Iron status in breast-fed full-term infants

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The aim of this study was to evaluate the iron status of full-term babies breast-fed exclusively for four months and the importance of iron supplementation.

One hundred sixteen term infants followed up since the newborn period by a well baby clinic were included in the study. Iron deficient and/or anemic infants were excluded from the study at four months. Some of the infants (51) were later given appropriate complementary food besides breast-feeding (Group A) and some (42) were given ferrous sulfate (1 mg/kg/d) (Group B). Blood count and serum iron and ferritin measurements were done at four and six months of age.

At the 4th month, iron deficiency was found in 23 (19.8%) infants, 11 of which had iron deficiency anemia. At the 6th month, 23 (45%) infants in Group A were iron deficient and 11 (21.6%) of them had iron deficiency anemia. In Group B, three (7.1%) infants were iron deficient and one (2.4%) of them also had iron deficiency anemia ($p < 0.0001$).

Significant iron deficiency and iron deficiency anemia have been found in four-month-old exclusively breast-fed full-term infants. It is observed that complementary food alone is insufficient; there is need for iron supplementation.

Key words: iron deficiency anemia, exclusive breast feeding, full-term infant, iron supplementation.

Iron deficiency anemia (IDA) is a common problem, especially in developing countries[1-3]. Usually in infants, iron deficiency anemia is seen between the 6th-24th months. It may occur for the following reasons: reduction of iron stores accummulated by the infant from the mother during intrauterine life by active transportation after the first months of life, foods unsupplemented with iron or intake of foods impairing iron absorption and increase in iron requirement during the rapid growth of the infant, and iron deficiency due to blood loss[4]. Iron deficiency (ID) and iron deficiency anemia may cause growth and development retardation and psychomotr disorders. Thus, prophylactic management and treatment have gained importance; however, the initial time of iron supplementation is controversial[5-7].

Breast milk contains small amounts of iron. Since its bioavailability is high, breast-feeding is important in prevention of iron deficiency anemia in early infancy. What remains controversial, however, is for how long exclusive breast-feeding is sufficient in meeting the nutritional requirements of an infant[1,8,9].

We designed this study in our well baby unit to evaluate the iron status of term infants who were followed from birth and were exclusively breast-fed for four months and to determine whether, after four months, iron supplementation is beneficial or not.

Material and Methods

One hundred and sixteen full-term infants born at the Department of Obstetrics of Cerrahpaşa Medical Faculty of İstanbul University and followed up between February-August 1997 at the Social Pediatrics Unit of the Pediatric Hospital were included in the study. All of them were exclusively breast-fed for four months. All of the infants were over 2500 g at birth. There was no perinatal or postnatal problem (i.e., no major congenital anomalies, no hemorrhage, transfusion, delayed cord clamping or infection).

None of the mothers had hypertension, chronic diseases, preeclampsia, or ablatio placentae. The families were informed about the study and their consent obtained. At the 4th month venous blood was drawn. Hemogram was done by cell counter analysis method (Coulter Micro Diff 18, Miami, USA). Serum iron (SI) and total iron binding capacity (TIBC) were measured by the colorimetric method (Iron/TIBC Reagent set-pointer Scientific Inc.). Serum ferritin (SF) was measured by radioimmunoassay method (Active™ Ferritin, Diagnostic Systems Laboratories-3000, Inc., USA).

Hemoglobin (Hb) < 9.5 g/dl, mean corpuscular volume (MCV) < 74 fl and SF < 12 ng/ml were the criteria for iron deficiency anemia. Hb > 9.5 g/dl and SF < 12 ng/ml were considered as iron deficiency[10].

Ferrous sulfate (6 mg/kg/d) was started in infants having these parameters and they were removed from the study. After the 4th infants (51) with even registration numbers were given complementary food besides breast-feeding (Group A). The other infants (42) with odd registration numbers were given ferrous sulfate (1 mg/kg/d) besides complementary food and breast-feeding (Group B). The infants of both groups were fed the same complementary foods in similar volumes following one week intervals. A cup of fruit juice (100 cc apple or carrot) has 0.1-0.3 mg elementary Fe, a cup of yogurt (150 g) has 0.15 mg elementary Fe and a plate of vegetable puree has 0.5-0.7 mg elementary Fe. At the 6th month, a venous blood sample was drawn and all parameters determined at the 4th month were repeated. Hb < 11 g/dl, MCV < 70 fl and SF < 12 ng/ml were accepted as iron deficiency anemia and Hb > 11 g/dl with SF < 12 ng/ml were accepted as iron deficiency[10,11].

Chi-square (χ^2) test, Student's-t test and paired and unpaired t test for statistical analysis were performed using statistical program of SPSS for Windows for 6.1.

Results

Fifty-eight of 116 infants included in the study were male and 58 were female. Educational status of their mothers was as follows: 16.8 percent literate or primary school graduate, 60.1 percent secondary school graduate, 23.1 percent university graduate; 0.7 percent of the families were in the lower income group, 95.8 percent were in the middle and 3.5 percent were in the higher income group.

Demographic features and hematological values of the infants are shown in Table I.

