

IRON-DEFICIENCY ANEMIA

Iron-deficiency anemia typically involves red blood cells that are abnormally small in size, with decreased hemoglobin or hematocrit, and a reduced capacity to deliver oxygen to body cells and tissues. In 1998, the Centers for Disease

Control and Prevention (CDC) updated the criteria for defining anemia in a healthy reference population (Table 16). The distribution of hemoglobin and hematocrit values for anemia differs in children and adolescents and in males and females.

Table 16. Maximum Hemoglobin Concentration and Hematocrit Values for Anemia^a

Sex/Age, Years	Hemoglobin, < g/dL	Hematocrit, < %
Males and Females		
1 to < 2 ^b	11.0	32.9
2 to < 5	11.1	33.0
5 to < 8	11.5	34.5
8 to < 12	11.9	35.4
Males		
12 to < 15	12.5	37.3
15 to < 18	13.3	39.7
≥ 18	13.5	39.9
Females^c		
12 to < 15	11.8	35.7
15 to < 18	12.0	35.9
≥ 18	12.0	35.7

Source: Adapted from Table 6, Centers for Disease Control and Prevention.¹

^aAge- and sex-specific cutoff values for anemia are based on the 5th percentile from the third National Health and Nutrition Examination Survey (NHANES III).

^bAlthough no data are available from NHANES III to determine the maximum hemoglobin concentration and hematocrit values for anemia among infants, the values listed for children ages 1 to < 2 years can be used for infants ages 6 to 12 months.

^cNonpregnant and lactating adolescents.

Table 17. Adjustment of Maximum Hemoglobin Concentration and Hematocrit Values for Iron-Deficiency Anemia

	Hemoglobin Concentration, < g/dL	Hematocrit, < %
Altitude, feet		
3,000–3,999	+0.2	+0.5
4,000–4,999	+0.3	+1.0
5,000–5,999	+0.5	+1.5
6,000–6,999	+0.7	+2.0
7,000–7,999	+1.0	+3.0
8,000–8,999	+1.3	+4.0
9,000–9,999	+1.6	+5.0
10,000–11,000	+2.0	+6.0
Cigarette smoking		
0.5 to < 1.0 pack per day	+0.3	+1.0
1.0 to < 2.0 packs per day	+0.5	+1.5
≥ 2.0 packs per day	+0.7	+2.0
All smokers	+0.3 ^a	+1.0

Source: Reproduced from Table 7, Centers for Disease Control and Prevention.¹

^aIn place of the adjustments based on packs per day, a single hemoglobin concentration adjustment of 0.3 g/dL may be used for all smokers.

High altitudes and cigarette smoking increase anemia cutpoints (Table 17). Altitudes above 3,000 feet raise the cutpoint for anemia because of lower oxygen partial pressure, a reduction in oxygen saturation of blood, and an increase in red cell production. Cigarette smoking also raises the cutpoint for anemia because carboxyhemoglobin formed from carbon monoxide during smoking has no oxygen-carrying capacity.

Significance

Iron deficiency is the most prevalent form of nutrition deficiency in this country. The risk of iron-deficiency anemia is highest during infancy and adolescence because of the increased iron requirements from rapid growth. In healthy full-term infants, iron stores are adequate until age 4 to 6 months. Iron requirements may exceed dietary

iron intake after this time. The onset of menarche and low dietary iron intake also contribute to a higher risk of iron-deficiency anemia among adolescent females. Iron-deficiency anemia is more common in populations with low incomes.

Iron-deficiency anemia has been associated with delayed psychomotor development, cognitive deficits, and behavioral disturbances in young children. Iron-deficiency anemia has also been associated with impaired growth and development, depression of the immune system, fatigue, decreased resistance to infection, decreased physical performance, decreased levels of endurance, reduced attention span, decreased school performance, and increased susceptibility to lead poisoning. Among pregnant adolescents and women, iron deficiency in early gestation may increase the risk of giving birth to a preterm or low-birthweight infant.¹

Risk Factors

Increased demand for iron, decreased intake of iron, and/or greater loss of iron from the body are associated with a higher risk of iron-deficiency anemia. The following conditions are associated with an increased risk of developing iron-deficiency anemia:

- Periods of rapid growth
- Preterm or low-birthweight birth
- Low dietary intake of meat, fish, poultry, or foods rich in ascorbic acid
- Macrobiotic diets
- Inappropriate consumption of cow's milk (infants should not consume cow's milk; children should not consume more than 24 oz of cow's milk per day)

- Use of non-iron-fortified infant formula for more than 2 months
- Exclusive breastfeeding after age 6 months without the addition of iron-fortified supplemental foods in the infant's diet
- Meal skipping, frequent dieting
- Pregnancy
- Participation in endurance sports (e.g., long-distance running, swimming, cycling)
- Intensive physical training
- Recent blood loss, recent pregnancy, heavy/lengthy menstrual periods
- Chronic use of aspirin or nonsteroidal anti-inflammatory drugs (e.g., ibuprofen)
- Parasitic infections

Screening

Following are the CDC recommendations for iron-deficiency anemia screening (based on the hemoglobin and hematocrit values in Table 16).¹

Infants and Children Ages 1 to 5

Health professionals should assess all infants and children for risk of iron-deficiency anemia.¹ Those at high risk or those with known risk factors need to be screened for iron-deficiency anemia with a standard laboratory test.

