

Exclusive breast-feeding for 9 months: Risk of iron deficiency

Thirty-six infants who were exclusively breast-fed were observed for 9 months. Thirty-two infants who were completely weaned prior to age 3½ months served as controls; these infants received iron supplementation in formula and solid foods. A great majority of exclusively breast-fed infants were able to maintain their iron status at the same level as that of the control infants. The mean concentration of hemoglobin was higher in breast-fed infants than in control infants at ages 4 and 6 months. However, six breast-fed infants required iron medication because they had laboratory evidence of iron deficiency, although none had anemia. Maternal iron supplementation during breast-feeding, even in large daily doses, did not have any effect on the infants' iron nutrition, nor prevent infants from developing some signs of iron deficiency. Our data indicate that it is safe in exclusively breast-fed infants to shift the starting age for introduction of iron to 6 months. (J PEDIATR 104:196, 1984)

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THE CONCENTRATION OF IRON IN HUMAN MILK is much lower than in mixed foods and tends to decrease further during lactation.¹ On the other hand, the absorption of iron from human milk, both in adults² and in 6-month-old healthy infants,³ is usually effective. The mechanism of iron absorption from human milk seems to be complicated.^{4,5} Introduction of solid foods may impair the bioavailability of iron in human milk.^{6,7}

Some studies indicate that breast-feeding may prevent or decrease the risk of iron deficiency, so that routine iron supplementation may not be necessary before 6 months of age.⁸ Breast-fed infants may also have a higher concentration of hemoglobin if they are given supplemental iron, compared with similarly supplemented formula-fed infants.⁹ These data have been obtained when solid foods have been given together with human milk or when no specific attention has been paid to the quality or quantity of solid foods.

We have assessed the risk of iron deficiency in healthy

full-term infants receiving no other food than human milk up to the age of 9 months. This age was selected because prolonged more or less exclusive breast-feeding is practiced by many mothers in the hope of improving health or preventing diseases in their infants.

SUBJECTS

We observed a group of 198 infants for 1 year. They were born at the Helsinki University Central Hospital between June and December 1981. The criteria for selection were as follows: (1) healthy, nonsmoking mother, with uncomplicated pregnancy and delivery; (2) full-term infant (37 to 42 weeks gestation), singleton, appropriate for gestational age, with Apgar score ≥ 8 at 1 minute and no evidence of disease by the third day of life; and (3) an adequate sample of cord blood.

Mothers were encouraged to breast-feed exclusively as long as possible during our follow-up at ages 0, 2, 4, 6, 7½ (exclusively breast-fed), and 9 months. This resulted in 169 infants who were exclusively breast-fed for 3 months, 116 infants for 6 months, 71 infants for 7½ months, and 36 infants for 9 months. We focus particularly on the 36 infants breast-fed for 9 months.

Those 32 infants who were completely weaned prior to age 3½ months, at a mean age of 63 days, served as controls. These infants were fed according to present

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recommendations: formula up to 9 months (obtained from Valio Co., Helsinki), fruit and vegetables from 3 to 3½ months, and cereal and meat dinners from 5 to 6 months. The two groups were comparable with respect to duration of gestation, sex ratio, birth weight, and maternal age.

Iron supplementation of infants. The exclusively breast-fed infants were given no iron supplementation. In contrast, the controls received supplementation in formula (6 mg iron per liter) and wheat cereal (40 mg/kg).

Maternal iron supplementation. The breast-feeding mothers were randomized to receive either 66 or 266 mg iron per day, divided into two doses. The supplementation was started 5 days after delivery and continued through the period of lactation. Regular checks during the visits showed that the compliance was excellent. Maternal mean (\pm SEM) concentration of hemoglobin was 14.1 ± 0.13 gm/dl in the 36 breast-feeding mothers at 9 months of lactation. None of the mothers had any evidence of iron deficiency by mean corpuscular volume, serum iron, transferrin, or ferritin determinations. The dose of iron did not influence the concentration of hemoglobin, but the mean concentrations of serum ferritin and serum iron were 39 (34 to 45) $\mu\text{g/L}$ and 98 ± 8 $\mu\text{g/dl}$, respectively, in the mothers receiving the lower supplementation dose, and 76 (67 to 87) $\mu\text{g/L}$ ($P = 0.0013$) and 127 ± 5 $\mu\text{g/dl}$ ($P = 0.003$) in those receiving the higher dose.

METHODS

At each visit, venous blood was drawn for determination of hemoglobin, red blood cell counts, and indices by Coulter Counter, and for serum iron,¹⁰ transferrin,¹¹ and ferritin determinations.¹² All results were analyzed by Honeywell computer, using a BMDP program,¹³ for statistical calculations and drawings. The calculations for serum ferritin were performed after log transformation.¹²

Criteria for anemia and iron deficiency, and initiation of iron medication. We used a concentration of hemoglobin <10.5 gm/dl as the criterion for anemia from 6 to 9 months of age. The respective limits were 70 fl for MCV, 55 $\mu\text{g/dl}$ for serum iron concentration, 375 $\mu\text{g/dl}$ for total iron-binding capacity, 10% for transferrin iron saturation, and 10 $\mu\text{g/L}$ for serum ferritin. Iron medication was initiated if four of these six criteria were present.

