

# Iron Supplementation: What is it and how to use it to overcome iron deficiency

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One of the more common problems that occurs with elite level athletes, especially females, involves an excessive loss of iron from training and an inadequate intake of iron in their diets resulting in something called “iron deficiency” and at the extreme level “anaemia”. Although iron supplementation in excess of normal iron stores does not enhance performance, a decrease of the iron stores has been found to decrease an athletes performance.

Iron deficiency affects performance in two ways [9]. If iron stores are **low**, then haemoglobin (Hb) production will be negatively affected. Haemoglobin is one of the primary transport mechanisms for oxygen to move throughout the body and is located inside red blood cells (RBCs). If Hb production is limited or reduced this will negatively impact peak oxygen uptake and reduce the delivery of oxygen to the working muscles. Secondly, reduced iron decreases the ability of the muscles to use oxygen for the chemical production of energy (via the formation of ATP), thus aerobic exercise can be impaired. An iron deficiency not only can affect competitive performance, but it may also affect training. Iron deficiency may reduce the ability of the athlete to train in the right intensity zones. Thus, the training process may be impaired and the resulting adaptation will also be negatively impacted.

This review will give a brief introduction of the role iron plays in the production of RBCs and Hb as well as other important chemical energy reactions in the body. Then the paper will define the different stages of iron deficiency, how iron is lost from the body, and the more practical methods for replacing iron to help maintain athletic performance.

## **Why is iron important with regard to performance?**

Iron plays an essential role in the body because:

1. It is essential for the production of oxygen transport proteins, Hb in the blood and myoglobin in the muscle;
2. It is a component of **erythropoiesis** (production of new RBCs);
3. It is a component in the electron transport system that controls the release of energy from the cells (using about 2% of iron stores).

Unfortunately, the body does not manufacture it's own supply of iron and thus, the athlete must rely on their diet for their iron source. The body contains about 3-4 grams of iron at any one time. The largest component of iron in the body is found in Hb (60-70% of total iron) and myoglobin in the muscle tissues (10% of total iron) [17]. About 30% of the body's total iron in a healthy young adult male (and about 10% in females) is stored in the form of **ferritin** (known as storage iron) located in such areas as the liver, bone marrow, and muscle. From these

locations, iron is transported through the body via the blood by **transferrin**. Table 1 depicts a typical range of these substances for adult females. However, it must be understood that each laboratory establishes their own normal range based on the general population in their immediate geographic area and these values can vary from lab to lab due to this fact.

Table 1. Average iron profile range for female adult

Blood Parameter	Unit	Normal Range
Serum Iron	umol/L	7 - 24
Transferrin	umol/L	20 - 40
Saturation	%	12 - 44
Ferritin	ug/L	20 - 180

The average adult absorbs 1 to 1.5 mg of iron per day from a typical Western diet containing 12-20 mg of iron [10]. The normal rate of iron loss from the body is roughly 1 to 2 mg per day and is balanced primarily by absorption of new iron in the small intestine [17]. Absorption levels are greatly increased when the body's stores of iron are reduced such as when there is an increased rate of erythropoiesis.

**What do RBC's do?** The primary function of the circulating **erythrocytes** (mature red blood cells) is to supply the muscles with adequate amounts of oxygen through the Hb located in the RBC [5]. In other words, making sure tissues such as the working muscles have enough oxygen to continue functioning. Males generally tend to have higher values than females for both RBC count (red cell count =  $5.5 \pm 1.0$  vs.  $4.8 \pm 1.0$  /pl for males and females respectively) and Hb ( $15.5 \pm 2.5$  vs.  $14 \pm 2.5$  g/dl, for males and females respectively). Interestingly, although these blood parameters have a large range between people ( $\pm 7$ ), they remain remarkably constant for each individual from the point of puberty onward [5]. The body tightly monitors itself for these values and the number of RBC's is kept within fairly narrow limits for a healthy young adult. This is a very remarkable process considering that 6 billion new red cells are produced hourly to replace RBCs that have completed their life span [5].