Universal Screening (Those at High Risk)

At 9 to 12 months, 6 months later (at 15 to 18 months), and annually from ages 2 to 5 years, screen those at high risk for iron-deficiency anemia, including

- Infants and children in families with low incomes
- Infants and children who are eligible for WIC
- Infants and children who are migrants or recently arrived refugees

Selective Screening (Those with Known Risk Factors)

In populations of infants and children not at high risk, screen only those individuals who have known risk factors for iron-deficiency anemia.

Before age 6 months, screen preterm and low-birthweight infants who are fed infant formula that is not fortified with iron.

At 9 to 12 months, and 6 months later (at 15 to 18 months), screen the following:

- Infants born preterm or with low birthweight
- Infants fed non-iron-fortified infant formula for more than 2 months
- Infants fed cow's milk before 12 months of age
- Breastfed infants who do not receive adequate iron from supplemental foods after 6 months of age
- Children who consume more than 24 oz of cow's milk per day
- Children with special health care needs who use medications that interfere with iron absorption (e.g., antacids, calcium, phosphorus, magnesium), or those with chronic infection, inflam-

matory disorders, restricted diets, or extensive blood loss from a wound, an accident, or surgery

At ages 2 to 5 years, annually screen the following:

- Children who consume a diet low in iron
- Children with limited access to food because of poverty or neglect
- Children with special health care needs

Children Ages 5 to 12 and Adolescent Males Ages 12 to 18

Screen only those with known risk factors (e.g., low iron intake, special health care needs, previous diagnosis of iron-deficiency anemia).

Adolescent Males Ages 18 to 21

Adolescents 18 or older should be screened if risk factors are present.

Adolescent Females Ages 12 to 21

Screen annually those with known risk factors (e.g., extensive menstrual or other blood loss, low iron intake, a previous diagnosis of iron-deficiency anemia).

Screen every 5 to 10 years during routine health examinations.

Assessment and Treatment

Low hemoglobin values should be confirmed by a repeat hemoglobin or hematocrit test. This is especially true when screening with capillary samples (fingerstick), because of the reported variability in capillary samples.

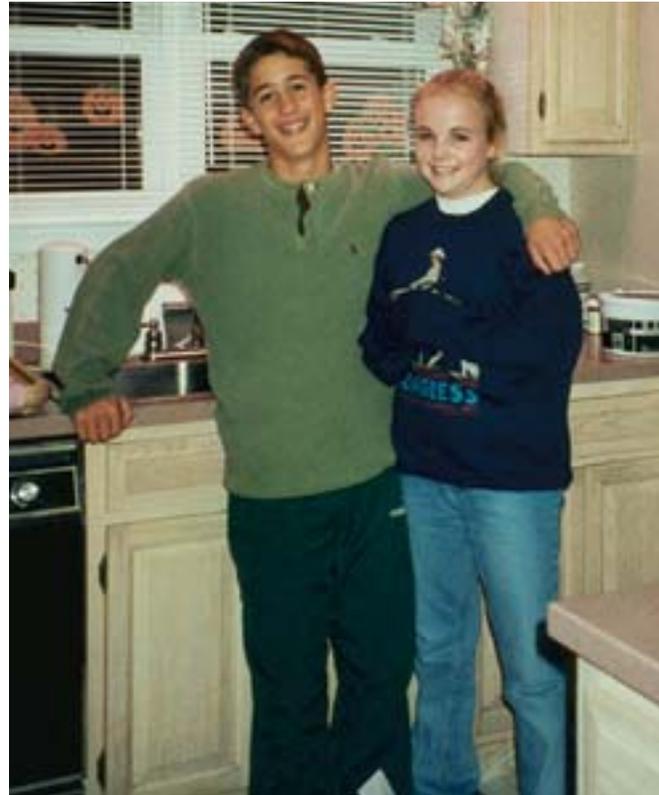
Parents of infants, children, and adolescents should receive information on the treatment of iron-deficiency anemia. Treating iron deficiency involves both iron therapy and improving eating behaviors. After anemia of dietary origin has been treated successfully, recurrence can be prevented with an improved diet.