RESULTS

None of the exclusively breast-fed infants had any evidence of anemia or iron deficiency prior to age 6 months. Indeed, the concentration of hemoglobin remained higher in the breast-fed infants than in controls at 4 ($P = 0.009$) and 6 months ($P = 0.02$). The mean values were similar at 2 and 9 months (Fig. 1).

At age 6 months, three of the six laboratory criteria of

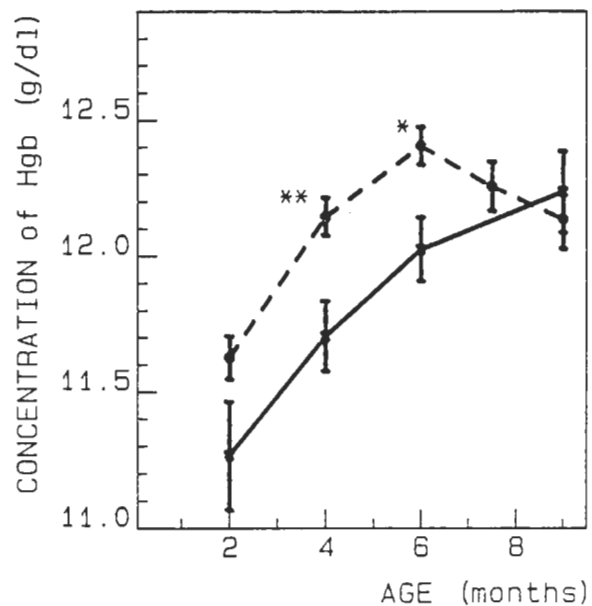


Fig. 1. Concentration of hemoglobin in exclusively breast-fed infants (dashed line) and in control subjects. * $P < 0.05$; ** $P < 0.01$.

iron deficiency were present in nine exclusively breast-fed infants (8%). One infant met four such criteria, and iron medication was started. At age 7½ months, five of those nine infants met the criteria for initiation of iron medication. Three of the infants, who had started to receive solid foods between ages 6 and 7½ months, had less evidence of iron deficiency. One of the infants continued exclusive breast-feeding up to age 9 months and did not require iron medication. At age 9 months, one additional infant had four criteria of iron deficiency, and iron medication was begun. Three infants had three criteria of iron deficiency.

In none of the six infants who received iron medication did pretherapy laboratory values indicate anemia; the lowest recorded concentration of hemoglobin was 10.6 gm/dl. However, in all of the infants, all individual hemoglobin values had decreased from the earlier levels; the mean decrease was 0.4 gm/dl, with a range from 0.1 to 1.2 gm/dl. Only one of the six infants had reticulocytosis ($>2\%$) from 10 to 14 days after initiation of iron medication. In four of the infants, the concentration of hemoglobin rose >0.5 gm/dl during 1 month of iron therapy.

The lowest concentration of hemoglobin in the controls at age ≥ 6 months was 10.7 gm/dl. One control infant had serum ferritin concentration <10 $\mu\text{g/L}$, but the values for MCV and serum transferrin were normal. Two infants had transferrin iron saturation $<10\%$, but no infant had $<7\%$.

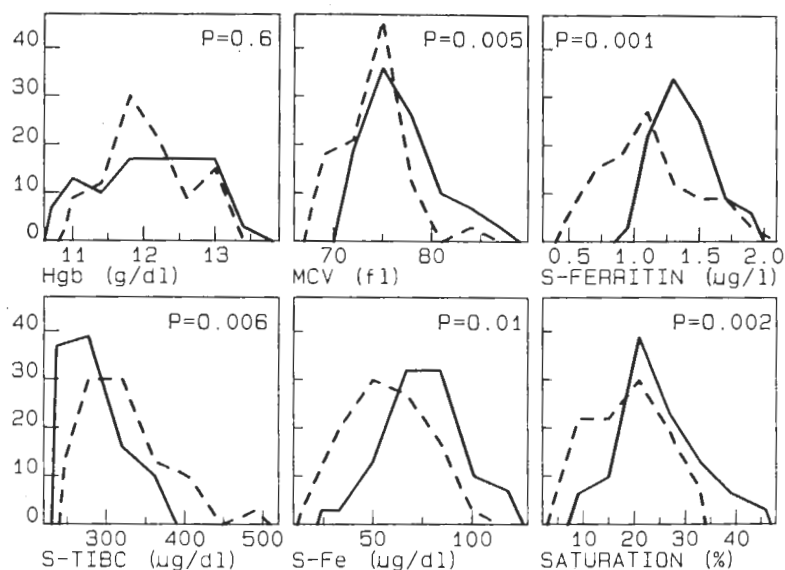


Fig. 2. Distribution of values of several laboratory studies in exclusively breast-fed infants (dashed line) and in controls at age 9 months. Concentration of serum ferritin in logarithmic values.

