

Randomized, Placebo-Controlled Trial of Iron Supplementation in Infants With Low Hemoglobin Levels Fed Iron-Fortified Formula

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ABSTRACT. In spite of the declining prevalence of iron-deficiency anemia, a large proportion of low-income infants have "low-normal" (11–11.5 g/dL) and "low" (< 11 g/dL) hemoglobin (Hgb) values. Because most of these infants are fed iron-fortified formulas, it was of interest whether additional iron supplementation would enhance Hgb values. A cohort of 334 healthy, inner-city, minority, 6-month-old infants, fed iron-fortified formulas, with Hgb values ranging from 9 to 11.5 g/dL, participated in a double-blind, randomized, placebo-controlled trial of supplemental iron at 0, 3, and 6 mg/kg per day for 3 months. Hemoglobin values increased significantly with age, regardless of assignment to placebo or supplemental iron (means for the entire cohort: 6 months 10.9 g/dL, 8 months 11.2, 10 months 11.3, and 12 months 11.4). The proportion of "responders" (Hgb level increased ≥ 1 g/dL) was 34% and did not differ significantly by placebo or iron dose. There were no significant differences in mean corpuscular volume or levels of erythrocyte porphyrins or serum ferritin between treatment groups. The implications of this clinical trial are twofold: (1) screening healthy infants fed iron-fortified formula at the age of 6 months is not justified, regardless of socioeconomic status; (2) the clinical practice of routinely treating low-income, "low-Hgb" infants with iron supplementation, without regard to dietary considerations, is unwarranted. *Pediatrics* 1991;88:320–326, hemoglobin level, iron-deficiency anemia, infant formula, iron supplementation.

ABBREVIATIONS. WIC, Special Supplemental Food Program for Women, Infants and Children; Hgb, hemoglobin; FERR, ferritin; EP, erythrocyte porphyrin; MCV, mean corpuscular volume.

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Several recent surveys have documented a decline in the prevalence of childhood anemia in the United States.^{1–4} These changes probably result from improvements in iron nutrition during infancy: breast-feeding has become more popular, iron-fortified formulas essentially replaced cow's milk, and the bioavailability of iron in cereals has improved.^{5,6} Public health programs have facilitated these improvements in iron nutrition among low-income children. In particular, the Special Supplemental Food Program for Women, Infants and Children (WIC), initiated in 1973, had been credited with a major contribution.^{1,2,7}

Despite the decline in anemia, a large percentage of low-income infants have low hemoglobin (Hgb) values, as defined by standards endorsed by the American Academy of Pediatrics and the Centers for Disease Control.^{8,9} In a recent Centers for Disease Control nationwide survey among 1 million children participating in public health programs, 15.9% of children 0.5 to 2 years of age had a Hgb level <11 g/dL.¹⁰ A high prevalence of low Hgb levels was also found in our population of low-income minority infants.¹¹

Low Hgb values among low-income infants are considered a reflection of dietary iron deficiency.¹² In the second National Health and Nutrition Examination Survey, 1- to 2-year-old children in families below the poverty level had three times greater risk of iron deficiency than those above the poverty level (20.6% and 6.7%).¹⁰ Likewise, in the Centers for Disease Control 1975 to 1985 survey, anemia correlated with socioeconomic status, with children of low socioeconomic status having the highest prevalence.⁴ Participation in the WIC program was associated with reduced prevalence of anemia and

improved iron nutrition in each socioeconomic status group.^{7,13}

In clinical practice, the assumption that low-income infants are at risk for iron-deficiency anemia generally overrides individual dietary considerations. When a low-income infant is found to have a low Hgb value, practitioners are inclined to give supplemental iron, inasmuch as it has been advocated that only Hgb response (≥ 1 g/dL) to a therapeutic trial of iron confirms the diagnosis of iron deficiency.¹⁴ In studies in 1-year-old children, 28% of those with low-normal Hgb values (11 to 11.5 g/dL) and 48% with low Hgb values (< 11 g/dL) showed a response to iron.¹⁵ Although earlier studies reported that infants with iron-deficiency anemia showed Hgb response when treated only with iron-fortified formula,^{16,17} supplemental oral ferrous sulfate at 3 or 6 mg/kg per day is the most common treatment approach.^{14,18}

