Iron and Performance

Quick Summary

Sports Anemia is extremely common among competitive female swimmers. The mineral, iron, plays an important role in the body’s delivery and use of oxygen to and by working muscles. It has been postulated that a lack of iron in the body can reduce aerobic capacity and impair endurance performance. What remains unclear is the extent to which (1) iron depletion without anemia and (2) iron repletion affect athletic performance.

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The mineral, iron, plays an important role in the body’s delivery and use of oxygen to and by working muscles. It binds oxygen to hemoglobin, which then travels in the bloodstream to locations throughout the body. Iron is also needed to support the intricate chemical process of “electron transport,” an essential part of the aerobic (oxygen-requiring) breakdown of fuels (ex. carbohydrate and fat). Generally, the more oxygen there is being delivered, the greater the body’s ability to perform work. For this reason, iron receives much attention for its role in supporting aerobic exercise, and it has been postulated that a lack of iron in the body can reduce aerobic capacity and impair endurance performance.

There are a number of markers that, collectively, describe an individual’s iron “status,” including serum (circulating) iron, red blood cell count, hemoglobin, hematocrit, total iron binding capacity, and serum ferritin. The most sensitive is serum ferritin, a marker of stored iron. Similar to a bank account, this iron “reserve” is not tapped into until circulating levels of iron become too low to support demands. For example, if the body is using (via exercise) and excreting (via sweat, menstrual cycle) more iron than it is receiving (via ingestion, absorption, storage), the ferritin level will slowly decline. For this reason, practitioners have historically used the ferritin value to identify cases of iron deficiency anemia (poor iron status). The normal range for ferritin is 30-180 mg/L. But ferritin can rise and fall, depending on the stage of anemia. Therefore, additional markers, such as those mentioned above (hemoglobin in particular), must also be considered in making any stage-specific diagnosis. Hemoglobin is often singled out because of its ability to carry oxygen and thus, its direct link to oxygen delivery. The lower limit for normal hemoglobin concentration is around 12.0 g/dL for females and 14.0 g/dL for males. It is not unusual for athletes to be
1.0-1.5 g/dL below these values and still be considered within the normal range.

The most recent research on iron and athletics was conducted in the early- to mid-90’s. What we learned from this is that while ferritin remains a critical marker of iron stores and overall iron status, it is possible for athletes to experience iron deficiency without experiencing frank or full-blown iron deficiency anemia. In other words, their ferritin levels can be low, while their levels of hemoglobin remain within the normal range. This condition is known as Sports Anemia and is very common among competitive female swimmers. What remains unclear is the extent to which (1) iron depletion without anemia and (2) iron repletion affect athletic performance.

The following studies address these issues:

**1. Iron depletion without anemia can impair maximal capacity.**


The purpose of this study was to examine the effects of iron depletion without anemia on aerobic exercise capacity. Thirty women (age 19-36 yrs) were separated into two groups: Iron-Depleted (ferritin < 12 mg/L; normal hemoglobin) and Iron-Sufficient (ferritin > 12 mg/L; normal hemoglobin). Each group performed a maximal oxygen consumption (VO2max) test on a stationary bicycle.

**Results**

- Hemoglobin concentration was similar between the two groups.
- Relative to total body weight, VO2max was not different between the two groups.
- Taking into account fat-free mass and activity level, VO2max was significantly lower for the Iron-Depleted group compared to the Iron-Sufficient group.

**Implications**

- Swimmers with ferritin levels below 12 mg/L may not be anemic, but their performance at maximal intensities may be compromised. This can impact their ability to train day-to-day.
- Compromised performance in iron-depleted, non-anemic women may be due more to a decrease in the body’s ability to use oxygen than to a decrease in its ability to deliver it. So the traditional signs of poor iron status that a coach might observe are not evident, and the effects may only be experienced during exercise.
2. **Iron depletion without anemia can impair sub-maximal capacity.**


The purpose of this study was to examine the effects of iron depletion without anemia on sub-maximal endurance capacity. Sixteen recreationally trained females (age 21-35 yrs) were separated into two groups based on their serum ferritin levels: Low-Ferritin (ferritin <12 mg/L; normal hemoglobin) and Normal-Ferritin (ferritin >26 mg/L; normal hemoglobin). Aerobic endurance in both groups was measured as the length of time exercise could be performed at 80% of maximal effort on a stationary bicycle.

