to iron deficiency anemia or latent iron deficiency. Therefore, the study aimed to determine the frequency of iron deficiency in female athletes in Sulaymaniyah city. A total of 140 healthy habitual female athletes were screened for eligibility. One hundred and twenty were eligible and participated in the current study. Sampling was collected based on a stratified sampling method. Blood samples were taken from the participants in 23 Sports centers based on socioeconomic distribution. The parameters included complete blood counts (CBC), serum ferritin, serum iron, total iron-binding capacity (TIBC), and unsaturated iron binding capacity (UIBC). Of the participants, 25 (20.8%) had low ferritin levels (<10 ng/ml), indicating iron deficiency, while 95 (79.2%) had normal ferritin levels (10-291 ng/ml). Only 16 (13.3%) participants had been exercising for 6-12 years, and about half of them exhibited iron deficiency anemia. A significant difference was found in iron deficiency across exercise duration groups (P<0.05). No significant relationship was observed between menstrual patterns and iron deficiency (P>0.05), nor between BMI categories and iron deficiency (P=0.487). Despite 40% of athletes taking supplements, 25% remained iron-depleted, whereas only 15% of non-supplement users had iron deficiency. The high prevalence of iron deficiency, both with and without anemia, among female athletes highlight the urgent need for implementing regular screening programs. Such initiatives are essential to mitigate the negative effects of iron deficiency on overall health and athletic performance, ensuring that athletes receive timely intervention to maintain optimal iron status.

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Introduction

Anemia is characterized by a low hemoglobin concentration, leading to reduced oxygen and carbon dioxide exchange between the blood and tissues (1). According to the World Health Organization, anemia in women is defined as hemoglobin levels below 12.0 g/dL, while in men, it is defined as levels under 13 g/dL (2). Iron deficiency progresses through three stages: iron depletion, iron deficiency, and eventually iron deficiency anemia (3). Iron depletion occurs when serum ferritin levels drop, although hemoglobin and red blood cell indices remain normal. Notably, iron depletion is more common than iron deficiency anemia, which affects approximately 2-5% of adult men and postmenopausal women in developed countries. However, iron depletion is more prevalent in developing regions, particularly among women due to menstrual blood loss (4).

Iron in the body is tightly regulated, as excessive amounts can cause tissue damage. Disorders of iron

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metabolism are widespread and can manifest as either anemia or iron overload (5). Iron plays vital roles, including oxygen transport via hemoglobin, electron transport within cells, and as an essential part of enzymes in various tissues (6). Additionally, iron is necessary for immune function, DNA synthesis, cellular respiration, and even influences neurochemical pathways and emotional health (7,8).

Female athletes are particularly vulnerable to iron deficiency due to factors such as increased red blood cell turnover from exercise, inadequate dietary intake, menstrual blood loss, and other contributors like hemolysis, sweating, gastrointestinal bleeding, and exercise-induced inflammation (9). Consequently, they are at a higher risk of developing iron deficiency anemia or iron deficiency without anemia. The prevalence of iron deficiency is notably higher in physically active individuals, including athletes, compared to sedentary populations (10,11). In adolescent athletes, iron depletion is especially prominent (12), with female athletes experiencing a prevalence of iron disorders that is five to seven times higher than their male counterparts (13,14).

This study aims to assess the prevalence and factors contributing to iron deficiency and iron deficiency anemia among female athletes in Sulaymaniyah, Kurdistan Region, Iraq. By investigating the relationship between exercise duration, menstrual patterns, and iron status, we seek to establish a clearer understanding of how these factors influence iron deficiency in this population, which is critical for improving athletic performance and overall health.

Materials and Methods

Subjects and design

This prospective observational study was conducted between November 2018 and March 2019 at sports centers in Sulaymaniyah District, Kurdistan Region, Iraq. A total of 82 sports centers were registered in the district, with 23 dedicated to female athletes and 59 for male athletes. Written informed consent was obtained from all participants, ensuring their understanding of the study’s purpose and confidentiality of the results. All female athletes provided formal consent to participate in the study.

