The importance of monitoring iron levels in the female high school track and field athlete

by

Newton North High School, Girls Track and Field Coaching Staff;

Newtonville, Massachusetts

Iron is perhaps the most important trace nutrient that an athlete needs to monitor. Iron is a mineral, and is closely related to how we distribute oxygen to every cell in our body. Every cell in our body must have oxygen delivered to it - often! Every cell in the body dies if it is deprived of oxygen for approximately three minutes.

So, how does the oxygen get to all of the cells in our body? Red blood cells circulate through our body. They go through our lungs a pick up oxygen from the air that we breath. Then those Red Blood Cells travel through blood vessels to all of the different areas of our body. When they contact a target cell, the red blood cell drops off the oxygen to the cell, and then the red blood cell exchanges it for a waste product (called carbon dioxide or "CO2") that the cell wants to get rid of. In the body, the red blood cell is both the "delivery truck" of good oxygen, and the "garbage truck" of the waste product carbon dioxide. The red blood cell eventually travels back toward the lungs, and drops off the waste product (the carbon dioxide), and picks up some more oxygen for another trip around the body. The lungs expel the carbon dioxide when we exhale - and brings in new oxygen when we inhale. Breathing is a good thing! We should all do it on a regular basis for the rest of our lives!

How does the oxygen attach to the red blood cell? Oxygen attaches to the red blood cell on a large iron-protein molecule called hemoglobin which is attached to the red blood cell. The hemoglobin molecule makes up approximately 30% of the red blood cell. The primary function of iron in the body, is the formation of hemoglobin - as iron is the central core of the hemoglobin molecule which is the essential oxygen carrying component of the red blood cell. Each hemoglobin molecule can carry four oxygen molecules.

> ***So, not enough iron = not enough hemoglobin = not enough oxygen attached to the red blood cells = body cells are not getting enough oxygen = not good!***

So, why is oxygen so important for athletes? Remember, almost all of our runners are doing "aerobic" types of running, to one degree or another. "Aerobic" means "requiring oxygen". In fact, a part of our training program design (except for purely power athletes) - to one degree or another - is focused on things like improving "Maximal Oxygen Uptake" (also known as VO2 Max). Maximal Oxygen Uptake (VO2 Max) is the maximum amount of oxygen that can be utilized in one minute during maximal exercise. The more oxygen that we can use during exercise, the better. Maximal Oxygen Uptake (VO2 Max) is one very important factor that can determine an athlete's capacity to perform sustained uninterrupted exercise and is linked to aerobic endurance. It is generally considered the best indicator of cardio-respiratory endurance and aerobic exercise performance.

Elite endurance athletes typically have a high VO2 max. Some studies indicate that - to one degree or another - it is largely due to genetics. However, numerous studies show that properly designed athletic training programs, increases VO2 max up to 20 percent! That may not sound like a lot, but it is. Our student-athletes are competing in events where sometimes hundredths of a second separate 1st place from 2nd place finishes! A 20 percent difference in VO2 Max is a significant difference!

A major goal of most endurance training programs is to increase this number as high as is possible for each individual athlete. A high VO2 Max, and a lower VO2 Max, is one of the main differences between being "in shape" and "out of shape" - for an endurance athlete.

So, clearly oxygen is very important to athletic training and performance - and iron is vital to oxygen being available to the body.

> ***So to summarize: Oxygen is very important = must have hemoglobin to get oxygen on to the red blood cell and out to the body cells = must have iron to form hemoglobin = must have iron = iron is a good thing!***

Approximately 3-5 grams of iron is normally contained in the body. About 80% of the iron in our bodies is in functionally-active compounds - predominantly combined with hemoglobin in the red blood cells. This iron-protein compound (hemoglobin) increases the oxygen-carrying capacity of blood by about 65 times!

Other functionally-active compounds:

Iron serves other important exercise-related functions aside from its role in oxygen transport in red blood cells. I*ron is a structural component of* ***Myoglobin*** *(about 5% of total iron), a compound similar to* ***hemoglobin****, which aids in the storage of iron within the muscle cells.*

Small amounts of iron are also present in specialized substances called ***cytochromes,*** which facilitate energy transfer within the muscle cell. *This allows us to use chemical energy (originally from the food that we eat) - to fuel our muscle cells to perform athletic work. When we are training to perform at elite athletic levels (like our student-athletes are), this is very important.*

When iron is not combined with functionally-active compounds:

About 20% of the body's iron is not combined with functionally-active compounds; this constitutes the iron stores located in the liver. spleen, and bone marrow as ***hemosiderin*** and ***ferritin.*** It is these stores that replenish iron lost from the functionally-active compounds and that provide the iron reserve in periods of insufficient dietary intake.