Table. Iron status according to laboratory values in exclusively breast-fed and in control infants at 9 months

	Breast-fed (n = 33)	Controls (n = 31)	Breast-fed (n = 16)	Breast-fed (n = 20)
Maternal iron dose (mg/day) †	66 to 266		66	266
Age (mo)	9	9	7½	7½
Hemoglobin (gm/dl)	12.1 ± 0.1	12.2 ± 0.1	12.1 ± 0.2	12.1 ± 0.1
MCV	75 ± 0.6	78.0 ± 0.7*	74.0 ± 0.6	76.0 ± 1.2
MCH	26.3 ± 0.3	27.3 ± 0.2*	26.0 ± 0.4	26.8 ± 0.4
Serum iron (μg/dl)	62.0 ± 4.0	77.0 ± 4.0†	54.0 ± 5.0	67.0 ± 5.0
TIBC (μg/dl)	335.0 ± 11.0	296.0 ± 7.0	33.0 ± 15.0	325.0 ± 9.0
Iron saturation (%)	19.0 ± 1.0	26.0 ± 2.0*	16.0 ± 2.0	21.0 ± 2.0
Serum ferritin (μg/L)				
Mean	15	27*	26	27
Range	13 to 17	24 to 29	22 to 30	23 to 32

Two groups of breast-fed infants differing in dose of maternal iron supplementation are also compared, using values at age 7½ months. These values include those of six infants given iron medication between ages 7½ and 9 months.

Data expressed as mean ± SEM (after log transformation for ferritin).

MCH, Mean corpuscular hemoglobin; MCV, mean corpuscular volume; TIBC, total iron-binding capacity.

*P < 0.01, compared with control values.

†P < 0.05.

At age 9 months, the distribution of the laboratory values in exclusively breast-fed infants without iron medication had shifted left (right in the case of total iron-binding capacity), except for hemoglobin (Fig. 2). The differences in the mean values from those of the control subjects were significant (Table).

The degree of maternal iron supplementation during breast-feeding had no influence on the iron status of their infants (Table). The mothers of four of the six infants in whom iron medication was started had received the higher level of iron supplementation.

DISCUSSION

Limited data are available on the iron status of infants who have been exclusively breast-fed beyond 6 months. McMillan et al.² reported their findings in four infants in the United States who were exclusively breast-fed for about 11 months. They found that all four infants had normal hemoglobin concentration, normal serum iron concentration, normal serum transferrin iron saturation, and normal erythrocyte protoporphyrin values, even though the infants had not, according to their history, received any supplemental or medicinal iron.² Pastel et al.¹⁴

obtained blood samples from seven healthy infants in the Peruvian Andes. The infants had been exclusively breast-fed for 7½ to 12 months. None had received supplemental water or iron prior to examination. The authors were unable to study hemoglobin concentration or red blood cell indices. They compared the serum ferritin and erythrocyte protoporphyrin values with those obtained from United States infants fed a variety of diets, with or without iron supplementation, and found the values similar in the two groups. These studies suggest that exclusive breast-feeding is sufficient to maintain adequate iron nutrition for most, if not all, of the first year of life. This is an important conclusion with practical implications for large populations of infants, both in industrialized and nonindustrialized countries. However, this conclusion is based on direct and indirect evidence obtained from a total of 11 infants.

Our results indicate that a great majority of exclusively breast-fed infants are able to maintain their iron status at the same level as that of control infants receiving iron supplements. Probably the most important finding was that we could not demonstrate any anemia in infants after exclusive breast-feeding for 9 months. However, detailed analysis of the data showed a shift of the distribution of the other laboratory criteria toward lower values, and indicates that the risk of developing iron deficiency, although relatively small at 9 months, increases as exclusive breast-feeding is prolonged. Nevertheless, six infants were given iron, because we considered that they showed enough evidence of iron deficiency. Later analysis of their data indicated that probably five, or even fewer, had iron deficiency as indicated by reticulocytosis or an increase in concentration of hemoglobin within the normal range after initiation of iron medication. Thus our results agree with the above conclusions that iron status is well maintained during prolonged exclusive breast-feeding, even when no iron supplementation is used. This may be related to effective availability of human milk iron^{3,6,9} or to decreased gastrointestinal tract loss of iron under these conditions; the latter possibility is not supported by any direct evidence.

Our findings indicate that maternal iron supplementation during breast-feeding, even in large daily doses, did not have any effect on the infants' iron nutrition nor prevent infants from developing some signs of iron deficiency. This observation is in accord with a recent study¹⁵ in which the authors found no correlation between iron concentration in human milk and maternal iron stores.

Fomon and Strauss¹⁶ have recommended iron supplementation in breast-fed infants from an early age, even for full-term infants. Our data indicate that it is safe, in

exclusively breast-fed infants, to shift the starting age for iron supplementation to 6 months, or even older. Some earlier data also suggest that, on average, iron sufficiency may be reduced in infants given solid food.^{6,7} Thus iron supplementation may be needed somewhat earlier in breast-fed infants given solid foods.

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