The study's sample was drawn using a stratified sampling method. The 23 female sports centers available in the city were officially authorized by the General Directorate of Sport in Sulaymaniyah. All centers, except one that did not grant consent, were included. The centers were categorized by their geographical location and socioeconomic status: 11 centers from high socioeconomic areas, 8 from medium, and 4 from low socioeconomic areas.

A structured questionnaire was used to collect demographic and baseline data, including age, body weight, height (for calculating body mass index), and the duration of exercise. Exercise duration was classified into three patterns: 2, 2.5, and 3 hours of daily exercise, with a minimum of three days per week. Menstrual history was categorized into three groups: heavy menstrual flow (more than 60 mL per cycle and lasting more than 5 days), normal menstrual cycles (9-12 cycles per year, with cycles ≤30 mL), and irregular cycles.

Laboratory tests included complete blood count (CBC), serum iron (SI), serum ferritin (SF), total iron-binding capacity (TIBC), unsaturated iron-binding capacity (UIBC), and transferrin saturation percentage, calculated as serum iron×100/TIBC. UIBC was calculated as TIBC-serum iron. Hematological parameters were analyzed using the MYTHIC 18 fully automated hematology analyzer, while serological parameters were measured with the Cobas e 411 Roche-HITACHI analyzer.

Statistical analysis

The collected data were reviewed and analyzed using the Statistical Package for Social Sciences (SPSS version 22). Descriptive statistics, including frequency and percentage, were used to summarize categorical variables. Continuous variables were analyzed using measures of central tendency and dispersion around the mean. Chi-square tests were employed to assess the significance of associations, with a P of less than 0.05 considered statistically significant.

Results

The sociodemographic characteristics of the female athletes are summarized in Table 1. Table 2 presents the use of serum ferritin as a marker for assessing iron stores and compares it with other indicators of iron deficiency anemia, categorizing the stages of iron deficiency across all participants.

Among the 25 female athletes with low serum ferritin levels, 12 (48%) were classified as iron-depleted, representing the first stage of iron deficiency. Two athletes (8%) were identified as having iron deficiency without anemia, corresponding to the second stage, while 11 athletes (44%) were diagnosed with iron deficiency anemia (Table 3).

Table 4 displays the distribution of iron status, including iron-depleted, iron-deficient without anemia, and iron-deficient with anemia, across three exercise duration categories: 1-6 years, 6-12 years, and 12-18 years.

Table 5 reveals that there was no significant relationship between menstrual patterns and iron deficiency status (with or without anemia) ($P>0.05$).

Additionally, Table 6 shows no significant difference in iron deficiency states between the different BMI categories ($P=0.487$). Among the athletes who were taking dietary supplements (48, or 40%), approximately 25% (12 athletes) were iron deficient, with 7 having iron depletion, 2 having iron deficiency without anemia, and 5 having iron deficiency anemia. Conversely, fewer iron-deficient athletes (11, or 15%) were observed among those who did not take dietary supplements (Table 7).

Table 1. Sociodemographic characteristics of the female athletes participated in the study (n=120)

Age	Frequency (*n*)	Percent %
Age under 20 years	11	9.2
20 -40	85	70.8
41 – 60	24	20
BMI		
Underweight < 18.5	3	2.5
Normal weight 18.5 - 24.9	43	35.8
Overweight 25 - 29.9	50	41.7
Obesity ≤ 30	24	20.0
Duration		
1 - 6 Years	101	84.2
6 - 12 Years	16	13.3
12 - 18 Years	3	2.5
Marital status		
Single	51	42.5
Married	69	57.5
Taking supplement		
Yes	48	40.0
No	72	60.0
Medical History		
No Disease	92	76.7
Chronic Disease	28	23.3
Smoking History		
Non-smoker	111	92.5
Smoker	9	7.5
Obstetrical History		
No child	62	51.7
Child	32	26.7
Child & Abortion	26	21.6
History of period menses		
Heavy (Twice a month)- 5ml	12	10.0
Regular (Every 28 days)-Medium-3ml	88	73.3
Irregular (2 or 3 or 6 months)– 1ml	20	16.7

