Dietary Iron: Birth to Two Years,
edited by L.J. Filer, Jr.
Raven Press, Ltd., New York © 1989.

Iron Nutrition: Growth in Infancy

George M. Owen

Medical Director, Bristol-Myers International Group, New York, New York 10154

In evaluating iron nutrition and growth in infancy and early childhood, many variables should be taken into account: iron endowment at birth, rate of weight gain, blood loss, the level and bioavailability of iron in diet, postnatal age, and possibly sex and race.

Because of rapid growth and low body content of iron, the preterm infant requires more iron than the full-term infant. Iron requirements are greatest and iron deficiency is most prevalent during periods of rapid growth. The importance of growth is apparent from the age distribution of iron deficiency anemia. The increase in blood volume and red blood cell mass correlates with weight gain during infancy and childhood (1) (Fig. 1). Hence, the curve depicting annual increments in red blood cell mass and the curve depicting the distribution of iron deficiency anemia are similar. By redistributing iron and by lowering hemoglobin concentration, the healthy term infant is able to double its birth weight without requiring an exogenous iron source. For full-term infants, this doubling of birth weight occurs at 4 to 5 months of age. Thereafter, iron must be absorbed from the diet if supply is to meet demand. Siimes (2) asked the logical question: Are fast-growing, full-term infants at higher risk of developing iron deficiency than those who grow slowly, or do those who grow more rapidly absorb more iron?

In all studies examining nutritional status, blacks tend to be smaller than whites at birth. By 2 years of age, black children are taller, heavier, and thinner than white children (3) (Table 1). Black infants, who probably have less total body iron at birth, grow more rapidly and accumulate relatively more lean tissue (bone and muscle) and less fat than do white infants, while consuming less protein, iron, and ascorbic acid.

Black children tend to grow faster, and they have lower levels of hemoglobin than do white children of the same age, socioeconomic status, and transferrin saturation (4) (Table 2). Oski and Pearson (5) noted that black children with hemoglobin concentrations in the 10.5 to 11.0 g/dl range were four times more likely to have low mean corpuscular volume or ferritin and high free erythrocyte protoporphyrin levels than black children with hemo-

Iron Nutrition:

Geor

Medical Director, Bri
New York

FIG. 1. Mean annual increment in red blood cell mass during childhood. Peaks in the curve correspond with peak periods in rate of growth and in the incidence of iron deficiency. (Reproduced from ref. 1 with permission from Harper and Row, © 1985.)

24 6 8 10 12 14 16 18

Age - Years

TABLE 1. *Anthropometric differences between black and white preschool boys of comparable socioeconomic status3*

Age interval (years)	Height (cm)	Weight (kg)	Skinfold (mm)
1.50-2.49	+1.29"	+0.37	-0.09
2.50-3.49	+1.86°	+0.70C	-0.29
3.50-4.49	+1.27	+0.48	-0.37
4.50-5.49	+2.20"	+1.10°	-0.45

'Adapted from ref. 3. (Reproduced with permission from the American Medical Association © 1973.)
"Difference between black and white boys: black boys are 1.29 cm taller than white boys
"Significant difference (p < 0.05).

TABLE 2. *Hemoglobin levels according to transferrin saturation, age, and race in preschool children of comparable socioeconomic status"*

Age and race	Transferrin saturation 15-19%	20-24%	**a:** 25%

ıore lean tissue (bone and muscle) and less fat than do white infants, while onsuming less protein, iron, and ascorbic acid.

Black children tend to grow faster, and they have lower levels of hemolobin than do white children of the same age, socioeconomic status, and :ansferrin saturation (4) (Table 2). Oski and Pearson (5) noted that black

Hemoglobin levels in g/liter.
'Adapted from ref. 4. (Reproduced with permission from the C. V. Mosby Co., © 1973.)

globin concentrations between 11.0 and 12.0 g/dl. They concluded that most children whose hemoglobin concentrations were between 10.5 and 11.0 g/dl had a nutritional basis for their mild anemia. Reeves et al. (6) also concluded that there was a nutritional basis for the difference in hemoglobin levels of black and white infants between 11 and 14 months of age. They found an equivalent response among both black and white infants following 3 months of treatment with iron (3 mg/kg/day), with 38% and 35%, respectively, manifesting an increase in hemoglobin concentrations of 1.0 g/dl or greater. It is of interest that in view of this similar response, these investigators concluded that black infants had a higher prevalence of iron deficiency.

Impaired growth has been attributed to anorexia, disturbances in nucleic acid synthesis, and altered small intestinal function associated with iron deficiency anemia. Naiman et al. (7) found decreased intestinal absorption of xylose and fat in infants with iron deficiency anemia. Iron deficiency that has progressed beyond depletion of iron stores (ferritin) will affect tissue iron compounds (heme iron compounds, and iron-sulfur and metalloflavoproteins) and enzymes that do not contain iron but require it as a cofactor (8). Factors that play a role include the rate of tissue growth, turnover of individual iron compounds, and work load of individual tissues.

It is entirely possible that an infant's diet may be deficient in iron but otherwise nutritionally adequate, so that infants become sufficiently iron-deficient to impair growth. Yet, in reviewing the literature, it is difficult to determine at what point such an effect might be observed. It is clear that a number of factors contribute to the variability in observations regarding iron nutrition and growth, such as iron stores at birth, rate and possibly composition of growth, level and bioavailability of iron in diet, and losses of iron from body.

RETROSPECTIVE STUDIES

As iron deficiency develops, the rate of weight gain may decline; more severe iron deficiency and iron deficiency of longer duration may cause failure to thrive (8). Morton et al. (9) found that full-term infants with iron deficiency at age 12 months had a greater weight gain from birth than did iron-sufficient infants. They speculated that infants with greater weight gain had become iron-deficient from excessive demands for dietary iron.

