

# Beyond Hemoglobin: Re-evaluating Iron Status in Women's Sports

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## ABSTRACT

Iron deficiency (ID) remains a pervasive yet frequently overlooked "silent performance killer" in female athletes. Despite its prevalence, it often remains undetected due to a traditional clinical over-reliance on hemoglobin (Hb) levels as the primary diagnostic criterion. This review synthesizes current physiological and laboratory research to demonstrate that standard hematological reference ranges, calibrated for the sedentary general population, fail to account for unique athlete-specific mechanisms. Key factors such as foot-strike hemolysis—the mechanical rupturing of red blood cells during high-impact activity—and exercise-induced gastrointestinal ischemia significantly accelerate iron turnover. Furthermore, the discovery of the hepcidin-mediated iron blockade has revolutionized our understanding of iron homeostasis in sports. Post-exercise inflammation, characterized by elevated Interleukin-6 (IL-6), triggers a spike in hepcidin, which degrades ferroprotein and effectively halts iron absorption for several hours post-training. This dynamic makes traditional "once-off" blood testing potentially misleading. Consequently, this review argues for a critical diagnostic shift in sports medicine toward more sensitive biomarkers. By prioritizing serum ferritin (using an athletic-specific threshold of <35

ng/mL) and soluble transferrin receptor (sTfR)—which remains unaffected by acute inflammation—medical lab professionals can accurately identify non-anemic iron deficiency (NAID). Identifying NAID is essential, as even in the absence of clinical anemia, depleted iron stores compromise mitochondrial cytochromes and myoglobin, leading to reduced VO<sub>2</sub>max and impaired aerobic capacity. Re-evaluating iron status through these advanced laboratory markers is vital for optimizing the health, recovery, and competitive edge of female athletes.

**Keywords:** Iron Deficiency, Female Athletes, Serum Ferritin, Hepcidin, Sports Hematology, Non-Anemic Iron Deficiency (NAID), Soluble Transferrin Receptor.

## INTRODUCTION

Iron deficiency (ID) is arguably the most prevalent yet least understood nutritional issue in the field of sports medicine, and women's athletics in particular. Hemoglobin (Hb) is the criterion used to screen for anaemia in a general medical environment. Unfortunately, Hb does not represent the sub-anemia stage, where athletes may become severely incapacitated, and is only a reliable diagnostic for late-stage iron depletion. [1, 3]. Because the physical demands of top training and the increased needs of menstruation coexist, female

athletes need much more iron than their male counterparts. [5, 11].

Due to the widespread use of large reference ranges in clinical laboratories, current diagnoses do not account for the "clinical blind spot." A female athlete may have a "normal" hemoglobin level of 12.5 g/dL if her liver and bone marrow have been deprived of iron. [6, 8]. The current diagnostic for this condition is Non-Anemic Iron Deficiency (NAID), which is a harmful diagnosis when performance is taken into account [4, 13]. As the primary cofactor for the cytochromes in the electron transport chain, iron plays a significant role in the energy-producing metabolic process inside the mitochondria in addition to merely delivering oxygen. [7, 9]. By decreasing recovery time and increasing reliance on anaerobic methods, marginal iron depletion is known to lower aerobic capacity [4, 15].

Recent advances in sports hematology have demonstrated that hepcidin is a crucial and controllable hormone that can change in response to inflammation brought on by exercise, further complicating the absorption of iron. [2,14]. To enhance and optimise women's health and athletic potential, sports hematology in medical lab technologies must go beyond hemoglobin. In addition to the complex physiologic control of iron loss specific to athletic women, this study will evaluate iron markers that are prescribed and tested, such as sferritin, sTfR, and reticulocyte haemoglobin [13,16,18].

## **PATHOPHYSIOLOGY OF IRON**

The pathophysiology of iron depletion in female athletes is multifaceted, including a combination of systemic, mechanical, and hormonal factors. Athletes have faster iron turnover than the sedentary population due to mechanisms that are frequently missed in routine clinical assessments [1, 2].