All athletes should be sure to include iron-rich foods in their ***DAILY*** diet. People who:

- 1) Do not take in enough iron (from dietary sources and/or effective supplements); or,
- 2) Who have limited rates of iron absorption; or
- 3), Who have high rates of iron loss,

can develop a condition in which the concentration of hemoglobin in red blood cells is reduced. This condition of iron insufficiency, commonly called ***iron deficiency anemia***, is characterized by:

- General sluggishness;
- Weakness;
- Loss of appetite;
- A reduced capacity for sustaining exercise;
- Reduced resistance to infections.

Can Iron Deficiency Anemia be "cured"?

With "corrective iron therapy", both the hemoglobin content of the blood and the exercise response can be brought back to normal levels.

How much Iron should I be getting each day?

The recommended daily intake of iron for reproductively mature females, is 18 mg. per day. This is 5 mg per day more than males.

<u>But if we eat/take 18 mg. of iron each day - will we actually be ABSORBING 18 mg. of iron each day?</u>

Almost certainly NOT!

That's because we don't absorb 100% of the iron that we eat or take as supplements - ***AND, NOT ALL IRON IS CREATED EQUAL!*** Let's look at why that is:

<u>"heme-iron" vs. "non-heme-iron"</u>:

There are two very different forms of iron:

- **"heme iron", and**
- **"non-heme iron"**

All vegetable sources of iron is called **"non-heme iron"**, whereas iron from animal sources is called **"heme iron"**.

<u>Why is the form of iron so important?</u>:

While iron absorption from the intestines varies with iron need, a considerable difference in iron absorption occurs in relation to the ***form of the iron food.*** For example as little as 2% of the iron ingested from foods in the plant kingdom **("non-heme iron"**) is absorbed - whereas as much as 35% of animal (or **"heme-iron"**) is absorbed. That can make a <u>considerable</u> difference when it comes to preventing and/or remedying ***Iron Deficiency Anemia.*** This places women on vegetarian-type diets at a much higher risk of iron insufficiencies - especially if they are athletes. In fact, recent research indicates that vegetarian female runners have a poorer iron status than counterparts who consumed the same quantity of iron from predominantly animal sources.

<u>The best sources of "heme iron" (in descending order) are:</u>

- Beef liver;
- Clams;
- Lean beef;
- Pork;

- Eggs;
- Lamb;
- Chicken;
- Salmon;

The best sources of "non-heme iron" (in descending order) are:

- Kelp;
- Brewers' yeast;
- Blackstrap molasses;
- Wheat bran;
- Pumpkin seeds;
- Sesame seeds, whole;
- Wheat germ;
- Sunflower seeds;
- Millet;
- Parsley;
- Almonds;
- Dried prunes;
- Cashews;
- Raisins;

Notice that spinach isn't even in the top 14 sources of vegetarian ("non-heme") iron.

Those of you who are vegetarians: look at the above list of the highest vegetarian sources of iron ("non-heme" iron). Do you eat much of those foods on a daily basis? Because as little as 2% of the vegetarian ("non-heme") iron eaten is actually absorbed - are you being scientific and rational about your vegetarianism?

<u>What can I do to help to increase the absorption of iron?</u>

Iron absorption is ***inhibited*** by: low stomach acid, antacids, taking calcium at the same time as iron, low copper levels, phosphates in soft drinks and other carbonated beverages, coffee, black tea, and non-steroidal anti-inflammatories such as ibuprofen ("Nuprin", "Advil") and naproxen ("Allieve").

Iron absorption is ***increased*** by: life stages that stimulate increased absorption (such as adolescent growth periods, pregnancy, and lactation); sufficient levels of hydrochloric acid in the stomach, Vitamin C taken at the same time as iron, direct blood loss or iron deficiency (stimulates increased iron absorption), red meat ("heme iron"), protein foods, sufficient copper levels, sufficient cobalt levels, sufficient manganese levels.