Implementing this therapeutic strategy nationally entails administering supplemental iron to thousands of low-income infants, most of whom participate in the WIC program and are fed iron-fortified formulas. It is estimated that one in three infants in the United States is a WIC recipient (*New York Times*, June 30, 1990:1, 9) and, consequently, is screened for anemia every 6 months. Therefore, a determination whether iron supplementation beyond that provided by the diet actually improves the hematologic outcome in low-income infants with low-normal and low Hgb values is relevant to clinical and public health considerations. Our study addresses this question.

METHODS

Design

A randomized, double-blind, placebo-controlled trial of iron supplementation at 0, 3, and 6 mg/kg per day was initiated in a cohort of 334 6-month-old healthy, low-income, minority infants, fed iron-fortified formulas, with venous Hgb values ranging from 9 to 11.5 g/dL. Infants were followed up for a period of 6 months.

Subjects

Between April 1985 and May 1987, 719 unselected 6-month-old (± 1 month) infants were screened for anemia at the time of their well-baby visit to a faculty practice at a teaching hospital in New York City. Ferritin (FERR) and erythrocyte porphyrin (EP) values were measured in 75% of cases. The mean Hgb value in the 719 infants was 11.5 g/dL, standard deviation (SD) 0.9.¹¹ We found 396 infants (55%) to have a Hgb value ≤ 11.5 g/dL

(mean Hgb level 10.9 g/dL, SD 0.5). Twenty of these infants (5%) (mean Hgb level 10.8 g/dL, SD 0.7) were excluded on the basis of predetermined health and dietary criteria: prematurity (< 32 weeks) (9), milk allergy (1), failure to thrive and human immunodeficiency virus seropositivity (1), recent *Haemophilus influenzae* type b meningitis (1), fed low-iron formulas (2), breast-fed exclusively (5), and primary physician refusal (1). Of the 376 eligible infants, the parents of 42 (11%) refused participation in the clinical trial (mean Hgb level 10.9 g/dL, SD 0.5). The demographic characteristics of these infants (sex, race, public assistance, WIC) were comparable with those of the randomized infants, except for Medicaid (refused 67%, randomized 88%, $P < .001$).

Clinical Trial

The remaining 334 infants were randomly assigned in a double-blind fashion to one of three groups: placebo ($n = 106$), ferrous sulfate at 3 mg/kg per day ($n = 111$), and ferrous sulfate at 6 mg/kg per day ($n = 117$), for 3 months (hereafter referred to as Fe0, Fe3, Fe6 groups). Iron dosage was based on an estimated weight of 7500 g at 6 months of age; the average actual weight was 7950 g, SD 1002 g (no significant differences between groups). Parents were instructed to give one drop per three times a day, before meals, and to continue feeding their infants iron-fortified formula throughout the study. Mead Johnson provided the study medication in identical, coded bottles and found both ferrous sulfate supplements to have adequate potency at two times during the study period.

We scheduled three visits during the following 6 months. The mean age of the infants at entry into the trial was 6.3, SD 0.7 months; 7.9 months, SD 1.4 at the first follow-up visit; 10 months, SD 1.4 at the second visit; and 12.6 months, SD 1.2 at the third visit (no differences between groups). Of the entry cohort, 72% came for the 8-months visit, 68% for the 10-months visit, and 62% for the 12-months visit (no significant differences between groups). Thirty-one patients (9%) entered the study but never returned (10, 12, and 9 in the Fe0, Fe3, Fe6 groups); their Hgb, mean corpuscular volume (MCV), EP, and FERR values were similar to those of the entire cohort at baseline. Follow-up data refer to all patients who were randomized and returned for at least one of the follow-up visits.