**Results**

- Hemoglobin concentration was similar between the two groups.
- Time to exhaustion was 14% less for the Low-Ferritin group compared to the Normal-Ferritin group. This difference was not statistically significant, but could be practically significant.
- Ferritin concentration was related to the amount of absorbable iron in the diet and total iron intake.

**Implications**

- Swimmers with ferritin levels below 12 mg/L may not be anemic, but their performance at sub-maximal intensities near 80% may be compromised.
- Low ferritin levels are likely due to inadequate dietary intake of iron. The best sources of absorbable iron are “heme” sources, such as meat, fish and poultry. Other sources of iron (“non-heme” iron), such as the dark leafy greens and legumes, are less absorbable than heme-iron but are good sources nonetheless.
- Female swimmers should be encouraged to get enough heme-iron in their diet to maintain ferritin levels at or above 26 mg/L.

3. **Iron depletion without anemia affects endurance performance.**


The purpose of this study was to test the effect of iron depletion without anemia on endurance performance in a practical (non-laboratory, uncontrolled, sports-like) setting. Thirty-seven physically active, iron-depleted (ferritin <16 mg/L), non-
anemic (hemoglobin >12.0 g/dL) women (age 19-36 yrs) were randomly divided into two groups. One group was provided with an extra 45 mg of extra iron per day for 8 weeks, while the other group received an iron-free placebo. Both groups maintained their normal activity level during this time. A 15-km cycling time trial as fast as possible was performed at the beginning and end of the 8-week trial.

**Results**

- Iron intake at the start of the study averaged 16-18 mg/day for both groups.
- The extra-iron group maintained their initial levels of hemoglobin and raised ferritin levels from around 12 mg/L to >35 mg/L over the 8-week trial.
- The placebo-iron group experienced a significant drop in hemoglobin over the 8-week trial, while their ferritin stayed the same.
- Time trial results were similar between the two groups at the end of 8 weeks, **BUT** the actual energy required to perform the time trial (measured during the test) was lower for the extra-iron group compared to the placebo-iron group.

**Implications**

- For iron-depleted females, an intake of 16-18 mg/day of elemental iron may not be enough to keep hemoglobin levels within the normal range. If hemoglobin levels are allowed to fall, the onset of full anemia becomes inevitable.
- Repletion of iron stores makes a non-anemic individual more energy-efficient. Completing the same amount of work requires a lower level of physical exertion, which translates into the potential for an energy “reserve” to be available for work at higher intensities.

**4. Iron repletion can restore aerobic capacity.**


The purpose of this study was to examine the effects of a high-dose of iron every day for 12 weeks on red blood cell volume and performance in iron-depleted, non-anemic athletes. Forty-one elite junior endurance athletes who were iron-depleted (ferritin <20 mg/L) and non-anemic (hemoglobin >13.5 g/dL for males and >11.7 g/dL for females) were randomly assigned to two groups. The Iron Group received 200 mg of extra iron per day for 12 weeks, while the Placebo Group received an iron-free placebo. Both aerobic and anaerobic capacity were measured on a treadmill before and after the 12-week treatment.
Results

- The Iron Group’s ferritin increased from around 15 mg/L to around 36 mg/L. The Placebo Group’s ferritin did not increase at all and remained significantly lower than the Iron Group’s (around 13 mg/L) at the end of the 12-week trial.
- Hemoglobin concentration did not change significantly for either group during the 12-week trial.
- Red blood cell volume was similar between groups and remained unchanged throughout the study.
- Aerobic capacity increased for the Iron Group, but not for the Placebo Group.
- Anaerobic capacity was similar between groups and remained unchanged throughout the study.

Implications

- If an athlete’s ferritin is below 15 mg/L, there is a very good chance that his/her aerobic capacity is not being maximized. In other words, “untapped potential.”
- Bringing a low ferritin level back into the normal range can restore an athlete’s potential to work aerobically for longer periods of time.