Table 2. Laboratory investigations of Iron Deficiency Parameters in Female Athletes in Sport Centers in Sulaymaniyah City n=120

	Normal (n=95) Mean ± SD	Depletion (n=12) Mean ± SD	Iron deficiency without anemia (n=2) Mean ± SD	Iron deficiency anemia (n=11) Mean ± SD	*P*
Ferritin ng/mL	46.52 ± 55.45	8.03 ± 1.67	8.21 ± 1.05	5.76 ± 1.56	0.008
Iron µg/dl	74.94± 29.67	73.08 ± 45.34	30.40 ± 5.09	26.63 ± 4.92	< 0.001
Total iron binding capacity TIBC	372.17 ± 46.69	423.75 ± 50.47	387.5 ± 26.16	392.45 ± 75.61	< 0.001
Hb g/dl	13.17 ± 0.96	12.32 ± 1.05	12.75 ± 0.21	10.59 ± 0.87	< 0.001

Table 3. Distribution of Iron Deficiency with or without anemia among participant with low ferritin level n=25

		Ferritin Low <10		*P*
		Low <10	%	
Group	Depletion	12	48%	< 0.001*
	Iron deficiency without anemia	2	8%	
	Iron deficiency anemia	11	44%	
Total		25		

Table 4. Duration of exercise and Iron deficiency with or without anemia n=120

		Duration 1 - 6 Years n=101	6 - 12 Years n=16	12 - 18 Years n=3	Total	
Group	Normal	89 (88%)	4(25%)	2(66.6%)	95	0.000
	Depletion	7(6.9%)	5(31.25%)	0(0.0)	12	
	Iron deficiency without anemia	1(0.9%)	1(6.25%)	0(0.0)	2	
	Iron deficiency anemia	4(3.96%)	6(37.5%)	1(33.3%)	11	
Total		101(100%)	16(100%)	3(100%)	120	

Table 5. History of menstrual pattern (period) and Iron deficiency with or without anemia.

		History of menstrual pattern (period)			Total	
		Heavy	Regular	Irregular (Abnormal)		
Group	Normal	8(8.4)	73(76.8)	14(14.7)	95(100.0)	0.075
	Depletion	0(0.0)	8(66.7)	4(33.3)	12(100.0)	
	Iron deficiency	1(50.0)	1(50.0)	0(0.0)	2(100.0)	
	Iron deficiency anemia	3(27.3)	6(54.5)	2(18.2)	11(100.0)	
Total		12(10.0)	88(73.3)	20(16.7)	120(100.0)	

Table 6. Body mass index and iron deficiency with or without anemia

		BMI (kg/m^2)				Total	*P*
		Underweight < 18.5	Normal weight 18.5 - 24.9	Overweight 25 - 29.9	Obesity ≤ 30		
Group	Normal	1(1.1)	35(36.8)	38(40.0)	21(22.1)	95(100.0)	0.487
	Depletion	1(8.3)	4(33.3)	5(41.7)	2(16.7)	12(100.0)	
	Iron deficiency	0(0.0)	1(50.0)	1(50.0)	0(0.0)	2(100.0)	
	Iron deficiency anemia	1(9.1)	3(27.3)	6(54.5)	1(9.1)	11(100.0)	
Total		3(2.5)	43(35.8)	50(41.7)	24(20.0)	120(100.0)	

Table 7. Taking supplement and Iron deficiency with or without anemia

		Taking supplements		Total	*P*
		Yes	No		
Group	Normal	34	61	95	0.129
	Depletion	7	5	12	
	Iron deficiency without anemia	2	0	2	
	Iron deficiency with anemia	5	6	11	
Total		48(40%)	72(60%)	120(100.)	

