

Iron status in breast-fed infants

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Iron status of 30 infants who had been breast fed until their first birthday and who had never received cow milk, medicinal iron, or iron-enriched formula and cereals was investigated; 30% were anemic at 12 months of age. The duration of exclusive breast-feeding was significantly longer among nonanemic infants (6.5 vs 5.5 months). None of the infants who were exclusively breast fed for 7 months or more and 43% of those who were breast fed for a shorter time were anemic. Infants who were exclusively breast fed for a prolonged period had a good iron status at 12 and 24 months. (J PEDIATR 1995;127:429-31)

Because of common feeding practices, studies of iron status in breast-fed infants have examined infants who were exclusively breast fed for 6 months and who thereafter received solid foods or other types of milk.¹⁻³ The presence of other foods in the diet may compromise the unique bioavailability of iron in human milk,⁴ and the prevalence of iron deficiency anemia among such infants has been reported to be between 20% and 30%.^{1,2} This high frequency of anemia represents the reason for the recommendation that breast-fed infants receive iron supplementation.⁵ It remains to be explained why some infants remain iron sufficient longer than others; factors such as growth rate, iron content of solid foods, and age at introduction of cow milk have been suggested as affecting iron status at 1 year.^{3,6} No study has investigated the iron status of infants who had received human milk as the only milk during the first 12 months of life and who had not been fed other foods containing iron. The objective of this study was to evaluate the iron status of such infants.

METHODS

Fifty-five term infants whose weight was appropriate for gestational age and who were born at the University of Naples Department of Obstetrics were selected for the study

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when they were 6 months of age. All the mothers attending our well-baby clinic during 1992 were enrolled if they expressed the intent to breast-feed for a prolonged time. Only infants who met the following criteria were eligible: birth weight more than 2.5 kg, singleton birth, no congenital malformations, no perinatal disease, no cesarean section, no delayed cord clamping, human milk as the only milk, and no iron supplementation of any type. The infants were visited monthly by two of us, and the mothers were advised to use standard spoons or scales for preparing solid foods. Among the 55 infants, 20 received medicinal iron or iron-enriched cereals from their private pediatricians, and 5 stopped breast-feeding and were introduced to cow milk before they were 12 months of age. These 25 infants were excluded from the study. Thus 30 infants who were breast fed until their first birthday without receiving either other milk or medicinal iron, iron-fortified formula, or cereals represented our study group.

At each visit, the infant's diet on the previous day and the weight, length, and head circumference were recorded. Iron status was determined at the ages of 12 and 24 months by request of our ethics committee, which did not authorize a determination at 6 months because the iron status of breast-fed infants is usually satisfactory at this age.⁷ A 3 ml blood sample was drawn from a superficial vein of the forearm with the use of sterile vacuum tubes. Hemoglobin concentration, mean corpuscular volume, and cell count were measured in a Coulter counter (Coulter Electronics, Hialeah, Fla.), and serum ferritin measurements were performed by radioimmunoassay. Iron intake from solid foods was calculated from

Table I. Background characteristics and iron status of 30 infants at 12 months

Characteristic	Anemic (Hb <110 gm/L) (n = 9)	Nonanemic (Hb ≥110 gm/L) (n = 21)
Mean age in months (SD)	11.6 (1.1)	11.6 (1.0)
Maternal schooling		
<8 yr, No. (%)	4 (44)	10 (48)
≥8 yr, No. (%)	5 (56)	11 (52)
Birth weight, kg (SD)	3.240 (372)	3.383 (479)
Mean weight, kg (SD)	9.880 (673)	9.770 (1010)
Mean length, cm (SD)	74.5 (1.5)	74.6 (2.3)
Mean weight gain from birth, kg (SD)	6.420 (856)	6.626 (1.500)
Duration of exclusive breast-feeding, mo (SD)	5.5 (0.5)	6.5 (1.2)*
Mean intake of iron (mg/day) from solid foods (SD)	1.95 (0.75)	2.4 (0.87)
Heme iron as % (SD) of daily iron intake	39 (19)	34 (16)
Serum ferritin, µg/L (SD)	15.4 (15.6)	13.6 (12.3)

Hb, Hemoglobin.

* $t = -2.4$; $df = 28$; $p = 0.024$.**Table II.** Influence of dietary factors on iron status at 12 months

	Exclusive breast-feeding for ≥7 mo (n = 9)	Exclusive breast-feeding for <7 mo (n = 21)
Hb concentration, gm/L (SD)	11.7 (0.4)	10.9 (0.7)*
No. (%) of Hb concentration <110 gm/L	0 (0)	9 (43)
Mean serum ferritin, µg/L (SD)	17 (15)	12.3 (11.7)
No. (%) with serum ferritin level <10 µg/L	2 (22)	11 (52)
No. (%) with Hb >110 gm/L and serum ferritin level >10 µg/L	7 (78)	10 (48)

Hb, Hemoglobin.

* $t = 3.2$; $df = 28$; $p = 0.003$.

standard food-composition tables or according to the manufacturer's information.

At 24 months of age, a second iron-status determination was performed in 20 of the 30 children who had not received any iron supplementation between the ages of 12 and 23 months. Nine infants who were treated with ferrous sulfate because of a hemoglobin concentration less than 110 gm/L at 12 months and one infant whose parents had moved were excluded.