Table I. Demographic Characteristics and Hematological Findings at 4th Month

Number (n)	116	Hb (g/dl)	10.1 (0.7)*
Girls	58	Hct (%)	30.0 (1.9)*
Boys	58	MCV (fl)	77.6 (3.2)*
Mother's age (y)		RDW (%)	14.6 (0.8)
Range	19-37	SI (µg/dl)	39.1 (15.4)*
Mean (SD)	27.7 (4.4)	SF (ng/dl)	29.3 (18.2)*
Birth weight (g)		TIBC (µg/dl)	349.2 (52.6)
Range	2510-4400	Iron deficiency	23 (19.8)**
Mean (SD)	3299.2 (405.9)	Iron deficiency anemia	11 (9.5)**
Four-month weight (g)			
Range	5900-9750		
Mean (SD)	7138.5 (676.8)		

* Mean (SD).
** Numbers in parentheses represent percentages.
Hb: hemoglobin; Hct: hematocrit; MCV: mean corpuscular volume; RDW: red blood cell distribution width; SI: serum iron; SF: Serum ferritin; TIBC: total iron binding capacity.

Evaluation of Infants at 4th Month: The distribution of age was 118-124 days (mean 122.6) at the time of examination. Iron deficiency was found in 23 (19.8%) of the 116 infants and iron deficiency anemia in 11 (95%) of these. There was a significant correlation between the educational level of the mothers and iron deficiency/iron deficiency anemia ($p = 0.015$). While nine infants (37.5%) of the 24 literate or primary school graduate mothers were iron deficient and five (20.8%) had iron deficiency anemia, just one infant (2.03%) of the 33 university graduate mothers was iron deficient. Iron deficiency anemia was more frequent in the lower income group ($p = 0.01$). No significant correlation was determined between the hematological values (serum iron, serum ferritin, total iron binding capacity, mean corpuscular volume, hemoglobin, red cell distribution witdth), birth weight, four-month weight and age of mother ($p > 0.05$).

Evaluation of Infants at 6th Month: 51 of the 93 infants remaining in the study were classified as Group A and 42 infants as Group B. The distribution of age was 179-184 days

(mean 182.2) and 179-186 days (mean 182.8) in Groups A and B, respectively. There was no significant difference between the mother's age, the distribution of age, the educational status of the mothers, income level of the families, birth weight and four-month weight within the two groups ($p > 0.05$). However, the mean weight of infants at six months in Group B was higher than in Group A ($p = 0.018$). Iron deficiency was found in 23 (45%) infants and iron deficiency anemia in 11 of the 23 infants (21.6%) in Group A. In Group B, deficiency was found in three (7.1%) infants and iron deficiency anemia in 1 (2.4%) of those.

Hemoglobin, hematocrit, mean corpuscular volume, serum iron and serum ferritin in Group were higher than in Group A ($p < 0.0001$). Red cell distribution width (RDW) and total iron binding capacity were higher in Group A ($p < 0.01$, $p = 0.005$, respectively). Hematological values at the 6th month are shown in Table II.

Evaluation of Groups at the 4th and 6th Month: In the 6th month, hemoglobin (Hb) and hematocrit (Hct) values when compared to those at the 4th month were not significant in Group A ($p > 0.05$). Mean corpuscular volume, serum iron and serum ferritin values at the 6th month, were significantly decreased ($p < 0.0001$, $p = 0.29$, $p < 0.0001$, respectively). In Group B at the 6th month, hemoglobin, hematocrit, serum iron and serum frritin when compared to the 4th month were significantly increased ($p < 0.0001$, $p < 0.0001$, $p = 0.001$, $p = 0.002$, respectively).

Hemotological values at the 4th and 6th month are shown in Table III.

Table III. Hematological Findings of Groups at 4th Month and 6th Month

		4th Month*	6th Month*	p
Group A (n = 51)	Hb (g/dl)	10.2 (0.5)	10.5 (1.0)	> 0.05
	Hct (%)	30.6 (0.8)	30.7 (2.9)	> 0.05
	MCV (fl)	78.7 (2.8)	74.7 (3.9)	< 0.0001
	RDW (%)	14.5 (0.8)	15.3 (0.8)	> 0.05
	SI (µg/dl)	42.6 (12.7)	37.0 (12.7)	0.029
	SF (ng/dl)	35.0 (19.2)	16.6 (9.2)	< 0.0001
	TIBC (µg/dl)	331.0 (51.2)	370.3 (46.2)	< 0.0001
Group B (n = 42)	Hb (g/dl)	10.3 (0.5)	11.6 (0.8)	< 0.0001
	Hct (%)	30.6 (1.9)	33.2 (2.3)	< 0.0001
	MCV (fl)	77.9 (2.7)	77.7 (2.4)	> 0.05
	RDW (%)	14.7 (0.8)	14.1 (0.7)	> 0.05
	SI (µg/dl)	40.9 (18.3)	61.3 (29.9)	0.001
	SF (ng/dl)	33.6 (13.3)	49.9 (29.1)	0.002
	TIBC (µg/dl)	347.5 (48.2)	350.0 (58.4)	> 0.05

* Mean (SD).

