Nutrition and Health Info Sheet:

Iron

For Health Professionals

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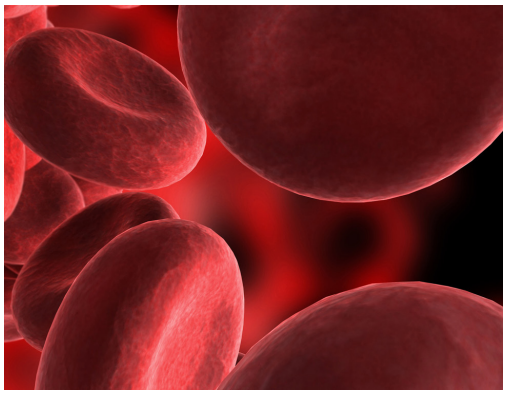
Why is iron important?



Iron is a major component of hemoglobin, a substance that carries oxygen to all parts of the body. Iron also plays a critical role in overall cell function, assisting in oxygen utilization, enzymatic systems, and especially neural development. Thus, all body functions are affected by iron deficiency and not only by anemia, which appears late in the process of tissue iron deficits.

What is iron deficiency?

Iron is found in the body in two forms, as functional iron (serving a metabolic function) and as storage iron. When people have depleted their stores of iron, they are said to be "iron deficient." When the depletion progresses, the hemoglobin concentration in red blood cells falls below the normal range. At this point, a person is classified as having anemia. Iron deficiency can exist with or without anemia, and other nutrient deficiencies besides iron can also lead to anemia.[1,2] Anemia is a general term used to describe inadequate delivery of oxygen to body tissues.

What are the consequences of iron deficiency?

The continuum from iron deficiency to iron deficiency anemia has a host of associated consequences, depending on the severity of iron depletion.

Iron deficiency without anemia has few discernable outcomes but it has been shown to reduce work capacity, particularly in regards to endurance. As iron deficiency progresses to anemia, further consequences become more evident, including changes in behavior and intellectual performance, reduced resistance to infection, increased susceptibility to lead poisoning, loss of appetite, tachycardia, and cardiomegaly.

In young children, prolonged iron deficiency anemia has been associated with motor and cognitive deficits and an inability to concentrate. These symptoms are not always reversed with iron supplementation.

In pregnant women, iron deficiency anemia has been associated with adverse effects for both the mother and fetus, including increased perinatal complications, premature delivery, and low birth weight.

What other nutritional conditions can cause anemia?

- A copper deficiency could result in anemia, as adequate copper intake is needed for the transport of iron throughout the body.
- A riboflavin deficiency, seen most frequently in alcoholics, can contribute to poor iron absorption and utilization, and to a decrease in the oxygen-carrying capacity of red blood cells.
- A vitamin E deficiency can impair the integrity of the red blood cell membrane and lead to hemolytic anemia.
- Deficiencies of other essential nutrients such as vitamins A, C, and B12, folic acid, thiamine, and pyridoxine can also cause anemia.

In what forms is iron found in the diet?

Dietary iron is found in two forms: heme and nonheme iron. Heme iron, comprising about half the iron in red meats, fish, and poultry, is readily absorbed regardless of the other components in a meal. By contrast, nonheme iron is found in both plant and animal sources, is absorbed to a much smaller degree, and is frequently affected by other food constituents.

What are good sources of nonheme iron?

Nonheme iron accounts for more than 85 percent of the iron in the diet. Good sources of it include dried apricots, oatmeal, spinach, pine nuts, beans, and iron-fortified breads and cereals. Although the quantity of iron absorbed from breads and cereals may be low, these sources are eaten in large enough amounts that the iron found in them can be an important portion of daily intake. Other sources of iron are foods that have been cooked in iron cookware.

What affects the absorption of dietary iron?

The amount of iron absorbed by the body depends on its form in food, the body's iron stores, and other factors. Iron absorption can vary significantly from person to person and also from meal to meal: coffee or tea taken with a meal can reduce absorption by as much as 50 percent. Individuals can absorb anywhere from less than 1 percent to more than 50 percent of the iron in their diet.

Dietary factors that can reduce nonheme iron absorption include phytates (found in grains, legumes, and rice); soy protein and soy fiber; oxalates (found in spinach) and tannic acid (found in teas and coffee). Calcium (found in dairy products) can reduce the absorption of both nonheme and heme iron.[2]

In order to maximize iron uptake, foods high in nonheme iron should be eaten at the same time as those that are a good source of vitamin C, such as orange juice, tomatoes, bell peppers, strawberries, cantaloupe, or broccoli. Absorption of nonheme iron can also be enhanced by the presence of heme iron.[2] A stew made with beans, tomatoes, and a small amount of meat, for example, would maximize the iron potential of both the meat and the beans.