5. Iron repletion compliments training effects.


The purpose of this study was to test the effects of iron supplementation on metabolic training adaptations. Forty-nine iron-depleted (ferritin <16 mg/L), non-anemic (hemoglobin >12.0 g/dL) physically active women (age 20±4 yrs) were randomly assigned to two groups. The Iron-Training Group received 20 mg of extra iron per day for 6 weeks, while the Placebo-Training Group received an iron-free placebo. The 6-week trial included a 4-week aerobic training program on a cycle ergometer (25 min/day, 5 days/wk). Both groups performed a 15-km cycling time trial as fast as possible at the beginning and end of the 6-week experiment.

Results

- The Iron-Training Group experienced an increase in ferritin levels (from about 10 mg/L to about 14 mg/L) over the 6-week trial.
- Both groups made significant improvements over their time trial performance from pre-test to post-test.
The Iron-Training Group improved their performance to a greater extent than the Placebo-Training Group.
The improvement experienced by the Iron-Training Group was due to faster times in the second and third segments of the test compared to pre-test times.

Implications

- An athlete does not have to stop training to experience the benefits of restoring iron to sufficient levels. Even in the presence of the increased demand introduced by training, increasing the intake of iron in the diet can reverse iron-depletion.
- The daily requirement to achieve this effect may be higher (>20 mg/day) for athletes involved in more strenuous programs.
- Repleting iron stores has a positive effect on efficiency during the latter stages of endurance performance lasting around 30 minutes.

6. If it ain’t broke...Don’t fix it.


The purpose of this study was to determine whether an intramuscular iron injection could improve serum ferritin concentration and physical performance in iron-depleted, non-anemic female athletes. Fifteen elite female iron-depleted (ferritin <40 mg/L), non-anemic (hemoglobin >12.5 g/dL) Australian netballers (age 19+3 yrs) were divided into two groups. The Ferritin Group received five intramuscular injections (500 mg of elemental iron each) over 8 days, while the Placebo Group received placebo injections. Each group completed a battery of sprint-sport performance tests before and after the injection trial.

Results

- Ferritin concentration increased significantly (22±3 mg/L up to 61±5 mg/L) for the Ferritin Group but did not change for the Placebo Group.
- Hemoglobin concentration was similar between the two groups and did not change for either group over the 8-week study.
- Performance results were similar between the two groups both before and after the injection trial.

Implications
Increasing ferritin beyond 22 mg/L does not appear to improve performance in sprint-sport tests in non-anemic athletes.

A ferritin level of 40 mg/L is too high a cut-off for suggesting iron-depletion.

If a non-anemic athlete is not iron-depleted, supplemental iron will not improve sprint performance.

If it ain’t broke...don’t fix it. Over-supplementation does not improve potential or performance.

The Final Word

1. **Know your athlete’s iron status.** An athlete whose ferritin level is below 15 mg/L may not be optimizing his/her potential to perform.

2. Iron deficiency can interfere with the adaptive response to training by preventing performance at true maximal intensities. At sub-maximal intensities, the efficiency of the body suffers, which translates into a lower quality workout.

3. Replenishing iron stores is different from increasing iron in general. Improving an athlete’s iron status from *deficient* to *sufficient* is clearly warranted and beneficial, whereas the effects of simply adding extra iron to an iron-sufficient diet may be minimal. Keep in mind that replenishment of iron stores takes time (6-8 weeks in most cases) and that dietary supplements are not necessary in most cases.

The recommended intake for iron for competitive, iron-sufficient athletes is 17.5 mg/day for males and 23 mg/day for females. Encourage your athletes to eat meat, fish and poultry to maximize the amount of iron their bodies can readily absorb. Dark leafy green vegetables, whole grains and legumes (beans, peas, etc) are also excellent sources of iron.

Recommended Reading


Chatard, J., I. Mujika, C. Guy and J. Lacour. (1999). Anaemia and iron deficiency...


**Additional Reading**

**Diet/Supplementation:**


**Other:**