### What is iron deficiency?

If the iron intake in an athlete's diet is inadequate and the rate of iron usage or excretion is more than intake then a negative iron balance will occur in that the body's stored iron will begin to be reduced. A prolonged negative iron balance will result in the development of iron deficiency, of which there are three stages. First there is **prelatent iron deficiency**, the earliest form of iron deficiency. It suggests that your storage iron is depleted. The second stage of iron deficiency is **latent iron deficiency** which suggests that your transport iron pool is impaired and not functioning at optimal standards. The final stage and most detrimental to

performance is ***manifest iron deficiency anaemia***. This suggests that erythropoiesis is blocked and no new RBC's are being produced [17], or that new RBC's are being produced but they are simply low quality and not very effective.

When evaluating an iron profile, when serum ferritin values drop below 12 µg/L, iron stores are considered to be completely exhausted, or in other words you are in a state of manifest iron deficiency. Whereas, serum ferritin values which lie between 12 µg/L and the normal lower limit of 35 µg/L may indicate varying degrees of prelatent and latent iron deficiency, or that your storage iron and your transport iron levels are lower than optimal [17]. Having said this, it is very important for you to understand that the results from a blood test are individual in nature. Differences exist relative to age and gender as well as athlete and non-athlete. For the most part, only about 2 and 13% of the male athletic population have been found to have serum ferritin values below 12 µg/L. However, some studies have found between 20 and 47% of the female athlete populations in Canada and the United States to be below 12 µg/L [6].

Another condition that should be understood by the coach and athlete is something referred to as sports anaemia. Sports anaemia has a similar iron profile to that of iron deficiency, but upon closer scrutiny, the RBCs are of proper size and colour indicating that they are functioning normally [9]. Sports anaemia is not thought to affect performance and is therefore not considered to be a genuine iron deficient state. Sports anaemia is thought to be caused through an expanded plasma volume experienced by most athletes. Sports anaemia most often occurs in athletes early in a training program (especially after a rest period, initiation of endurance training, or after injury) [8]. As the body begins to produce more RBCs to keep up with an increased exercise demand (either increased intensity training or increased volume training), the body must also increase the plasma volume to reduce the resistance caused by the increased RBC count.

**Are there any special considerations?** Serum ferritin levels and iron stores can vary with age, sex, and physical activity. Generally, serum ferritin levels are low in young children and adolescents during their growth phases [2]. It is not uncommon for male adolescent athletes to have low serum ferritin, despite high dietary iron intakes and iron supplements [21]. Low serum ferritin may be physiologically “normal” at this age as a slow increase in serum ferritin occurs during adolescence up through early adulthood in males [4]. On the other hand, female adolescents do not show this increase as they move into adulthood. Their levels tend to increase slowly until the age of menopause and then increase sharply. Thus, adult reference values for serum ferritin cannot be applied reliably to children and adolescents [3].

## **How is iron lost in an athlete?**

Intense physical activity can shift the iron balance towards iron deficiency. The factors thought to be most prevalent in the loss of iron from the body include:

- Gastrointestinal blood loss
- Increased loss of iron through sweat
- Increased loss of iron in the urine
- Iron malnutrition (inadequate intake of iron)
- Foot strike haemolysis

Women are at the greatest risk due to the loss of iron, which occurs with menstruation independent of intensive exercise training. Research has indicated an inverse relationship between menstrual flow and serum ferritin levels in addition to the fact that women generally have poor dietary intakes of iron averaging 43% of the recommended dietary allowance [18]. Currently, the greatest area for iron loss in male athletes was found to be through gastrointestinal blood loss resulting from competition and training [16]. The iron loss in these cases was found to be between 6 and 11 ml per day (roughly 3 to 5 mg iron/day). Iron loss through sweat or urine may also be increased during exercise; however, the contribution of this to total iron loss is negligible [16]. Malnutrition in the form of inadequate iron intake also appears to contribute to the athletes negative iron balance. The recommended dietary intake of total iron is roughly 10 mg/day for adult men and 15 mg/day for menstruating women [11]. Male athletes normally achieve the recommended iron intake; however, this does not seem to be true for female athletes [17].