What causes iron deficiency?

- Dietary iron intake. The diet may be low in iron or it may contain iron in forms that are poorly absorbed.
- Low iron stores. Body iron stores may be low as a result of rapid growth (this is especially common in young children) or as a result of blood loss. Women are particularly at risk for iron deficiency due to the blood losses associated with pregnancy, childbirth, and menstruation.
- Infant feeding. Infants (newborns up to 12 months) who have been fed cow's milk are more likely to develop iron deficiency than their breastfed counterparts, due to several factors. Iron deficiency may result from intestinal blood loss caused by a reaction to cow's milk. A deficiency can also be attributed to the lower absorption rate of iron from cow's milk as compared with breast milk (10 percent versus 50 percent). Furthermore, breastfed infants have been shown to have larger iron stores than non-breastfed infants.[1,2]

- Dietary calcium intake. High intakes of calcium can inhibit iron absorption if both are present in the same meal. Separating foods high in calcium from those high in iron during meals and snacks may prevent some of this calcium-induced inhibition.
- Low stomach acid. High intakes of antacids, among other factors that can reduce stomach acid production, can impair iron absorption.

How much iron is needed each day?

Several factors influence the body's iron requirement, including iron intake, stores, and loss.[3] The Recommended Dietary Allowance (RDA) for iron for all age groups of men and postmenopausal women is 8 mg/day, and for premenopausal women it is 18 mg/ day. The difference in values between the two groups is primarily related to the need to replace iron losses due to menstruation. Pregnant women require even more iron: 27 mg/day.[2] For children of both sexes between the ages of 6 months and 11 years, the RDA is 11 mg/day.

The typical Western mixed diet can provide only about 6 to 7 mg of iron per 1,000 calories. Because most men consume in excess of 2,000 calories per day, it is not very difficult for them to meet their RDA through diet. Women (and younger children), on the other hand, generally eat less meat and fewer calories, and thus should be particularly careful to include iron-rich foods in their daily diet.

Who is most at risk for iron deficiency?

Young children

Very young children are at particular risk for iron-deficiency anemia due to their rapid growth rate. In addition, children's diets may rely heavily on milk products, which, while providing an excellent source of calcium, are not good sources of iron and can decrease iron absorption from other foods.

Pregnant women

Because adequate intakes of iron are crucial for both the woman and her fetus, the RDA for iron during pregnancy is 27 mg/day. Iron is needed during pregnancy to replace iron lost in the course of daily activities, to allow for the needed expansion of the red blood cell mass, to provide iron to the placenta and fetal bone tissues, and to replace iron lost during delivery.

Vegetarians

Iron deficiency is seen more frequently in those children whose diets do not include meats (even though they may consume eggs or dairy products) as compared to omnivorous children. Care should be taken to ensure that foods containing available iron are included in the diet. In order to compensate for the lower bioavailability of iron in vegetarian diets, iron requirements for vegetarians are 1.8 times higher than those for people consuming a mixed diet.[4]

Women of childbearing age

Between 10 and 25 percent of women of childbearing age have iron deficiency, with prevalence higher among Mexican-American and Non-Hispanic black than Non-Hispanic white women in this group.[5] The EAR for iron is not met by approximately 1 in 6 women, among those taking no iron supplements. Meanwhile, rates are low among those using supplements.[6] Small iron stores coupled with loss of iron due to menstruation place women of childbearing age at risk. The additional requirements during pregnancy make it critical for a woman to ensure sufficient iron stores prior to the pregnancy.

Women with high menstrual losses (menorrhagia)

Menorrhagia (greater than 80 ml per month) occurs in about 10 percent of women and frequently leads to iron-deficiency anemia. Women with menorrhagia are characteristically unaware of their greater-than-normal menstrual blood loss; for this reason, anemia screening at the time of routine health examinations is worthwhile.

Who should be screened for iron deficiency?

Each of the high-risk groups (young children, pregnant women, vegetarians, and women of childbearing age, especially those with high menstrual losses) should be screened at the time of routine health examinations. Additionally, frequent blood donors and those engaging in strenuous activity on a regular basis should discuss anemia screening with their health-care professional.

How is iron deficiency anemia defined clinically?

