

Iron

Physiological Functions

Iron is involved in energy metabolism as an oxygen carrier in hemoglobin and as a structural component of cytochromes in electron transport. Iron is a structural component at the catalytic site of a large number of enzymes covering a wide array of diverse metabolic functions. These include neurotransmitter synthesis and function, phagocyte antimicrobial activity, hepatic detoxification systems, and synthesis of DNA, collagen and bile acids.

Factors Affecting Availability

Dietary iron can be obtained either as heme iron from beef, lamb, pork and poultry or as nonheme iron from vegetables, whole grains, fortified grain products, and supplements. Beef and chicken liver are the richest sources of iron. In general, red meats, e.g., beef, veal, lamb, are richer in iron than white meat, e.g., poultry, fish. Heme iron is more bioavailable than nonheme iron because it is a soluble complex absorbed intact by endocytosis. Nonheme iron may form insoluble complexes in the alkaline medium of the small intestines rendering it unavailable for mucosal uptake. Absorption of nonheme iron also depends on availability of an iron-binding mucosal transport protein (transferrin) to facilitate uptake from the intestines.

Of the two forms of nonheme iron in the diet, the reduced form (ferrous) is more bioavailable than the oxidized form (ferric). On average, 10% of dietary iron is available for mucosal uptake, but the efficiency of absorption can increase three-fold in times of need because of increased synthesis of mucosal iron-binding protein. In addition to increased demand, intestinal absorption of nonheme iron is enhanced in acidic pH and in the presence of free amino acids. Acidic foods such as tomato sauce or orange juice consumed with a nonheme iron food source such as pasta or breakfast cereal will significantly increase the amount of iron absorbed from the meal.

Nonheme iron absorption efficiency may be reduced by use of antacids or high dose calcium supplements. Phytates and oxalates may also decrease bioavailability of nonheme iron. High dose supplements of calcium, zinc,

manganese, magnesium or copper reduce iron absorption through competition for mucosal uptake. Tannic acid in coffee and tea also adversely affects iron absorption. Consumption of coffee or tea one hour before or after consumption of a nonheme iron dietary source can reduce absorption of this mineral by as much as 40%.

Deficiency

Iron deficiency anemia is the most common nutritional deficiency disease worldwide. Inadequate dietary intake and relatively inefficient absorption of iron from low cost sources contribute to poor iron status. Iron is distributed in small amounts in the food supply with an average of 10 mg provided in each 1000 kcal of consumed of a typical American diet. Groups most at risk of iron deficiency are children, pregnant and menstruating women, and repeat blood donors. Blood loss of significant amounts for any reason can also contribute to iron deficiency.

Impairment in energy metabolism and neurological function may occur with depletion of iron reserves even in the absence of hematologically detectable anemia. Uncorrected iron deficiency (> 120 days) will progress to iron-deficiency anemia which is characterized by low hemoglobin levels from lack of sufficient iron for synthesis, and by decreased mean corpuscular volume of red blood cells due to lack of sufficient iron to support growth. Microcytic hypochromic changes must be accompanied by low serum ferritin to confirm that the hematologic changes observed are specific to iron status and not related to either copper or vitamin B₆ status.

Other symptoms of iron deficiency with or without clinically detectable anemia include short attention span, apathy, irritability, hypoactivity, and impaired cognitive development in children. In the adult population, iron deficiency contributes to poor immunocompetence, irregular heart beat, and fatigue. Paleness of oral mucosal tissue, concave pale nail beds, and behavioral changes can also signify the presence of iron deficiency.

Toxicity

Since nonheme iron absorption efficiency decreases with increasing dosage, iron toxicity from consumption of food sources is rare. However, consumption of large amounts of alcohol increases mucosal iron uptake, particularly among individuals with hemochromatosis or who are carriers of this recessive trait which is characterized by failure to regulate iron absorption. Symptoms of this genetic

disorder include chronic fatigue, weight loss, arthritis, mouth pain, heart palpitations and depression.

Iron supplements may be fatal for adults when taken in doses of 200-250 mg/kg from body weight. Iron poisoning may also occur in children who take adult supplements even at low doses. Individuals who receive repeated blood transfusions are most at risk of iron toxicity.

The upper limit of safety for iron established by the Food and Nutrition Board of the Institute of Medicine is approximately 45 mg daily for adults. See table below for more age- and gender specific guidelines.

Iron Tolerable Upper Intake Levels	
Life Stage	Iron (mg/day)
Infants	
0-6 mo	40
7-12 mo	40
Children	
1-3 y	40
4-8 y	40
Males, Females	
9-13 y	40
14-18 y	45
19-70 y	45
70 y	45
Pregnancy	
≤ 18 y	45
19-50 y	45
Lactation	
≤ 18 y	45
19-50 y	45

Requirements

The Daily Reference Intakes (DRI) for iron are shown in the table below.

Iron Requirements	
Daily Reference Intakes	
Life Stage	Iron mg
Infants	
0-6 mo	0.27
7-12 mo	11
Children	
1-3 y	7
4-8 y	10
Males	
9-13 y	8
14-18 y	11
19-30 y	8
31-50 y	8
51-70 y	8
70 y	8
Females	
9-13 y	8
14-18 y	15
19-30 y	18
31-50 y	18
51-70 y	8
70	8
Pregnancy	
18 y	27
19-30 y	27
31-50 y	27
Lactation	
18 y	10
19-30 y	9
31-50 y	9

Dietary Sources

Foods rich in iron include red meats, organ meats, shellfish, pumpkin seeds, sunflower seeds, whole grains, nuts, dried beans, and iron-fortified grain products. See table below for a detailed listing.

Iron Content of Food	
Food	Iron (mg)
Clams, 3.5 oz, steamed	22.0
Oysters, 3.5 oz cooked	8.5

Chicken liver, 3.5 oz cooked	8.5
Pumpkin seeds, _ cup roasted	8.5
Tofu, _ cup	6.7
Beef liver, 3.5 oz cooked	6.3
Oysters, 3.5 oz raw	5.4
Pistachios, _ cup	4.4
Blackstrap molasses, 2 Tbl	3.6
Beef roast, 3.5 oz cooked	3.5
Ground beef, 3 oz, cooked	2.2
Lamb, 3.5 oz cooked	2.2
Unsweetened chocolate, 1 oz	1.8
Raisins, _ cup	1.75
Pinto beans, _ cup canned	1.75
Sunflower seeds, _ cup	1.7
Sweet potatoes, canned, _ cup	1.7
Pasta, 1 cup cooked	1.7
Pumpkin, _ cup cooked	1.7
Baked potato w/skin, _ cup	1.7
Turkey, white meat, 3.5 oz	1.6
Oatmeal, 1 cup cooked	1.6
Spinach, _ cup, cooked	1.4
Tomato juice, 1 cup	1.4
Canned tuna, 3.5 oz	1.3
Green peas, _ cup cooked	1.3