Data Collection

Parents were interviewed at each visit regarding socioeconomic, health, and dietary characteristics.

An attempt to have mothers return the medication bottles resulted in too few to analyze. Compliance was measured by parental report at each follow-up visit; mothers were asked when they administered the medicine, how much they gave, how many bottles were left, and the amount left in each bottle.

Laboratory Procedures

Blood samples were collected by venipuncture, following standard practice at the hospital; in an estimated 5% of cases, samples were capillary because of refusal or unsuccessful venipuncture. Hemoglobin concentration and red blood cell indices were measured in the Coulter counter; EP was determined by chemical extraction¹⁹ and FERR by radioimmunoassay (Ramco kit).

Statistical Analysis

The SPSS and SAS statistical packages were used. Chi-square calculation of goodness of fit was used for dichotomous variables; analysis of variance was used for continuous variables. Multivariate analysis of variance was performed to control for interactions and effects of variables. This study has a statistical power of $>.99$ to find a Hgb outcome difference of 0.5 g/dL or more between the treatment groups ($\alpha = .05$).

RESULTS

Baseline Characteristics

The baseline demographic, perinatal, and dietary characteristics of the infants were comparable and no statistically significant differences were found between the three groups (Table 1). The majority of the infants were Afro-American black and Hispanic (primarily Dominican descent, including various racial backgrounds).

Nearly half the infants were breast-fed during the first 2 months of age, in most cases supplemented by formula. Five percent ($n = 14$) of the infants were fed a combination of iron-fortified formula (12 mg/L) and cow's milk (mean age of introduction to cow's milk: 5 months). Cereal, juice, and pureed foods were started in most infants at 3 months.

Compliance, Side Effects, and Diet

No significant differences were found in compliance, side effects attributed to the study medication, or intake of some other iron medication, among the three groups (Table 2). Serial reports of compliance were consistent over time, with the exception of two mothers who reported more med-

ication left at the last visit than that reported at a previous visit. Using parental report of how much medication was left in the bottle, 61% reported administering all; 35%, half or more; 4%, less than half; and 2%, none. Overall, 25% of the parents attributed side effects to the study medication. A total of 16%, 21%, and 26% of the infants in the Fe0, Fe3, and Fe6 groups, respectively, received some other iron medication during the study period.

Parents largely complied with the instruction to continue iron-fortified formula. At 8 months of age, 94% of the infants were still fed iron-fortified formula, and at 10 months of age, 82%. By the 12-months visit, 28% were still fed iron-fortified formula and 72% had switched to cow's milk (no significant differences between groups).

Laboratory Values at Outcome of the Study

The overall Hgb value for the cohort at 6 months of age was 10.9 g/dL, SD 0.5. The Hgb level increased 0.5 g/dL over the study period to a mean of 11.4 g/dL, SD 0.8 at 12 months of age. There were no significant differences in Hgb level found between the Fe0, Fe3, and Fe6 groups during the 6 months of the study (Table 3).

The baseline MCV value (78, SD 5) was comparable in the three treatment groups (Table 3). Four percent of the infants had a baseline MCV <70 (4, 7, and 4 in the Fe0, Fe3, Fe6 groups). The MCV values remained almost unchanged throughout the 6 months of the study and no differences were evident by treatment group, regardless of the initial MCV value.

The mean FERR value at entry into the study was 32 (Table 4). Four percent (10/252) of the infants had a baseline FERR value <10 (2, 5, and 3 in the Fe0, Fe3, Fe6 groups). Analysis of variance did not demonstrate a treatment effect in the mean FERR values nor a significant change during the study. At the 12-months visit 3, 4, and 3 infants in the Fe0, Fe3, and Fe6 groups had FERR values <10 .

Mean EP values were similar in the three treatment groups at baseline. Twenty-four percent (60/252) of the infants had a baseline EP value >35 (21, 16, and 23 in the Fe0, Fe3, and Fe6 groups). The EP values evidenced a decreasing trend over time in the three groups, although the trend was not statistically significant (Table 4). No differences due to treatment with iron were demonstrated throughout the study.