In this study an infant was defined as exclusively breast fed when he or she received only human milk without any other fluid or beikost.

RESULTS

Among the 30 infants, 21 (70%) had a hemoglobin concentration of 110 gm/L or more and 9 (30%) of less than 110 gm/L at 12 months. Serum ferritin levels were greater than or equal to 10 µg/L in 17 infants (57%) and less than 10 µg/L in 13 infants; 6 of the 9 anemic infants were also iron deficient. There were no significant differences between anemic and nonanemic infants in socioeconomic level of the families, in age, in birth weight, in weight and length at the age of 1 year, in mean weight increase from birth, in serum fer-

ritin levels, and in the mean daily consumption of total and of heme iron (Table I). The duration of exclusive breast-feeding in nonanemic infants was 6.5 months (SD = 1.2) and in anemic infants was 5.5 months (SD = 0.5): $t = -2.4$, $df = 28$, $p = 0.024$. Among the infants who had been exclusively breast fed for at least 7 months ($n = 9$; mean duration of exclusive breast-feeding, 7.67 months; SD = 0.87, range, 7 to 9 months), none had a hemoglobin concentration of less than 110 gm/L: the mean hemoglobin concentration was 117 gm/L (SD = 4.3), and the range was 110 to 122 gm/L. Among the infants who had been given other feedings before the age of 7 months ($n = 21$; mean duration of exclusive breast-feeding, 5.6 months; SD = 0.59; range, 4 to 6 months), 9 (43%) were anemic; the mean hemoglobin concentration was 109 gm/L (SD = 7), and the range, 99 to 127 gm/L. Serum ferritin and the prevalence of ferritin levels less than 10 µg/L were not different between these two groups of infants (Table II). Maternal education and the consumption of foods containing iron, soft cheese, and ascorbic acid were not different for the nine infants who had been exclusively breast fed for a prolonged period compared with those of the others.

Among the 20 infants whose iron status was examined at

24 months of age, only one had a hemoglobin concentration lower than the concentration at 12 months (106 vs 115 gm/L). Overall, hemoglobin concentration remained constant: 117 gm/L (SD = 4) at 12 months and 118 gm/L (SD = 5) at 24 months; serum ferritin levels also did not change significantly: 16.7 µg/L (SD = 15) at 12 months and 14 µg/L (SD = 11) at 24 months.

DISCUSSION

These data confirm the high prevalence of anemia and of iron deficiency among infants breast fed during the first year of life when the diet is not supplemented with medicinal iron or with iron-enriched formula or cereals. The infants enrolled in this study were unique for two reasons: (1) they had received only human milk and no other types of milk until their first birthday and (2) they had not received any iron supplementation during this same period. They were not a representative sample of the general infant population, because they were breast fed for an unusually long time, but the data are helpful in understanding the role of some risk factors for iron deficiency anemia when cow milk and iron supplements are not present in the diet. Our data indicate that only 1 additional month of exclusive breast-feeding reduces the risk of anemia. Several explanations are possible for our findings that infants exclusively breast fed for 7 months or longer have a better iron status than those who start receiving other foods at an earlier age. It seems unlikely from our data that mothers who breast-fed for prolonged periods also fed foods with higher iron content or bioavailability or both. It could be that infants who started receiving other foods at an earlier age consumed more foods that contain inhibitors of iron absorption; we did not find significant differences in consumption of soft cheese, but a more accurate dietary investigation might detect a more frequent use of other inhibitors of iron absorption. Another possible explanation is that human milk may enhance iron availability from other foods, even if the presence of other foods in the diet may compromise the high bioavailability of human milk iron.^{4, 8, 9} Mothers who breast-feed for prolonged periods may have socioeconomic characteristics that can be associated with a reduced risk of anemia for their infants; nonetheless, this is not the case for the mothers enrolled in this study. Finally, it is possible that the concentration of iron in milk of the mothers who breast-fed for a prolonged period or the iron stores at birth of their infants were higher,⁶ but we have no data to answer these questions.

The high prevalence of iron deficiency anemia among breast-fed infants is the reason for the current policy of giving iron to breast-fed infants after the fourth month of life.

When the duration of exclusive breast-feeding was not taken into account, our infants had a high prevalence of iron deficiency and of anemia very similar to that of infants recently studied in Argentina.¹ However, among those who had been exclusively breast fed for 7 months or longer, anemia was absent, even if iron stores were low in about 20% of cases. Thus future studies should consider the duration of exclusive breast-feeding as an important variable. Hemoglobin and serum ferritin concentrations at 12 and 24 months of age did not significantly change in the absence of any iron supplementation; thus, among nonanemic infants, iron status at 12 months seemed to predict iron status at 24 months.

Infants who are exclusively breast fed for a prolonged time represent a very small proportion of all infants. For this reason, the current policy of iron supplementation in breast-fed infants should not be questioned. Nonetheless, there are populations, mainly in developing countries, in which breast-feeding is common and iron supplementation is not available or culturally acceptable. With the process of urbanization, these populations are gradually losing the breast-feeding tradition and are then being exposed to the risk of iron deficiency anemia and infection. A policy supporting prolonged and exclusive breast-feeding among these populations could be important from a public health point of view and could represent an effective measure to ensure normal iron status.

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