## **What are the most useful markers of iron deficiency?**

For the most part, the best way to find out if an athlete is iron deficient is to get a blood test. Blood tests can be performed by most general practitioners as well as sports medicine clinics. As a guideline, all blood draws should be taken on a rest day or prior to any strenuous exercise as exercise can falsify the results. Some of the markers to look for include:

### **Iron Profile Characteristics**

- Serum Iron – Serum iron is sensitive to the stage of mild iron deficiency, as levels decrease after body stores are fully depleted but before Hb levels drop. Serum iron may give false indications of iron deficiency if the athlete has recently been pregnant, had chronic infections had an inflammation or it may also increase with acute infections or inflammations.
- Transferrin – Transferrin is the iron transport protein, and its levels increase with iron deficiency but may be falsely reduced in acute inflammation, chronic infections, or renal diseases.

- Ferritin – Serum ferritin values are a reliable and sensitive parameter for the assessment of iron stores in healthy adults. A ferritin value of 12 ug/l or lower has been universally employed as a sign of iron deficient anaemia. False indicators of low ferritin levels include: recent exercise, dehydration, chronic inflammation, or infection. Alcohol consumption has also been found to raise serum ferritin values probably due to the diuretic effect it has on fluid balance [14].
- Saturation (percent saturation of transferrin) – Transferrin saturation is the ratio of serum iron to iron-binding capacity and is the most accurate indicator of iron supply to the bone marrow. Normally only about one third (between 20 and 40%) of the transferrin molecule is saturated with iron. If values drop below 20% saturation, this suggests an inadequate iron transport capability which may be due to low iron stores.

### What are the natural sources of iron in food?

The unfortunate aspect is the fact that athletes simply do not eat enough of the proper foods to meet their body's iron needs. The athletes diet should include cereals, protein, and other sources of food high in iron. A general idea of which foods are good sources of iron has been included below (Table 2). The recommended daily allowance (RDA) is 10 mg for men and 18 mg for women. Of additional importance is the realization that meat forms of iron (heme iron) are more readily absorbed than are plant forms of iron (non-heme iron).

Table 2. Suggested Sources of Iron in the Diet [7]

Meal	Food Type	mg/serving
Breakfast	Cereal - Raisin Bran (Kellogg's)	10
	Cereal - Corn Flakes	1
	Cereal - Frosted Flakes	1
	Cereal - Rice Krispies	1
	Milk Chocolate	1
	Bread (white)	1
	Other - Egg (1 large)	1
Lunch/Dinner	Fruits - Prune Juice (250 ml)	3
	Fruits - Apricots (12 halves dried)	2
	Fruits - Dates (10 dried)	1
	Fruits - Raisins (1/3 cup)	1
	Vegetables - Spinach (1/2 cup cooked)	2
	Vegetables - Green Peas (1/2 cup cooked)	1
	Vegetables - Broccoli (1/2 cup cooked)	1
	Vegetables - Baked Beans (1/2 cup)	2
	Vegetables - Kidney Beans (1/2 cup)	2
	Meat - Liver (75 g cooked)	8.3*
	Meat - Beef (75 g cooked)	2.3*
	Meat - Tuna (75 g)	1*
	Meat - Chicken breast (75 g)	1*
	Meat - Fish (75 g)	1*

Note: \* indicates a good absorption rate

Follow these tips to help you boost your iron intake [7].

1. Eat lean cuts of beef, lamb, and pork, and the dark meat of chicken or turkey, 3-4 times per week.
2. Select breads and cereals with the words “iron –enriched” or “fortified” on the label. This added iron supplements the small amount that naturally occurs in grains. Eat these foods with a source of vitamin C (for example, orange juice with cereal, tomato on a sandwich) to enhance iron absorption.
3. Use cast-iron skillets for cooking. They offer more nutritional value than stainless steel cookware! The iron content of spaghetti sauce simmered in a cast-iron skillet for 3 hours may increase from 3 to 88 mg for each half-cup of sauce.
4. Abstain from consistently drinking coffee or tea with all meals, particularly if you are prone to being anaemic. Caffeine in these drinks can interfere with iron absorption.
5. Combine poorly absorbed vegetarian sources of iron (10 percent absorption rate) with animal sources (40 percent absorption rate). For example, eat broccoli with beef, spinach with chicken, and chilli with lean hamburger.