Iron deficiency anemia may be initially detected through a medical history and/or a physical exam, although the condition will ultimately be determined based on blood tests.

A medical history may be used to determine any previous problems suggestive of iron deficiency, such as prior diagnoses of anemia or low iron status. A dietary assessment method may be used to determine dietary intake of iron. A

physical exam may be conducted to identify clinical signs of iron deficiency anemia. For example, a clinician may look at the color of skin, gums, and nail beds or examine for irregularity of the heartbeat or breathing.

There are several blood tests that can together determine the presence of anemia and its underlying etiology (iron deficiency or another cause). A complete blood count (CBC) may be used to ascertain multiple clinical measurements at once. These include:

- Hemoglobin. Hemoglobin, the oxygen-carrying component of red blood cells, is important in the general diagnosis of anemia. Red blood cells are rich in iron, so low hemoglobin is used to diagnose iron deficiency. However, low hemoglobin can also be the result of other types of anemia, which can be ruled out with additional tests.
- Hematocrit. This measurement describes how much of the total blood volume is made up of red blood cells. Like hemoglobin, low hematocrit levels are used to diagnose anemia, although the cause of that anemia requires further testing.
- Mean corpuscular volume (MCV). This measurement considers the amount of hemoglobin relative to the total number of red blood cells present. This test can be useful in differentiating between different types of anemia. For example, iron deficiency anemia results in smaller "microcytic" red blood cells, which are indicated by a low MCV value. In contrast, some types of anemia, such as B12 deficiency, result in larger "macrocytic" cells.
- Other tests include counts of the number of specific cell types in the blood (red blood cells, white blood cells, platelets). Besides anemia, these tests may be used to determine other diagnoses such as infection.

After determining the absence or presence of anemia, additional blood tests can be used to test whether or not iron deficiency is a cause. Measures of iron levels include:

- Serum iron. This measures the concentration of iron in the blood, but iron levels in the blood can appear normal when iron stores in the body are actually low. Consequently, other measures of iron status should also be examined.
- Serum ferritin. This measures the concentration of ferritin in the blood. Because ferritin is a protein used to store protein, the amount of ferritin in the blood serves a good proxy for iron stores.
- Transferrin. This measures the amount of a carrier protein that transports iron in the blood. Besides transferrin concentration, other related measures are total iron binding capacity (TIBC, a measure of how much iron can be bound to transferrin) and transferrin saturation (a measure of how much iron is bound to transferrin). When iron stores are low, transferrin and TIBC will be elevated while transferrin saturation will be reduced.

When are iron supplements warranted?

The 2015-2020 Dietary Guidelines recommendations include the statement that "women who are pregnant are advised to take an iron supplement when recommended by an obstetrician or health

care provider."[7] Consistent with that the Institute of Medicine recommends the routine consumption of 30 mg of ferrous iron per day beginning at about week 12 of gestation, in conjunction with a well-balanced diet that contains enhancers of iron absorption.

If diagnosed with iron deficiency anemia, a pregnant woman should be treated with 60 to 120 mg of ferrous iron daily until the hemoglobin concentration becomes normal for the stage of gestation; at this point the dosage can be decreased to 30 mg/day.[3]

The diagnosis of iron deficiency at any point in the life cycle warrants an examination of the diet and possible iron supplementation. Common forms of supplementation include ferrous sulfate (20 percent iron by weight), ferrous gluconate (12 percent) and ferrous fumarate (32 percent). The recommended dose depends on the patient's age and the severity of the deficiency. If there are gastrointestinal symptoms with a given dose, the dose can be divided or decreased. However, one dose per day has the advantage of favoring compliance. Older children can be given iron divided into 2 daily doses, ideally on an empty stomach, with water or 100% fruit juice (not milk) to enhance absorption. Rather than supplementing with iron daily during pregnancy, intermittent iron supplementation (1-3 times per week) may be an option; a recent meta-analyses found the risks and benefits of these two approaches were similar, although it called for more studies of higher quality to more rigorously compare these treatments.[8]

Can too much iron be toxic to the body?

Despite the high prevalence of iron deficiency, excessive iron intake is also a source of adverse affects. Iron overload occurs when excess iron is stored in the tissues and is most often due to genetic causes such as hemochromatosis.[5] Adverse effects are usually seen with intakes between 20 and 60 mg/kg, and, depending on the quantity of iron ingested, the cardiovascular system, central nervous system, kidneys, liver, and hematologic system can be affected.

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