<u>OK, so what does this mean?</u>

Try to eat iron rich foods - and take iron supplements (if they are indicated):

- On an empty stomach, in-between meals;
- With 250 mg. of vitamin C;
- With some orange juice (not the kind with added calcium).
- Don't take antacids at the same time as iron rich foods;
- Don't take calcium supplements at the same time as iron rich foods;
- Minimize your intake of soft drinks, coffee, and black tea - ***especially*** at the same time as iron rich foods;
- Minimize your use of non-steroidal anti-inflammatories such as ibuprofen ("Nuprin", "Advil") and naproxen ("Allieve") - ***especially*** at the same time as iron rich foods;
- Try to focus as much as possible on getting your iron from ***"heme iron" foods (animal proteins)***, as opposed to "non-heme" iron foods (plant kingdom foods).

<u>Females: A population at risk</u>:

Iron deficiency anemia frequently occurs among female teenagers, as well as females of child-bearing age - and is even more common among physically active females. Females can lose between 5 and 45 mg. (normally 30 to 45 mg.) of iron during the menstrual cycle.

The additional 5 mg. of iron intake requirements for females compared to males would increase the average monthly intake by about 150 mg. Because - on average - between only 10 and 15% (and as little as 2%) of the ingested iron is absorbed (depending upon iron status, form of iron, and composition of the meal), an additional 20 to 25 mg of iron would be available in females each month for the synthesis of red blood cells - ***lost during menstruation.*** When this added iron requirement for the female is combined with the fact that the normal American diet contains only about 6 mg. of iron in each 1000 calories of food ingested, it is not surprising that the average reproductively-mature female consumes only about 12 mg. of iron daily. This accounts for the 30 to 50% of American women who have significant dietary iron deficiencies.

As stated above, physically active females have a higher rate of Iron Deficiency Anemia. Please remember that our student-athletes are not just "physically active females". They are training at very high levels of intensity. The training program design for each individual athlete, is designed specifically to enable each individual athlete to be able to safely reach their optimal level of athletic performance - and safely compete at the high school level. It would therefore seem logical to assume that these student-athletes might naturally fall toward the top of the continuum of females prone to ***Iron Deficiency Anemia.***

Exercise-Induced Anemia:

Because of the great interest in endurance sports combined with the increased participation of women in such activities, much research has focused on the influence of hard training on the body's iron status. The term "sports anemia" is frequently used to describe reductions of hemoglobin to levels approaching ***clinical anemia*** (12 g. in females and 13 to 14 g. in males, per 100 mL of blood) that are believed to be due to intense training. Some researchers maintain that exercise training creates an added demand for iron that outstrips its intake. As a result, iron reserves are taxed, which eventually leads to a fall in hemoglobin levels and/or a reduction in iron-containing compounds within the cell's energy transfer system. Of concern is the possibility that individuals susceptible to "iron drain" may ultimately experience a reduced capacity for exercise due to the crucial role of iron in both oxygen transport and use.

It is postulated that heavy training creates an augmented iron demand because of the loss of iron in sweat and/or because of the loss of hemoglobin in urine due to the actual destruction of red blood cells with increased body temperature, spleen activity, and circulation rates, as well as mechanical trauma caused by the pounding of the feet on the running surface. This is due to the bursting of red blood cells in the foot of the runner, as the foot strikes the ground and "crushes" the red blood cells. This is known as "foot strike hemolysis" - and is more common in distance runners because of the high number of foot strikes.

In addition, gastrointestinal bleeding that is unrelated to age, gender, or performance time often occurs after long-distance running. Any such iron loss would certainly stress the body's iron reserves for the daily synthesis of more new red blood cells. This loss would be particularly significant to females, who have the greatest requirement, and lowest intake of iron.

Because adolescent and premenopausal females have a relatively high iron requirement, and because many females consume inadequate dietary iron, any increase in iron loss with training could strain an already limited iron reserve.

What should I be doing about this? This does not mean that all athletes in training should take supplementary iron or that all indications of "sports anemia" are the result of an iron intake deficiency or iron loss. It does suggest, however, that:

- All athletes should be very vigilant to ensure that a sufficient amount of iron-rich foods are being consumed ***each and every day***; and
- The iron status of all athletes needs to be monitored on a regular basis. This is especially important for female athletes in all sports and in all events, and for both male and female endurance athletes. This is best achieved by periodic evaluation of ***both*** hematological characteristics (hemoglobin and hematocrit levels), as well as iron reserves (ferritin levels). Many authorities recommend that the iron status of every athlete be monitored at least at the start of each season - or at least twice per year - if not more often. ***This is especially crucial for any vegetarian or vegan athlete!***

Many Physicians who are not extremely experienced with treating elite-level runners - often overlook the possibility of low iron reserves (low ferritin levels) - and don't test for that unless hemoglobin and hematocrit levels are abnormally low first. However, ferritin levels can be low - even when hemoglobin and or hematocrit levels are within the normal range.

