Iron Monitoring and Supplementation in the School-aged Athlete
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Iron deficiency is the most common nutritional deficiency in the United States. The most recent data from the 1999-2000 National Health and Nutrition Exam Survey in the United States found the overall prevalence of iron deficiency to be 6% in the population. The prevalence was 4-7% in children ages 1-11 yrs.; 5% in adolescent males; and 9% in adolescent females. The prevalence was 2% in males ages 16-69 yrs. and 12% in females ages 16-49 yrs.[1]

Iron deficiency occurs in three stages. The first stage is termed prelatent anemia. It is characterized by an isolated decrease in serum ferritin. Iron stores are being depleted but hemoglobin levels remain normal. The second stage is termed latent anemia or “iron-deficient erythropoeisis.” It is characterized by further decline in iron stores and a decrease in serum ferritin, serum iron and transferring saturation. TIBC rises, hemoglobin remains normal but a mild hypochromic normocytic anemia may develop. The third stage is termed “iron-deficiency anemia.” Iron stores are further depleted with a low serum ferritin and serum iron resulting in a decrease in hemoglobin production. A microcytic and hypochromic iron deficiency anemia develops.

The prevalence of iron deficiency in athletes appears to be higher than the general population. The disparity in diagnostic tests and the cut-off values used to define iron deficiency in athletes has resulted in a wide range of reported incidences. Most studies have found that the incidence is higher in endurance and female athletes. The incidence of iron deficiency in female athletes ranges from 25 – 60% and in male athletes 4 – 6%.[2-4] Adolescent athletes are also at risk, with studies of high school athletes demonstrating iron deficiency in 17% of males and 40 – 47% of female.[5-6] One study of elite gymnasts ages 12-18 years found the percentage of low iron in 36% of male gymnasts and in 30% of female gymnasts.[7]

The two primary causes of iron deficiency are blood loss and nutritional deficiencies. Gastrointestinal hemorrhage may play a role in some athletes particularly endurance athletes. Positive tests for stool occult blood following endurance events have ranged from 13 – 85%.[8-10] Gastrointestinal blood loss may be associated with nonsteroidal anti-inflammatory drug use or an increased intensity of exercise.[9] Other potential explanations of gastrointestinal hemorrhage include visceral ischemia due to decreased intestinal perfusion, trauma from impact on the intestinal wall, and hemorrhagic gastritis.[10] Genitourinary blood loss is a less common cause of iron loss in athletes. Urinary blood loss has been reported in contact and noncontact sports. Exercise-induced hematuria is microscopic and is thought
to be a result of hypoxic damage to the nephron caused by decreased blood flow from vasoconstriction or by impact trauma to the bladder wall. This is usually temporary and resolves in a few days.[11] Intravascular hemolysis due to foot impact or muscle constriction of blood vessels is another mechanism for blood loss in athletes.[12-14] Iron loss in sweat has been studied but is negligible.[15] Menstruation is another cause of blood loss in female athletes.

Poor dietary intake of iron is a common cause of nutritional deficiency in athletes. Many female endurance athletes may not meet the required RDA for iron and other nutrients in their diets. Several studies have shown that both male and female endurance athletes fail to meet the recommended daily energy intake.[16-17] Following a vegetarian or a modified vegetarian diet (no red meat) may also contribute to low dietary intake of iron. In children, dietary iron and iron status are usually normal but can be low if there is a limited access to food, if they are on a specialized diet low in iron or vegetarian diet, or if they have a medical condition that affects iron status. During adolescence, rapid growth increases the iron requirement needs and increases the risk for iron deficiency. The risk for boys subsides after the peak pubertal growth period. However, in girls the risk for iron deficiency continues as menstruation increases the risk throughout childbearing years. Data from CSFII suggest that only one fourth of adolescent girls and women of childbearing age (12-49 years) meet the recommended dietary allowances for iron through diet.[1,18]

Numerous studies have looked at the affects of iron deficiency on athletic performance. It is well documented that iron deficiency with anemia negatively affects athletic performance by impairing work capacity and by reducing aerobic capacity, endurance and energetic efficiency. The affects on athletic performance in the nonanemic iron deficient athlete is more controversial. Animal studies have shown a reduced endurance capacity and aerobic adaptation to exercise in iron deficient subjects.[19-20] Whereas, the affects of iron deficiency on human performance is not well established. Certain studies have shown a decline in athletic performance in iron deficient nonanemic athletes whereas other studies demonstrate no significant impairment.[21-22] Also, studies have demonstrated an improvement in performance with iron supplementation in the iron deficient nonanemic athlete whereas others demonstrate no significant improvement.[23-27] The disparity in these findings may be contributed the wide variability in the research design in defining cutoff values, length of treatment and measurements to assess athletic performance. The majority of the studies did find that iron supplementation in athletes with normal iron levels incurs no benefit on performance. In theory, iron deficiency adversely affects performance by: 1) reducing the ability to adapt to aerobic training; 2) decreasing energetic efficiency during submaximal exercise; 3) increasing muscle fatigability; 4) reducing
oxygen transport capacity; and 5) reducing oxidative capacity at the cellular level.