**Mechanical Stress: Hemolysis from Foot Strikes:** Foot-strike hemolysis is a major mechanism of iron loss in high-impact activities like field sports and long-distance

running. Red blood cells (RBCs) physically burst as they travel through the tiny capillaries of the soles due to the recurrent mechanical force of the foot striking a hard surface [1, 8]. Free hemoglobin is released into the plasma by this intravascular hemolysis. A considerable amount of this iron is either bound by haptoglobin or eliminated by the kidneys, resulting in a net loss over time, even though part of it is recycled [6, 17].

**Exercise-Induced Gastrointestinal (GI) Ischemia:** Extended periods of intense exercise cause a significant shift of blood flow. Blood is diverted from the splanchnic organs to meet the metabolic needs of the exercising muscles. The integrity of the intestinal lining may be compromised by this transient GI ischemia, which could result in occult gastrointestinal bleeding and microscopic mucosal damage [11, 15]. After intense activities, endurance athletes lose quantifiable amounts of iron through the GI tract, according to studies using radiolabeled red blood cells [17].

**Menstruation and Training: The Double Burden:** These exercise-induced losses are exacerbated for female athletes by the required menstrual blood loss. Women may lose 10–40 mg of iron every month, depending on the intensity of their cycles [18]. The athlete quickly moves from iron depletion to frank iron insufficiency when this "double burden" of biological and athletic loss is not addressed with sufficient food intake or effective absorption [3, 5, 11].

**The Inflammation-Hepcidin Blockade:** The hepcidin-inflammation axis is the most intricate layer. The body goes into a pro-inflammatory condition after exercise, which is marked by an increase in Interleukin-6 (IL-6) [14]. This cytokine instructs the liver to produce more hepcidin. The iron exporter ferroportin is then bound by hepcidin and broken down. This creates a "transient iron deficiency" state for a few

hours following each training session by effectively locking iron inside the macrophages and preventing absorption in the duodenum [2, 16].

## RESULTS AND DISCUSSION

It is evident from the synthesis of current sports hematology data that the traditional reliance on hemoglobin (Hb) concentrations is inadequate for determining female athletes' actual iron status [13]. According to our data, there is a substantial diagnostic discrepancy between the physiological demands of high-intensity training and traditional clinical reference ranges. In particular, sports literature regularly shows that performance deficits and metabolic tiredness start to appear when ferritin levels fall below 35 ng/mL, although conventional medical laboratories frequently use a serum ferritin threshold of 12–15 ng/mL [1, 8]. This disparity emphasizes the prevalence of Non-Anemic Iron Deficiency (NAID), a disorder that is often misdiagnosed as psychological burnout or overtraining syndrome because of "clinically normal" CBC values [1, 9].

Advanced laboratory indicators like Reticulocyte Hemoglobin (Ret-Hb) and Soluble Transferrin Receptor (sTfR) must be incorporated into routine screening in order to close this gap. sTfR continues to be a consistent and trustworthy measure of cellular iron demand in the bone marrow, in contrast to ferritin, which functions as an acute-phase reactant and may erroneously rise after exercise-induced inflammation [13, 17]. Moreover, Ret-Hb is a crucial real-time indicator that provides an overview of iron availability for erythropoiesis throughout the previous 48–72 hours [8]. Iron deficiency has physiological effects that go well beyond oxygen transport; it damages cytochromes in the electron transport chain, which directly impedes ATP synthesis and speeds up lactate accumulation [7, 15]. Thus, this study emphasizes that even when Hb is below normal ranges, focused iron supplementation can yield substantial

improvements in VO<sub>2</sub> max and overall aerobic efficiency [5, 9]. Therefore, Medical Lab Technology (MLT) professionals are pivotal in transitioning toward "Athletic Reference Ranges" that prioritize these sensitive biomarkers over generic population standards [6, 12].

## CONCLUSION

In conclusion, a "Beyond Hemoglobin" diagnostic shift is required as sports medicine advances in order to protect female athletes' health and performance. Since subclinical iron depletion can seriously impair metabolic efficiency and recovery long before hemoglobin levels fall, the conventional focus on identifying clinical anemia is no longer sufficient for the demands of elite training. We can transition to a more proactive form of athlete care by reassessing diagnostic procedures.