The effects of low ferritin levels in runners is significant. While low iron reserves (low ferritin levels) alone rarely results in the general lethargy associated with true "iron deficiency anemia", distance runners with low ferritin levels will often experience one or more of the following: abnormal exhaustion from exercise, muscles that "burn" from "lactic acid" earlier than they normally would; slow recovery from a run or a sprint; declining performances; "heavy" legs; muscular tightness; or loss of motivation.

And there's more. Overuse injuries (the type much more common with distance runners) double with ferritin levels under 20, and triple with levels under 12. Overuse injuries are unfortunately something that distance runners - and their Coaches - are forced to constantly work to prevent and recover from. How often is the possibility that low ferritin levels could be a contributing factor, considered? Perhaps, not often enough.

When a parent suspects the possibility of either Iron Deficiency Anemia or low iron reserves (low ferritin levels) - or when their child's coach reports performance changes in the child - it may very well be valuable for the parent to consider requesting that the child's Physician run tests for ***both*** hematological characteristics (hemoglobin and hematocrit levels), as well as iron reserves (ferritin levels).

What are the normal levels for these tests?

Normal values of serum ***ferritin*** range from 20-160 ng/ml for females 40 years old and younger. Levels below 20 ng/ml for females indicate depleted iron reserves, however, the lower the ferritin level, within the "normal" range, the more likely a person is to have negative athletic performance effects from low iron reserves.

Normal ***hemoglobin*** levels range from 11.1-15.7 g/dl, for a 16-18 year old person.

Normal **hematocrit** levels range from 35-48% for an adult female.

NOTE: The normal ranges for these levels will vary slightly between different laboratories.

Supplements:

An iron supplement may be necessary in several situations. These could include:

- When "iron therapy" is indicated because of low hemoglobin, hematocrit, or ferritin levels; or,
- When an athlete is just not getting enough ***highly-absorbable*** dietary iron on a daily basis; or,
- During and after the menstrual period.

Are all iron supplements created equal?

Absolutely NOT! Just as the absorption of different forms of iron rich foods are not the same ("heme iron" or "non-heme iron") - the absorption of different forms of iron supplements vary a great deal as well. Additionally, "less-desirable" forms of iron supplements are often constipating and/or cause nausea.

Well, which ones should I use?

The form of iron supplement that is probably the best assimilated and easiest on the intestinal tract is the hydrolyzed protein chelate of iron - that is, "chelated" iron. The suggested forms of chelated iron are:

- iron aspartate
- ferrous succinate
- ferrous fumarate
- iron bisglycinate

The least expensive form of iron supplement - and the one most commonly found in drug store chains - is ferrous sulfate. However, this form should be avoided, as it is the most constipating; causes the most intestinal disturbances; and is less-absorbed than "chelated" forms of iron supplements.

An excellent iron supplement is *Solgar Hematinic Formula*, and can easily be found on the internet, from many vitamin and supplement distributors.

Is there ever a concern of taking too much of an iron supplement?

When iron supplements are administered, they should not be used indiscriminately, because excessive iron can accumulate to toxic levels in the body and contribute considerably to diabetes, liver disease, and heart and joint damage. Iron supplements should always be used under the direction of a student-athlete's physician - and should be monitored by that physician with the use of laboratory tests to evaluate the effectiveness of the supplements; the sufficiency of dietary iron intake; and whether or not continued use of the iron supplement is indicated.

As with iron rich foods, iron supplements should be taken:

- On an empty stomach, in-between meals;
- With 250 mg. of vitamin C;
- With some orange juice (not the kind with added calcium).
- Don't take antacids at the same time as iron supplements;
- Don't take calcium supplements at the same time as iron supplements;

- Minimize your intake of soft drinks, coffee, and black tea - ***especially*** with iron supplements;
- Minimize your use of non-steroidal anti-inflammatories such as ibuprofen ("Nuprin", "Advil") and naproxen ("Allieve") - ***especially*** at the same time as iron supplements;
- In addition to the iron supplement, try to focus as much as possible on getting your dietary iron from ***"heme iron" foods (animal proteins)***, as opposed to "non-heme" iron foods (plant kingdom foods).

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