### **Is iron supplementation required in athletes?**

It has been previously shown that a diet high in meat sources was as effective as a 50 mg/day oral iron supplement in protecting the ferritin status of previously iron deficient sedentary women [15]. However, this seems questionable for athletes who generally tend to eat diets which are high in carbohydrate and low in fat. Also, dietary intervention alone is incapable of repleting iron stores within three months. Thus, for athletes it would appear that iron supplementation would be a more effective and practical way to treat iron deficiency.

With regards to iron deficiency anaemia (the more severe form of iron deficiency), there is no question as to the benefits of iron supplementation, for even mild cases of anaemia decrease the capacity to perform moderate physical activity [13]. The benefit of iron supplementation in non-anaemic athletes is still unclear. In general, a small but significant increase in serum ferritin levels is observed following iron supplementation in non-anaemic iron deficient athletes [17]. At present, the majority of studies in non-anaemic athletes do not show iron supplementation to produce any significant changes in physical capacity, however recent evidence contradicts this and thus the effect iron plays in improving an athlete's physical capacity remains to be determined.

### **If advised by a doctor to supplement with iron, how should I do it?**

The literature states that the most readily absorbable form of iron is ferrous sulphate followed closely by ferrous gluconate [19]. Ferrous fumarate has been found to have a relatively poor absorption rate and is typically found in the cheap generic multipurpose supplements. The more common brand names found at pharmacies include Ferro-Gradumet, FGF, or Fefol.

A daily dosage of approximately 100 mg/day appears to be the most appropriate for non-anaemic athletes (serum ferritin values between 12 and 35 µg/L). Higher dosages of up to 300 mg/day should be reserved for severe cases of iron deficiency (serum ferritin values below 12 µg/L) and only recommended by a physician [17]. In most cases, supplements are discontinued when serum ferritin levels return to an acceptable range for the individual athlete (approximately 50 to 60 µg/L), and then diet therapy is maintained. The importance of habitually consuming a diet with a high bioavailability of iron is crucial to continued recovery. Caution should be given here in that some women and most adolescents can have normally lower levels of serum iron stores. Remember each athlete is different and should be treated differently. A “one size fits all” does not apply in this situation.

The repletion of exhausted iron stores may be time consuming, taking upwards of 3 months or more even in individuals with no pathological iron loss. Research suggests that athletes with serum ferritin levels of 35 µg/L or lower should replenish iron stores by taking 100 mg of ferrous iron per day (usually 50 mg twice a day) for two or three months and then ferritin levels should be rechecked [17]. However, you should only supplement with iron based upon a recommendation from your doctor and they will recommend the proper dosages for you to take. In addition, tea or coffee with caffeine prevent iron from being absorbed whereas vitamin C enhances iron absorption. Thus, it is recommended that iron supplement pills should be taken with fruit juice [12].

### **Are there any special precautions or side effects?**

Iron intake may not be well tolerated by your athletes, as it can cause intestinal cramps and black stools when the dosage is too high (over 200 mg/day) or if the iron is consumed on an empty stomach [6]. Habitual intakes of iron as supplements can interfere with zinc and copper absorption and possibly induce deficiencies in these minerals [20]. Additionally, the vitamin C will help improve the absorption rate. Taking iron supplements for six months or more should be avoided without medical supervision. Excessive iron can be toxic for the liver and normal or supplemented ferritin levels higher than 200 µg/L is associated with increased coronary risk due to *haemochromatosis* (iron overload). Intramuscular injections of iron should only be prescribed and administered by a physician [6].

In Australia, the gene responsible for hereditary haemochromatosis occurs in 10% of the Caucasian population. This equates to approximately 3 in 1000

people [9]. In people with haemochromatosis, iron slowly accumulates in tissues leading to irreversible tissue damage and disease. Haemochromatosis is often detected during routine haematological screening of athletes or during investigation of persistent fatigue. Haemochromatosis highlights the need for correct diagnosis of iron deficiency in athletes prior to recommendation of iron supplementation [9].

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