Multivariate analysis of variance was conducted including the following variables: Hgb, MCV, FERR, EP, visit number, age, and treatment group. Because multivariate analysis of variance is an

TABLE 1. Baseline Characteristics of the Infants: Percentage in Each Treatment Group*

Characteristic	Placebo (n = 106)	Fe3 (n = 111)	Fe6 (n = 117)
Demographic			
Male	48	49	55
Afro-American	34	35	22
Hispanic	63	65	74
Premature birth (≥ 32 wk)	3	5	6
Medicaid	83	92	90
WIC	82	88	81
Hgb electrophoresis			
Abnormal	7	5	5
Unknown	8	10	3
Dietary			
Breast-fed	40	51	48
Iron-fortified formula	100	100	100
Milk-based	74	81	79
Soy-based	26	19	21
Cow's milk	7	5	2
Cereal, juice, pureed food	95	97	97
Vitamins with iron	16	21	26

* There were no significant differences among the groups. Abnormal hemoglobin (Hgb) as reported by the New York State Newborn Screening Program: AS (n = 12), AC (n = 5), AF (n = 1), AD (n = 1). Infants in Fe3 group were given ferrous sulfate, 3 mg/kg per day for 3 months; infants in Fe6 group were given ferrous sulfate, 6 mg/kg per day for 3 months. WIC, Special Supplemental Food Program for Women, Infants and Children.

TABLE 2. Medication: Compliance and Side Effects*

	Placebo	Fe3	Fe6
Compliance			
100%	60%	65%	58%
$\geq 50\%$	36%	32%	38%
$< 50\%$	2%	3%	4%
0%	2%	0%	0%
Side effects†			
No. of patients/group (%)	20/90 (22)	19/97 (16)	34/105 (32)
No. of reported instances			
Vomiting	0	3	3
Diarrhea	13	6	14
Constipation	6	6	14
Teeth stains	2	1	1
Abdominal pain	0	1	0
Other	1	2	2

* Treatment groups are described in the footnote to Table 1. There were no significant differences among the groups.

† Some patients reported more than one side effect.

analysis of repeated measures, only patients who completed all follow-up visits were included (44, 47, and 39 in the Fe0, Fe3, and Fe6 groups). Multivariate analysis of variance demonstrated only one significant finding: Hgb level rose in each group over time. The three treatment groups showed no significant differences in Hgb, EP, or FERR value.

Because the study included infants with Hgb values ranging between 9 and 11.5 g/dL, we considered it possible that the infants with the low-normal Hgb values (11 to 11.5 g/dL) may have masked a true effect of iron supplementation results. Therefore, the analysis of variance was repeated using

only the 162 infants with low Hgb levels (< 11 g/dL) at entry (50, 58 and 54 infants in the Fe0, Fe3, and Fe6 groups). The hematologic outcome in these infants was comparable with that of the entire cohort: Hgb level increased over time, regardless of the dose of iron (Table 5). Similarly, MCV, EP, and FERR values did not show a dose effect.

There were no significant differences in the proportion of responders (infants with increase in Hgb value ≥ 1 g/dL by the 8- or 10-months visit) between the placebo and the iron supplementation groups (Table 6). Overall, 34% of the infants showed an increase in Hgb level ≥ 1 g/dL; the lower the initial

TABLE 3. Red Blood Cell Characteristics at Entry and Follow-up*

	Age at Visit (mo)			
	6	8	10	12
Total n	334	240	226	208
Mean Hgb				
Placebo	10.9	11.1	11.3	11.5
Fe3	10.9	11.2	11.4	11.4
Fe6	10.9	11.2	11.3	11.4
MCV				
Placebo	78	77	77	77
Fe3	78	78	78	79
Fe6	78	78	78	78

* Treatment groups are described in the footnote to Table 1. There were no significant differences among the groups. Hgb, hemoglobin (g/dL); MCV, mean corpuscular volume (FL).