It is advised that medical and coaching staffs switch from the traditional yearly CBC to complete iron panels by implementing quarterly hematological screening. To detect early-stage depletion, a stricter ferritin threshold of 35 ng/mL must be established for active women. To further reduce the confounding effects of post-exercise inflammation, the schedule of laboratory testing must be standardized, ensuring that blood draws take place while the subject is fasting and at rest. Adopting these specific laboratory criteria will ultimately enable athletes to sustain optimal physiological function and a long career.

### *Declaration by Authors*

**Ethical Approval:** This study is a review of previously published literature and does not involve any direct experimental studies on human participants or animals by any of the authors.

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## REFERENCES

1. Sim M, Garvican-Lewis LA, Cox GR, Govus A, McKay AKA, Stellingwerff T, et al. Iron considerations for the athlete: a narrative review. *Eur J Appl Physiol.* 2019;119(7):1463-78.
2. Peeling P, Dawson B, Goodman C, Landers G, Trinder D. Athletic induced iron deficiency: new insights into the role of hepcidin. *Sports Med.* 2008;38(12):1041-58.
3. Clénin GE, Cordes M, Alba-Arolo A, Adami PE, Engebretsen L, Garcia-Manso JM, et al. Iron deficiency in exercising females. *Front Sports Act Living.* 2021; 3:686735.
4. Burden RJ, Morton K, Richards T, Whyte GP, Pedlar CR. Is iron deficiency without anaemia harmful? A review of the efficiency and efficacy of iron supplementation in non-anaemic iron-deficient endurance athletes. *Br J Sports Med.* 2015;49(20):1303-12.
5. DellaValle DM. Iron supplementation for female athletes: effects on iron status and performance outcomes. *Curr Sports Med Rep.* 2013;12(4):234-9.
6. Fallon KE. Utility of hematological screening in elite athletes: points of consideration. *Clin J Sport Med.* 2004;14(3):145-52.
7. McClung JP, Gaffney-Stomberg E, Lawrence-Reid IE. Effects of iron deficiency on physical performance in adult women and adolescent girls. *Curr Opin Clin Nutr Metab Care.* 2014;17(6):524-30.
8. Pedlar CR, Bruignara C, Bruinvels G, Burden R. Iron deficiency and the female athlete: a biomarker-guided approach to specimen collection and result interpretation. *Eur J Appl Physiol.* 2018;118(3):619-26.
9. Newlin MK, Williams MH. Effects of iron supplementation on muscle metabolism in nonanemic, iron-depleted women. *Am J Clin Nutr.* 1990;52(4):688-95.
10. Mettler S, Zimmermann MB. Iron excess in recreational marathon runners of training-induced inflammation. *Med Sci Sports Exerc.* 2010;42(5):835-42.
11. Alaunyte I, Stojanoska V, Plunkett A. Iron and the female athlete: a review of dietary treatment methods for improving iron status and exercise performance. *J Int Soc Sports Nutr.* 2015; 12:38.
12. Cowell JF, Lloyd-Davies A, Whybrow S. Effects of soccer training on iron status and physical performance in female players. *J Strength Cond Res.* 2003;17(4):694-700.
13. Thomas DG, Guillemins TG, Meyer AL. Comparison of ferritin and sTfR for diagnosis of iron deficiency in professional athletes. *Clin Chim Acta.* 2017; 471:1-6.
14. Govus AD, Abbiss CR, Garvican-Lewis LA, Swinkels DW, Laarakkers CM, Thompson KG, et al. Influence of altitude exposure on hepcidin levels and iron homeostasis in elite athletes. *Sports Med.* 2015;45(1):9-22.
15. Brownlie T, Utermohlen V, Hinton PS, Haas JD. Tissue iron deficiency without anemia impairs adaptation in endurance capacity after aerobic training in previously untrained women. *Am J Clin Nutr.* 2004;79(3):437-43.
16. Hintze KJ, McClung JP. Iron absorption and hepcidin levels in response to exercise-induced stress. *Nutr Rev.* 2011;69(1): S25-32.
17. Malczewska J, Raczyńska B, Stupnicki R. Iron status in female endurance athletes and in non-exercising controls. *Int J Sport Nutr Exerc Metab.* 2001;11(2):158-76.
18. Sandstrom G, Borjesson M, Rodger S. Iron deficiency in adolescent female athletes - is it common? *Scand J Med Sci Sports.* 2012;22(2):138-44.

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