Discussion

Iron deficiency, particularly in premenopausal women, has become an increasing concern globally. While both iron deficiency with and without anemia are prevalent, the frequency of iron deficiency without anemia tends to be higher among sedentary premenopausal women (16). Serum ferritin levels, which are strongly correlated with iron stores in the bone marrow (17,18), are commonly used to assess iron status. Low serum ferritin levels indicate latent iron deficiency. In the current study, 20.8% of the female athletes were found to have iron deficiency, as evidenced by serum ferritin levels below 12-20 ng/ml (19). This finding is consistent with other studies highlighting a significant prevalence of non-overt anemia among female athletes. These findings reinforce those female athletes, particularly those involved in intense or prolonged physical activity, are at an increased risk for iron deficiency (20).

Exercise, particularly chronic or long-duration physical activity, plays a crucial role in altering hematological parameters, such as iron stores, in athletes (21). A key finding from this study is that athletes with longer durations of exercise (6-12 years) had a much higher prevalence of iron deficiency (75%) compared to those with shorter durations of exercise (11%). This suggests that prolonged exercise may lead to increased iron depletion over time. Additionally, menstruating women lose approximately 1 mg of iron per day through menstruation, and this loss is significantly higher in those with heavy menstrual bleeding (22). While this study assessed menstrual patterns and blood loss using a structured questionnaire and pictograms, no significant relationship was found between menstrual pattern and iron deficiency with or without anemia. This result contrasts with studies suggesting that heavy menstrual bleeding is more common among athletes at all levels (23).

Furthermore, no significant association was found between BMI and iron deficiency status. This is at odds with previous studies that suggest an inverse relationship between BMI and serum ferritin, where higher BMI correlates with increased iron deficiency anemia in some populations. In contrast, some recent studies report a positive association between BMI and ferritin levels in obese individuals, likely due to inflammation associated with obesity (24,25). However, this study did not observe such an effect, which may suggest that factors beyond BMI play a more significant role in iron status among female athletes.

In terms of supplementation, 40% of the athletes reported taking dietary supplements, but none of these supplements contained iron. As a result, no significant was observed between those taking supplements and those not taking them regarding iron deficiency. This finding is at odds with previous research, which indicates that more than 50% of female athletes typically consume iron-containing supplements (29). This discrepancy highlights a potential area of concern, as iron deficiency is not adequately addressed by non-iron supplements.

Rogulski *et al*., and Chatterjee *et al*., reported that female athletes experience iron loss through sweat and foot strike hemolysis, which is exacerbated during intense training (30,31). Also, Dunn *et al*., showed that, heavy menstrual bleeding significantly contributes to iron deficiency in female athletes (32).

Many female athletes, especially vegetarians, may not consume sufficient heme iron, which is more bioavailable than non-heme iron found in plant sources (33).

The present study has several limitations that should be considered when interpreting the findings. First, the cross-sectional design limits the ability to establish causal relationships between risk factors and iron deficiency among female athletes. Second, the sample size was relatively small, which may reduce the statistical power to detect significant associations. Additionally, subgroup analyses were further limited by low participant numbers, potentially affecting the reliability of stratified results. Despite these limitations, the study provides valuable preliminary data on the prevalence and risk factors of iron deficiency among female athletes in the Sulaymaniyah District, which can inform future larger-scale or longitudinal studies.

The frequency of iron deficiency, both with and without anemia, is notably high among female athletes in this study, emphasizing the importance of establishing regular screening programs to assess iron status and mitigate its impact on health and athletic performance. Athletes with longer exercise durations exhibited higher rates of iron deficiency, suggesting that prolonged physical activity is a significant factor in iron depletion. However, menstrual patterns, BMI, and supplementation did not show a significant impact on iron deficiency. It is crucial for female athletes to receive appropriate dietary supplementation, particularly with iron-containing formulas, to prevent iron deficiency anemia and avoid the risks of iron overload. Further research is needed to explore the complex interplay between exercise, menstrual patterns, BMI, and iron status, as well as the role of supplementation in maintaining optimal iron levels in this population.

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