Iron Therapy

If low hemoglobin is confirmed, the following treatment is recommended:¹

- Infants and children younger than 5 years: 3 mg/kg body weight of elemental iron drops per day
- Children ages 5 to 12 years: one 60-mg elemental iron tablet per day
- Adolescent males ages 12 to 18 years: two 60-mg elemental iron tablets per day
- Adolescent females ages 12 to 18 years: one to two 60-mg elemental iron tablets per day

Iron preparations are absorbed most effectively when taken between meals or at bedtime. If gastrointestinal intolerance (e.g., nausea, cramping, diarrhea, constipation) occurs, iron can be taken with meals. Tolerance may also be improved by using a lower dosage, gradually increasing the dosage, or using a different form (e.g., ferrous gluconate). Since iron absorption occurs primarily in the duodenum, timed-release iron preparations may be less effectively absorbed. Iron preparations should not be taken within 1 hour of substances that may inhibit iron absorption (e.g., dairy products, casein, antacids, calcium supplements, coffee, tea, bran, whole grains). To prevent accidental poisoning, iron preparations should be stored out of the reach of infants and children.



Iron-deficiency anemia can usually be resolved effectively through 6 to 8 weeks of treatment with ferrous sulfate. If the hemoglobin does not respond to iron therapy (increase of 1 g within approximately 1 month), iron deficiency should be confirmed by a serum ferritin determination. Values less than or equal to 15 $\mu\text{g/L}$ in infants older than 6 months, children, and adolescents indicate depleted iron stores. Ferritin values may be falsely elevated when infection or inflammation is present. Serum transferrin-receptor concentration may be a more reliable indicator of iron stores because it is not influenced by chronic infection, inflammation, or disease.^{1,2} To replace iron stores, iron therapy should be continued for an additional 3 months after the hemoglobin has returned to normal (i.e., when serum ferritin is greater than 15 $\mu\text{g/L}$).

Dietary Strategies

Dietary strategies can improve iron status and help prevent recurrence of iron-deficiency anemia.

Iron status can be improved through increased consumption of lean meat, fish, and poultry, which contain heme, an effectively absorbed form of iron from hemoglobin and myoglobin; meat, fish, and poultry also enhance absorption of the less-bioavailable plant sources of iron (e.g., grains, dried peas and beans, spinach).

Sources of vitamin C (e.g., citrus and fortified fruit juices, citrus fruit, strawberries, cantaloupe, green peppers, broccoli, cabbage) taken with meals increase the absorption of nonmeat sources of iron by maintaining the iron in its reduced, more soluble form. The use of highly fortified breakfast cereals can also improve iron intake. Liver is not recommended because of its high cholesterol content and potentially high level of environmental toxins.

Counseling

Primary prevention of iron-deficiency anemia should be achieved through diet. The following general guidelines are based on CDC recommendations for preventing iron-deficiency anemia in infants, children, and adolescents.¹

Infancy

- Breastfeed throughout the first year of life, with exclusive breastfeeding for the first 4 to 6 months (without supplementary liquid, formula, or food).
- When exclusive breastfeeding is stopped, provide a supplemental source of iron (approximately 1 mg/kg body weight per day), preferably from supplementary foods.
- Use iron-fortified infant formula for infants who are not breastfed or who are partially breastfed.
- Provide iron supplement (2 to 4 mg of iron drops per kg body weight per day, not to exceed 15 mg per day) for preterm or low-birthweight breastfed infants, beginning at age 1 month and continuing through age 12 months.
- Encourage use of only breastmilk or iron-fortified infant formula for any milk-based part of the diet and discourage use of low-iron milk (e.g., cow's, goat's, soy) for infants.
- Provide iron-containing foods when exclusive breastfeeding is stopped (e.g., 4 tablespoons [dry measure, before adding milk³] of iron-fortified infant cereal per day).
- Supplement with iron drops (1 mg per kg body weight per day) for breastfed infants who receive insufficient iron from foods by age 6 months.
- Encourage one feeding per day of foods rich in vitamin C by age 6 months.
- Introduce pureed or soft fruits, vegetables, and meats after age 6 months or when the infant is developmentally ready to consume such foods.

Early Childhood, Middle Childhood, and Adolescence

- Children ages 1 to 5 years should consume no more than 24 oz of cow's, goat's, or soy milk per day.
- Include sources of iron-rich foods (e.g., fortified breakfast cereals, meat, fish, poultry) and vitamin C-rich foods (e.g., citrus and fortified fruit juices, citrus fruit, strawberries, cantaloupe, green peppers, broccoli, cabbage) to enhance iron absorption.
- Limit snacks that are low in nutrients.
- Avoid skipping meals or chronic dieting.
- Limit coffee, tea, and colas.

Referral

Referral to a dietitian is helpful in cases of severe or prolonged iron-deficiency anemia. All infants, children, and pregnant or lactating adolescents who are eligible should be referred to WIC. (See Tool J: Nutrition Resources.)

References

1. Centers for Disease Control and Prevention. 1998, April 3. Recommendations to prevent and control iron deficiency in the United States. *Morbidity and Mortality Weekly Report* 47(RR-3):1–29.
2. Cook JD. 1994. Iron-deficiency anaemia. *Bailliere's Clinical Haematology* 7(4):787–804.
3. Fomon SJ, ed. 1993. *Nutrition of Normal Infants*. St. Louis, MO: Mosby-Year Book.