TABLE 4. Serum Ferritin (FERR) and Erythrocyte Porphyrin (EP) Levels at Entry and Follow-up*

	Age at Visit (mo)			
	6	8	10	12
Total n	252	189	168	144
Mean FERR				
Placebo	29	33	27	28
Fe3	31	36	31	31
Fe6	36	39	33	29
Mean EP				
Placebo	32	31	28	30
Fe3	29	28	26	25
Fe6	31	30	30	25

* Treatment groups are described in the footnote to Table 1. There were no significant differences among the groups. FERR, ng/mL; EP, μ g/dL.

TABLE 5. Hemoglobin (Hgb) and Ferritin (FERR) Values at Entry and Follow-up: Subgroup of Patients With Entry Hgb Values <11 g/dL*

	Age at Visit (mo)			
	6	8	10	12
Total n	162	116	114	112
Mean Hgb				
Placebo	10.5	10.7	11.0	11.3
Fe3	10.5	10.9	11.1	11.2
Fe6	10.3	10.9	11.0	11.2
Total n	117	89	82	76
Mean FERR				
Placebo	32	38	29	31
Fe3	33	36	28	25
Fe6	38	33	29	32

* Treatment groups are described in the footnote to Table 1. There were no significant differences among the groups.

TABLE 6. "Responders": Patients with Increase in Hemoglobin (Hgb) Value ≥ 1 g/dL by 10 Months of Age*

	Responders	
	Total	Entry Hgb <10.5
Placebo	31/84 (37%)	10/18 (56%)
Fe3	29/90 (32%)	13/18 (72%)
Fe6	33/103 (32%)	9/22 (41%)
Total	93/277 (34%)	32/58 (55%)

* Treatment groups are described in the footnote to Table 1. There were no significant differences among the groups.

Hgb value, the higher the proportion of responders, regardless of group assignment. Twenty-five percent of the infants with low-normal Hgb values (11 to 11.5 g/dL) were responders, compared with 40% with low Hgb values (<11 g/dL). Among the infants with baseline Hgb values <10.5 , overall 55% were responders: 56% in Fe0, 72% in Fe3, and 41% in Fe6 (average for Fe3 and Fe6: 55%). Although the sample size may be too small to detect differences, no iron dose-response pattern was observed.

DISCUSSION

The results of this randomized, double-blind, placebo-controlled trial indicate that in this cohort of 6-month-old, low-income, minority infants followed up for 6 months, iron in a diet including iron-fortified formula proved adequate to ensure maximum Hgb levels. Iron supplementation with ferrous sulfate, at the doses of 3 or 6 mg/kg per day, for 3 months did not lead to improved Hgb levels over placebo. The Hgb values increased with age, a developmental phenomenon not modified by additional iron supplementation beyond that provided by the diet. Furthermore, the number of responders—infants whose Hgb level increased ≥ 1 g/dL—was similar, regardless of assignment to placebo or iron.

In interpreting the results of this trial, it should be noted that compliance was measured by parental report. Lack of biologic validation is an inherent weakness in this type of methodology, shared with other trials of iron supplementation.^{15,20-23} In addition, although trial eligibility was determined on a single Hgb measurement and repeated sampling may have excluded some participants, this does not affect the study outcome because patients were randomly assigned to the three treatment groups. Finally, our results relate solely to the effect of iron supplementation on hematologic outcome in infants fed iron-fortified diets and other studies are required to assess the impact of iron supplementation on other organ systems.