No standard protocol exists for the screening of iron status in athletes. A survey of NCAA division I-A schools revealed no consistency in screening standards and indices and values used to determine iron deficiency in athletes.[28] The screening for iron deficiency in athletes at most schools is not a routine procedure and of the schools that do implement screening, a wide variability exists in the criteria for diagnosis and the treatment protocols. In high schools, screening for iron deficiency is usually individual and performed by the athlete’s primary care physician or team physician. The CDC recommends screening all infants, preschool and school-aged children that are at a high risk for iron deficiency as well as all adolescent girls.[1] No recommendations are specified in regards to children and adolescents actively involved in sports.

**Who should be screened?** A survey of sports medicine physicians and practicality suggest that the following athletes should be routinely screened for iron deficiency: all female athletes; all male endurance athletes; athletes on a low calorie intake diet or a diet that avoids red meat; adolescent athletes; and any athlete that presents with symptoms of fatigue, pallor, shortness of breath, elevated resting heart rate or performance decline.

Screening should best be performed annually at the beginning of the season. Periodic screening may be necessary based upon variations in individual training regimens and menstrual cycles. Athletes that are detected with low iron should be monitored monthly until iron values normalize. For adolescents and school-aged children it may be more practical to screen during the pre-participation physical exam.

The serum hemoglobin level is one test used for screening for iron deficiency. It is useful in detecting the stage of iron deficiency with anemia but, it may not be sensitive enough to detect the early stages of iron deficiency. A Hgb level of <12 g/dl is the most agreed upon level to define iron deficiency with anemia. The best overall test to assess iron status is serum ferritin. The ferritin level is highly sensitive and specific for iron deficiency. It is directly proportion to the levels of iron stores in the body. Variability exists in the ferritin cut-of value used to define iron deficiency. A serum ferritin value of <20 ng/ml is most commonly used. Some authors recommend that levels between 30-35 ng/ml need supplementation with iron.[29, 31-34] USA Track and Field recommends using ferritin cutoff values of 40 ng/ml in male athletes and 30 ng/ml in female athletes. Other indices that may be helpful in assessing iron status in athletes are TIBC(total iron binding capacity) and percent transferrin saturation.
Inadequate intake of dietary iron is the primary cause of iron deficiency in both athletes and nonathletes. Nutritional counseling and improving dietary intake of iron is the primary means of preventing iron deficiency. Nutritional counseling should provide the athlete with information regarding iron rich foods, foods that inhibit and enhance iron absorption, encouraging more red meat in the diet, calculating adequate caloric intake and guidelines on taking supplements. Supplementation with iron is a common pharmacological treatment for iron deficiency. Iron in the form of ferrous sulfate is the most readily bioavailable form of oral iron. No standard protocol for treatment exists in regards to both iron dose and cutoff values to initiate treatment. Most sources recommended providing ≥300 mg/day as ferrous sulfate (≥60 mg elemental iron) for iron replacement therapy.[30-34] Doses greater than this are often associated with increased side effects such as constipation and nausea. Supplementation with 125 mg/day of ferrous sulfate (39 mg elemental iron) is sufficient to maintain serum ferritin levels. Ascorbic acid (vitamin C) enhances iron absorption and therefore iron should be taken with orange juice and Vitamin C (250 – 500 mg/day). Iron repletion takes at least 3 months and may take up to 6-12 months in some patients. Follow-up testing should be performed monthly until levels normalize then yearly afterwards. Eichner suggests the following recommendations in regards to treatment: [32-34]

- Serum ferritin levels above 40ng/ml warrants no treatment
- A daily multivitamin with 27 mg elemental iron for serum ferritin levels between 20 and 40 ng/ml
- 325 mg ferrous sulfate once daily for serum ferritin <20 ng/ml with a follow-up after 100 tablets

Currently no standards or policies for the screening and treatment of iron deficiency in athletes have been developed.

The development and implementation of standard protocols for athletes are needed especially for the young developing school-aged and adolescent athlete.

REFERENCES