Hb: hemoglobin; Hct: hematocrit; MCV: mean corpuscular volume; RDW: red blood cell distribution width; SI: serum iron; SF: Serum ferritin; TIBC: total iron binding capacity.

Discussion

Iron deficiency and iron deficiency anemia are more common in developing countries[12,13]. A study in our country performed among infants who were breast-fed for the first four months, who took appropriate complementary food but no iron supplementation after four months and who were followed up until the end of the first year determined iron deficiency in 13.9 percent of cases[14]. It is reported that anemia in pregnancy may affect the infant's iron stores negatively even though active transportation of iron is peresnt. Hussain et al.[15] and Singla et al.[16] reported that cord blood hemoglobin, hematocrit, serum ferritin and serum iron values are low in infants of anemic mothers in comparison to infants of mothers without anemia. Tekinalp et

Table II. Heatological Findings of Groups at 6th Month

	Group A	Group B		Group A*	Group B*	p
Number (n)	51	42	Hb (g/dl)	10.5 (1.0)	11.6 (0.8)	< 0.0001
Girls	26	24	Hct (%)	30.7 (2.9)	33.2 (2.3)	< 0.0001
Boys	25	18	MCV (fl)	74.7 (3.9)	77.7 (2.4)	< 0.0001
Iron deficiency n (%)	23 (45)	3 (7.1)	RDW (%)	15.3 (0.8)	14.1 (0.7)	< 0.001
			SI (µg/dl)	37.0 (12.7)	61.3 (29.9)	< 0.0001
Iron deficiency anemia n (%)	11 (21.6)	1 (2.4)	SF (ng/dl)	16.6 (9.2)	49.9 (29.1)	< 0.0001
			TIBC (µg/dl)	370.3 (46.2)	350.0 (58.4)	< 0.005

* Mean (SD).

Hb: hemoglobin; Hct: hematocrit; MCV: mean corpuscular volume; RDW: red blood cell distribution width; SI: serum iron; SF: serum ferritin; TIBC: total iron binding capacity.

al.[17] found positive correlation between maternal and neonatal iron stores. In our study, we did not find gestational and postnatal maternal hematological values. We also did not determine how much and for how long iron supplementation was taken by pregnant women, even though obstetricans suggest it in Turkey. In one study[18], iron deficiency during pregnancy was found to be 51 percent. However, we still believe that iron deficiency and iron deficiency anemia in infants at the 4th month which persist at the 6th month in spite of appropriate complementary food are a result of deficient stores because of gestational anemia. In Turkey, there is no iron-supplemented food product aside from formula, so complementary foods cannot prevent iron deficiency.

Even though breast-feeding is an ideal source of nutrition and its low iron content has a high bioavailability, for how long it is sufficient in meeting the iron requirement of infants is controversial. McMillian et al.[19] and Saarinen[20] reported that breast-feeding until the 6th month does not result in anemia, while Garry et al.[9], Duncan et al.[8] and Kim et al[21]. stressed the need for supplementary iron at six months. Calvo et al.[1] found anemia in 27.8 percent of the 9th month breast-fed infants, but 7.1 percent of the anemic had taken iron-fortified formulas which thus suggested iron supplementation after four months. While Pizarra et al.[22] suggested iron supplementation at the 6th month for infants who were exclusively breast-fed for nine months, Pisacane et al.[23] found no anemia in infants who were exclusively breast-fed for seven months or more. The American Academy of Pediatrics Nutritional Committee has suggested 1 mg/kg/d iron supplementation in full-term infants starting after the 4th month of life[6]. In fact, in our stduy the rates of iron deficiency and iron deficiency anemia were low (7.1% and 2.4%, respectively) in infants given supplementary iron after the 4th month (Group B).

If complementary food is given to infants before the 6th month, it will affect iron absorption in human milk negatively. Thus, it is believed human milk is enough for the first six months[20,22]. However, in most countries, exclusive breast-feeding is not done for long because of urbanization, traditional events and educational failure regarding the importance of human milk, etc. The percentage of exclusively breast-fed infants in the first three months is 14 percent in Turkey[24]. In our unit, this percentage is 40 percent despite intensive efforts to educate mothers. After the 4th month we give complementary food in addition to breast-feeding in our wall baby unit. All of the infants were fed the same complementary food. None of the infants included in this study were exclusively breast-fed or given bovine milk or formula after the 4th month.

In conclusion, in our study iron deficiency and iron deficiency anemia in infants exclusively breast-fed for the first four months were found to be higher when compared to previous reports. We think this was caused by gestational anemia, even though we did not know the iron status or hematological values of the mothers. Persistence of iron deficiency and iron deficiency anemia even after appropriate complementary food raised the need for supplementary iron in full-term infants. Since it is obvious that gestational anemia contributes to a great extent to anemia in early infancy, iron supplementation in pregnancy and exclusive breast-feeding for the first six months must be suggested in developing countries. However, when the iron status in mothers is not known and complementary foods are begun at the 4th month (as in most countries), it is more suitable to give iron supplementation at the 4th month and preferably, even before.

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