In this cohort of low-income infants fed diets including iron-fortified formulas, Hgb level increased from 10.9 g/dL at 6 months to 11.4 g/dL at 12 months, regardless of assignment to placebo or iron supplementation at 3 mg/kg per day or 6 mg/kg per day. Lack of effect on Hgb levels with additional iron supplementation may be explained by the adequacy of iron intake in the infants' diet. Two nutritional studies found 6- to 12-month-old infants fed diets including iron-fortified formulas had a daily iron intake of 20 mg, a value exceeding the 10 mg recommended daily allowance.²⁴⁻²⁶ Infants participating in the WIC program had a similar iron intake.¹³

We found comparable rates of responders to those reported in the literature. In uncontrolled studies conducted by Driggers et al,¹⁵ 28% of 1-year-old infants with Hgb values 11 to 11.5 g/dL and 48% with Hgb values <11 g/dL were responders to iron supplementation; in our trial 25% and 40% of the infants at the same Hgb levels were responders. In a subsequent controlled trial, Reeves et al²² reported similar responses to placebo or iron supplementation in healthy 1-year-olds previously fed iron-fortified formulas, although concurrent intake of dietary iron was not reported. In our cohort of 6-month-old infants fed diets including iron-fortified formulas, there was no response benefit derived from iron supplementation.

Ferritin levels have been reported by Tunnessen and Oski²⁷ to be normal in 99% of the infants fed iron-fortified formulas during the first year of life. In our cohort, baseline mean FERR levels were normal and remained relatively unchanged throughout the study, regardless of iron dose. The iron dose that will cause a FERR increment in nontransfused, healthy children is not known.²⁸ In spite of normal FERR levels at this age, iron stores may be marginal and the iron doses administered may meet the erythropoietic requirements at a time of rapid developmental growth of the red cell mass but may not cause an increase in FERR levels. Alternatively, the absorption of iron and homeostasis of FERR in infants may be closely regulated and require higher dosages than those administered in this clinical trial to show an iron dose effect on FERR level.

The clinical and public health implications of this clinical trial are relevant both to clinicians and WIC policy planners.²⁹ Screening healthy infants receiving iron-fortified formula at the age of 6 months is not justified, regardless of socioeconomic status. WIC age requirements for screening infants should be changed accordingly. In addition, the clinical practice of routinely treating low-income, "low-Hgb" infants with iron supplementation,

without regard to dietary considerations, is unwarranted, provided the infants continue to receive diets including iron-fortified formulas after 6 months of age.

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REFERENCES

1. Miller V, Swaney S, Deinard A. Impact of the WIC program on the iron status of infants. *Pediatrics*. 1985;75:100-105
2. Vazquez-Seoane P, Windom R, Pearson HA. Disappearance of iron-deficiency anemia in a high-risk infant population given supplemental iron. *N Engl J Med*. 1985;313:1239-1240
3. Yip R, Walsh KM, Goldfarb MG, Binkin NJ. Declining childhood anemia prevalence in a middle-class setting: a pediatric success story? *Pediatrics*. 1987;80:330-334
4. Yip R, Binkin NJ, Fleshood L, Trowbridge FL. Declining prevalence of anemia among low-income children in the United States. *JAMA*. 1987;258:1619-1623
5. Martinez GA, Krieger FW. 1984 Milk-feeding patterns in the United States. *Pediatrics*. 1985;76:1004-1008
6. Rees JM, Monsen ER, Merrill JE. Iron fortification of infants foods. *Clin Pediatr (Phila)*. 1985;24:707-710
7. Yip R, Binkin NJ, Fleshood L, Trowbridge FL. Does WIC improve the health outcomes of low income children? An evaluation based on Tennessee-linked WIC and birth data. *Am J Clin Nutr*. 1987;45:841. Abstract
8. Committee on Nutrition, American Academy of Pediatrics. Iron deficiency. In: *Pediatric Nutrition Handbook*. 2nd ed. Elk Grove Village, IL: American Academy of Pediatrics; 1985:213-220
9. CDC. Criteria for anemia in children and childbearing-age women. *MMWR*. 1989;38:400-404
10. Yip R. Iron nutritional status defined. In: Filer LJ Jr, ed. *Dietary Iron: Birth to Two Years*. New York, NY: Raven Press; 1989:19-36
11. Irigoyen M, Davidson LL, Seaman C. Hemoglobin norms for minority inner city infants. *AJDC*. 1990;144:442. Abstract
12. Yip R. The changing characteristics of childhood iron nutritional status in the United States. In: Filer LJ Jr, ed. *Dietary Iron: Birth to Two Years*. New York, NY: Raven Press; 1989:37-56
13. Rush D, Leighton J, Sloan NL, et al. National WIC evaluation, VI: study of infants and children. *Am J Clin Nutr*. 1988;48:484-511
14. Dallman PR, Yip R. Changing characteristics of childhood anemia. *J Pediatr*. 1989;114:161-164
15. Driggers DA, Reeves JD, Lo EYT, Dallman PR. Iron deficiency in one-year-old infants: comparison of results of a therapeutic trial in infants with anemia or low-normal hemoglobin values. *J Pediatr*. 1981;98:753-758
16. Marsh A, Long H, Stierwalt E. Comparative hematologic response to iron fortification of a milk formula for infants. *Pediatrics*. 1959;24:404-412
17. Gorten MK, Cross ER. Iron metabolism in premature infants, II: prevention of iron deficiency. *J Pediatr*. 1964; 64:509-520

