Iron and fat – Peter Sandery

The role of iron in oxygen transportation

Oxygen is taken in through the lungs and transported in blood, as dissolved oxygen (1.5%) and bound to haemoglobin in red blood cells (98.5%). Haemoglobin is thus the major means of transporting oxygen throughout the body. In muscle tissue, a similar molecule, myoglobin acts as the oxygen store, although it only binds 1/4 as much oxygen per molecule, it has a greater affinity for oxygen, saturating at lower partial pressure of blood oxygen. Each haemoglobin molecule contains 4 iron atoms and each myoglobin molecule contains 1 iron atom.

Oxygen moves from the lungs to blood to muscle cells to the mitochondria in those cells where it is needed for aerobic metabolism of carbohydrates (glucose and glycogen) and fats. The mitochondria are the powerhouses of the muscles. More mitochondria means more energy can be provided for muscle contraction. One of the functions of training for middle and long distance is to increase the density of mitochondria in muscles.

A red blood cell has no nucleus and cannot reproduce itself. These cells have a lifetime of around 120 days, or less if they are damaged as described below. They are replaced by cells that are made in the bone marrow. The precursor cells in the manufacture of red blood cells require an enzyme, ribonucleotide reductase, needed for DNA replication, which contains iron. Iron is therefore required both for the process that produces red blood cells and for the haemoglobin component of those cells. Many of the enzymes essential for aerobic metabolism also require iron.

Ferritin is the primary iron storage molecule in all cells. Serum ferritin correlates well to bone marrow iron stores and is therefore a good indicator of stored iron levels. Low ferritin indicates iron depletion rather than iron deficiency. Iron deficiency is associated with low haemoglobin levels in circulating blood. Iron depletion limits the body’s capacity to produce red blood cells and hence the capacity to transport oxygen.

Increased breakdown of red blood cells may be caused by:
- mechanical trauma resulting from foot impact forces;
- elevated muscle cell acid levels resulting from anaerobic metabolism;
- mechanical trauma from increased velocity of blood flow through narrow blood vessels as the heart rate increases in response to the demands of training and racing.

All three of the above can be outcomes of running training and racing, but need not necessarily lead to iron deficiency or iron depletion.

An elevated level of reticulocytes and shift cells (both forms of immature red blood cells) in the blood is an indication of bone marrow activity to produce more red blood cells.

When red blood cells are damaged, the body reclaims the iron for re-use. Haptoglobin is a plasma protein that binds to free haemoglobin resulting from red blood cell breakdown. A decrease in serum haptoglobin indicates possible increased red cell breakdown. The haptoglobin-haemoglobin complex is captured either by the liver or by specialised cells lining blood vessels and the iron is reclaimed for reuse. Serum ferritin levels indicate metabolism of iron stores from this process. If free haptoglobin levels fall, unbound haemoglobin may be filtered by the kidneys. The kidney tubules have a maximum level of absorption of iron, bound to an insoluble protein hemosiderin, after which excess iron is lost in urine. Iron can also be lost through perspiration, through the gastrointestinal tract in faeces, and in menstruation.

With a normal diet, including red meat, and foods such as raisins, dates, leafy vegetables, dried fruits, broccoli, brussels sprouts, lima and soybeans, and with any increase in training and/or racing intensity and/or duration phased in over time, absorption of iron from food should be sufficient to satisfy needs. Tea and coffee, some other foods and some anti-inflammatory medications may act to inhibit iron absorption from food and hence increase iron loss from the body that may otherwise have been available for use. Exercise may contribute to sloughing of intestinal cells that contain already absorbed iron and hence loss of that iron.

Iron supplementation, usually in the form of ferrous sulphate tablets, may be beneficial as a short-term measure, but may have side effects. It should not be taken as a "just in case" measure as too much iron can be harmful. A blood test (including haemoglobin and serum ferritin levels) and medical advice is needed to diagnose whether or not lack of iron or some other condition, such as a vitamin B12 deficiency, is a factor in tiredness associated with athletic performance. Vitamin B12 is also essential for a range of cellular functions, including cell reproduction. <u>If you have a problem with feeling fatigued as a result of increased levels of activity, see your doctor</u>. It is a good idea to have a thorough medical examination, including blood tests, before embarking on regular high demand physical activity and to repeat the blood tests at least annually to monitor your iron and B12 levels.

Body fat levels

Percentage body fat is difficult to measure accurately, but several methods can be used to estimate it, the least intrusive of which is derived from measuring skinfold thickness at standard places on the body. For healthy, trained, young, elite distance runners, % body fat values are typically 5-8 for men and 10-14 for women. For active, healthy young adults the values are 12-20 for men and 16-25 for women[1] Percentage body fat typically increases with age.

Although a high % body fat is considered to be excess baggage for runners, fat is essential for a healthy life. Lipids (fats) are required to transport oestrogen, other steroid hormones and the fat-soluble vitamins (A, D, E & K) around the body. Fat also provides cushioning in the plantar foot pad. If % body fat is too low, some or all of the following may occur:

a) Reduced vitamin D inhibits calcium uptake and this can lead to osteoporosis.
b) Reduced foot cushioning increases transmission of foot impact forces.
c) The effect of a) and b) can lead to stress fractures.
d) Lowered steroid hormone transport can result in menstrual cycle cessation.
e) Psychological pressures associated with an overemphasis on fat loss may promote eating disorders which exacerbate a) -> d).

A loss of bone mineralisation can become permanent unless detected and corrected quickly.
Bone acts as a store of minerals that are used elsewhere in the body, but over time, a balance between movement of minerals out of and into bone tissue is needed to maintain bone strength.

Amenorrhoea (loss of menstrual cycle activity in a young woman) involves a reduction in the hormonal output of the pituitary gland, hypothalamus and ovaries. This may lead to an energy drain, decreased food intake, emotional and physical stress, and decreased body fat. An unhealthy feedback cycle may be established. An athlete needs muscle mass and a healthy body fat level to be able to train and race well.

In summary, while excessive body fat contributes to inefficient running, fat deficiency is dangerous to health – the key word is “excessive”. Fat is used by the body as a fuel for distance running. Too much or too little body fat can both be detrimental to running efficiency. Healthy athletes should have a diet that is approximately 60% carbohydrate, 25% fat and 15% protein[2] and in sufficient quantities to sustain physically demanding activities. Eating is part of training and, just as a focus on one aspect of training to the exclusion of other aspects is not recommended, eliminating or excessively reducing any one of these three food groups will eventually lead to a decline in performance as well as contributing to health problems. The general rule is to eat a range of foods that include a range of colours.

1. Martin, D. E. & Coe, P. N., 1997, “Better Training for Distance Runners”, 2nd Edition, Human Kinetics, Champaign, Ill, p. 203

2. as above, p. 84