Editorial

MEETING THE IRON NEEDS OF INFANTS AND YOUNG CHILDREN

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Iron deficiency remains a nutritional problem among infants and young children in Saudi Arabia, although at present there is no national data available on infants at low risk. The prevalence of iron deficiency anemia in the USA ranges from 3.5% for those six months of age, to 10.5% for those 18 months of age and 24.3% among infants aged 10 to 14 months in low-income families. At high risk for iron deficiency are preterm infants and infants from a low socioeconomic background. The Canadian Task Force on the Periodic Health Examination recommends that high-risk infants be screened for iron deficiency at nine months of age. Other risk factors include low birthweight, perinatal bleeding, a low hemoglobin concentration at birth, chronic hypoxia, frequent infections, early intake of cow's milk or solid food, or both, frequent and excessive tea intake, low vitamin C or meat intake, breast-feeding for more than six months without supplemental iron, intake of infant formula not fortified with iron for more than four months without other foods, and ethnic practices affecting diet.

Non-hematologic consequences of iron deficiency include poor weight gain, anorexia, irritability, decreased attention span, exercise intolerance and decreased physical activity. A recent study of iron deficiency anemia and psychomotor development concluded that when iron deficiency progresses to anemia, performance on developmental tests is adversely affected for up to at least three months, despite correction of the anemia with iron therapy. Some of these abnormalities may persist indefinitely among infants with severe or chronic iron deficiency, despite adequate iron therapy. The relation between iron deficiency and behavioral development has been the subject of a recent international conference.

Infant feeding patterns have undergone some notable changes since the mid-1970s. Fewer mothers are breast-feeding and those that do usually breast-feed for less than six months. Fewer mothers introduce solid foods before four months or unmodified cow's milk before six months. However, these changes have not occurred in all parts of Saudi Arabia, and whether they will continue is unknown.

Iron requirements vary for term and newborn infants. Newborn term infants have approximately 75 mg/kg of body iron, 75% of which is in the form of hemoglobin. On average, infants almost triple their blood volume during the first year of life and will require the absorption of 0.4 to 0.6 mg of iron daily during that time to maintain adequate stores. Premature infants have a lower level of body iron at birth, approximately 64 mg in infants weighing 1 kg. The loss of blood drawn for laboratory tests and the rapid rate of postnatal growth lead to a higher requirement for dietary iron than in term infants—2.0 to 2.5 mg/kg daily—in order to prevent late anemia.

In the normal infant born at term, iron stores are adequate to maintain iron sufficiency for approximately four months of postnatal growth. In the premature infant, total-body iron is lower than in the full-term newborn. Iron deficiency can develop by two to three months of age in premature infants.

Assuming that 10% of the iron in a mixed diet is absorbed, the recommended iron intake is approximately 7 mg/d for term infants aged 5 to 12 months, 6 mg/d for toddlers aged 1 to 3 years and 8 mg/d for children aged four to 12 years.

There is a large difference in amounts and absorption of iron from various dietary sources. One litre of human milk contains 0.3 to 0.5 mg of iron. About 50% of the iron is absorbed, in contrast to a much smaller proportion from other foods. Term infants who are breast-fed exclusively for the first six months may not be at risk for iron depletion or for the development of iron deficiency. However, if solid foods are given they may compromise the bioavailability of iron from human milk. Although some term infants who are exclusively breast-fed may remain iron-sufficient until nine months of age, a source of dietary iron is recommended starting at six months (or earlier if solid foods are introduced into the diet) to reduce the risk of iron deficiency.

Infant formulas based on cow's milk contain 1.0 to 1.5 mg of iron per litre; soy-based formula and iron-fortified formula based on cow's milk contain 12 to 13 mg of iron per litre. The absorption of iron from breast milk is uniquely high in about 50% of cases on average, and tends to compensate for its low concentration of iron, while in contrast only 10% of the iron in whole cow's milk is absorbed. About 4% of the iron is absorbed from iron-fortified cow's milk formula that contains 12 mg of iron

TABLE 1. *Iron requirements for a normal infant during the first year of life.*

Characteristic	At birth	At 1 year
Weight (kg)	3.0	10
Hemoglobin (g/dL)	17.0	11.0
Blood volume (mL/kg)	90.0	75.0
Total blood volume (mL)	270.0	750.0
Total body hemoglobin (g)	47.9	82.5
Iron in hemoglobin (mg)	162.8	280.5
Iron in tissue (7 mg/kg)	21.0	70.0
Stored iron (10 mg/kg)	30.0	100.0
Total body iron	213.8	450.0
Total yearly iron losses*	—	47.0
Exogenous iron requirement (mg)	—	283.0
Daily iron requirement (mg)	—	0.78

*At a rate of 20 mg per kilogram of body weight per day.

per litre. The reasons for the high bioavailability of iron in breast milk are unknown, although it appears that the high concentrations of calcium, phosphorous, and protein in conjunction with the low concentration of ascorbic acid, are responsible, in part, for the poor absorption of iron from cow's milk. The iron source of fortified formulas is ferrous sulfate, which is significantly more available than the iron used in infant cereals. The availability of iron from soy-based formulas appears to be lower than that from milk-based products. The optimal amount of iron in formulas based on cow's milk remains to be determined. Formulas in North America contain higher amounts of iron than those suggested in the United Kingdom (1.0 mg/100 kcal) and France (1.5 mg/100 kcal).

Breast-feeding remains the best source of nutrition for newborns and infants. Mothers should be encouraged to practice breast-feeding, as long as there is no contraindication, for at least six months. Hospital personnel involved with pregnant mothers should counsel the mothers about the benefits of breast-feeding and try to identify the reasons behind any lack of interest in breast-feeding.

Term infants who are exclusively breast-fed do not need supplemental iron until they are six months of age. If solid foods are introduced earlier they should contain an adequate amount of iron. After six months of age breast-fed infants should receive extra iron in the form of iron-fortified infant cereals and other iron-rich foods. These infants should be offered an iron-fortified infant formula after they have been weaned from breast milk.

Term infants who are not breast-fed should be given an iron-fortified infant formula from birth. Studies are still under way to determine the optimal iron content of these formulas, and further studies are encouraged. Until the results are known the use of currently available iron-fortified formulas seems appropriate. After four to six months of age iron-fortified infant cereals provide a good additional source of iron.

For premature infants an iron supplement should be started by at least eight weeks of age and continued until the first birthday. Iron-fortified formula for bottle-fed infants and commercial iron drops for breast-fed infants are the recommended source of supplemental iron.

Cow's milk should not be introduced until an adequate amount of solid food containing iron and vitamin C is included in the diet, preferably at 12 months of age.

For children over one year of age, the recommended daily nutrient intake of iron should be given. Iron-containing foods such as meats, some vegetables, legumes, fruits and iron-fortified infant or toddler cereals provide iron in sufficient amounts. Supplemental iron is not required unless the diet is lacking in these foods.

Caution should be practiced in adding iron to formula or diet in infants with family history of hematologic problems, for example, thalassemia, hemolytic anemia or children who require multiple blood transfusions for various medical reasons. Low-iron formulas have no defined role in infant feeding except in those babies whose condition could lead to a state of iron overload.

In conclusion, breast-feeding remains the optimal means of providing nutrition for the infant. If this is not feasible, then iron-fortified formulas are recommended for all formula-fed infants. There is no justification for the use of low-iron formulas in infant feeding.

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