18. Pearson HA. Diseases of the blood. In: Nelson WE, ed. *Nelson Textbook of Pediatrics*. 13th ed. Philadelphia, PA: WB Saunders Co; 1986:1042-1044
19. Piomelli S. A micromethod for free erythrocyte porphyrins: the FEP test. *J Lab Clin Med*. 1973;81:932-940
20. Dallman PR, Reeves JD, Driggers DA, Lo ETL. Diagnosis of iron deficiency: the limitations of laboratory tests in predicting response to iron treatment in 1-year-old infants. *J Pediatr*. 1981;98:376-381
21. Reeves JD, Driggers DA, Lo EYT, Dallman PR. Screening for iron deficiency anemia in one-year-old infants: hemoglobin alone or hemoglobin and mean corpuscular volume as predictors of response to iron treatment. *J Pediatr*. 1981;98:894-898
22. Reeves JD, Yip R, Kiley VA, Dallman PR. Iron deficiency in infants: the influence of antecedent infection. *J Pediatr*. 1984;105:874-879
23. Reeves JD, Yip R. Lack of adverse side effects of oral ferrous sulfate therapy in 1-year-old infants. *Pediatrics*. 1985;75:352-355
24. Montalto MB, Benson JD, Martinez GA. Nutrient intakes of formula-fed infants and infants fed cow's milk. *Pediatrics*. 1985;75:343-351
25. Martinez GA, Ryan AS, Malec DJ. Nutrient intakes of American infants and children fed cow's milk or infant formula. *AJDC*. 1985;139:1010-1018
26. Food and Nutrition Board, National Research Council. *Recommended Dietary Allowances*. 10th ed. Washington, DC: National Academy Press; 1989:201-202
27. Tunnessen WW, Oski FA. Consequences of starting whole cow milk at 6 months of age. *J Pediatr*. 1987;111:813-816
28. Siimes MS, Addiego JE, Dallman PR. Ferritin in serum: diagnosis of iron deficiency and iron overload in infants and children. *Blood*. 1974;43:581-590
29. *The Health of America's Children: Maternal and Child Health Data Book*. Children's Defense Fund; 1989:78

EAST GERMAN SPORT STRUGGLE

East Germany's training system for swimmers, the most successful in the world, is close to going under, an official of the sport's federation said.

After years of close attention and lavish financing, swimmers face mounting problems in training, medical care and other areas because money has dried up. "The most successful swimming country is disappearing," a federation official lamented. "People are going to other jobs or abroad, years of experience is just flowing away."

The official said "considerable parts of our swimming structure are already broken," including the system for selecting youngsters, cultivating them in training centers and allocating clubs. "The structures are cracking right down to sports medical care," he said.

West Germany's swimming federation has agreed to merge with its East German counterpart. That decision sparked protests among West German swimmers who fear they will lose their places on the team to more powerful counterparts.

East German Sport Struggle. *The Wall Street Journal*. August 30, 1990. World Wire.