Grindulis et al. (10) examined 145 children between 21 and 23 months of age: 55 (31 %) had hemoglobin concentrations of less than 11.0 g/dl, and 25 (19%) had hemoglobin concentrations of less than 10.0 g/dl. Fifty-seven percent had plasma ferritin values of less than 7.0 ng/ml and transferrin saturation values of less than 15%. These investigators found no association between hemoglobin concentrations at age 22 months and body weight at birth or at 22 months (Table 3). They reported only mean values and appar-

TABLE 3. *Nutritional characteristics of Asian children at 22 months3*

	Hemoglobin (g/dl)		
	> 11.0	< 11.0	< 10.0
Body weight			
Birth (kg)	3.07	3.15	314
22 months (SDS")	+0.1	+0.3	+01

'Adapted from ref. 10. (Reproduced with permission from the *British Medical Journal* © 1986.)
"Standard deviation scores.

ently did not evaluate separately children comprising the lower quartile with respect to hemoglobin concentration and weight gain from birth.

Owen et al. (11) found that preschool children whose heights for age were below the 25th percentile tended to have lower levels of hemoglobin and transferrin saturation than children whose heights were above the 25th percentile (Fig. 2). This was particularly true for children between 1 and 3 years of age.

Judisch et al. (12) reviewed medical records of 156 children (Fig. 3) less than 3 years of age who were diagnosed as having moderately severe iron deficiency anemia (hemoglobin < 9.0 g/dl, microcytosis and hypochromia, and low transferrin saturation). All infants were between 12 and 17 months of age when diagnosed, and one-third had a birth weight below 2,500 g. The majority (86%) were black. In 88 of 156 children, sufficient follow-up information was available to examine pre- and posttreatment body weights (6 mg of elemental iron/kg/day for 2 months). The frequency distribution of weights is shown in Fig. 4. It is evident that treatment with iron was associated with an improvement in weight.

A study of 10-month-old infants in two health districts in Paris (13) showed that plasma ferritin was low in 21 %, and 12% of infants were anemic (hemoglobin < 11.0 g/dl). Apparent weight gain was inversely correlated with ferritin, suggesting a major effect of growth on iron metabolism (Table 4).

PROSPECTIVE STUDIES

Burman (14), in a study in Bristol (England), noted that birth weight was significantly related to hemoglobin concentration at age 3 months in boys only and at no other age. Among infants who did not receive supplementary iron, there was a slight sex difference in mean hemoglobin concentration; girls had a 0.4 g/dl greater concentration than boys at ages 15 and 18 months. The sex-related difference in hemoglobin concentration at these

[25.0-, edited by L. J. Fil
Raven Press, Ltd.

Iron Nutrition: Growth in Infanc

George M. Owen

Medical Director, Bristol-Myers International Group,
New York, New York 10154

uating iron nutrition and growth in infancy and ear iables should be taken into account: iron endowmen gain, blood loss, the level and bioavailability of iro , and possibly sex and race.

e of rapid growth and low body content of iron, the nore iron than the full-term infant. Iron requiremen deficiency is most prevalent during periods of rapi ce of growth is apparent from the age distribution of i The increase in blood volume and red blood cell m

15 21 27 33 39 45 51 57 63 69

Age (months)

FIG. 2. Hemoglobin and transferrin saturation values in relation to age and stature, x = average hematological values of children whose heights were below the 25th percentile. 0 = values of children whose heights were equal to or above the 25th percentile. (Reproduced from ref. 11 with permission from the C. V. Mosby Co., © 1971.)

TABLE 4. *Ferritin concentration in relation to weight gain from birth to 10 months"*

slowly, or do those who grow more rapidly absorb more iron?

In all studies examining nutritional status, blacks tend to be smaller th whites at birth. By 2 years of age, black children are taller, heavier, a thinner than white children (3) (Table 1). Black infants, who probably ha less total body iron at birth, grow more rapidly and accumulate relativ more lean tissue (bone and muscle) and less fat than do white infants, wh consuming less protein, iron, and ascorbic acid.

Black children tend to grow faster, and they have lower levels of hen

'Adapted from ref. 13. (Reproduced with permission from the *Archives of French Pediatrics,* ©1984.)

35-,

Raven Press, Ltd.,

Nutrition: Growth in Infanc

George M. Owen

cal Director, Bristol-Myers International Group,

•5 New York, New York 10154

nutrition and growth in infancy and ear
ld be taken into account: iron endowment
d loss, the level and bioavailability of iron
bly sex and race.
growth and low body content of iron, the p
han the full-term infant. Iron requirement
is most prevalent during periods of rapid

10 25 50 75 90 97 100

Weight (Percentile)

FIG. 3. Frequency distribution of weights at time of diagnosis of the entire group of 156 iron-deficient children. (Reproduced from ref. 12 with permission from *Pediatrics,* © 1966.)

ages may reflect the more rapid weight gain of boys during the first year of life.

Burman (15) randomly selected a cohort of infants at age 3 months to receive supplementary iron (10 mg daily), while the other infants received a placebo. In the placebo group, weight gain was significantly greater in boys than in girls at 3, 6, and 9 months. In the treatment group, weight gain was significantly greater in boys than in girls at 3, 6, 9, 12, 21, and 24 months. Weight gain was significantly greater in iron-supplemented than in non-iron-supplemented boys at ages 21 and 24 months. Iron supplementation had no significant effect on weight gain in girls at any age.

Among 470 children between 17 and 19 months of age in four health clinics in central Birmingham (England), 25% were found to have hemoglobin concentrations between 8.0 and 11.0 g/dl (16). Fifty-four children were treated with iron (24 mg) and vitamin C (10 mg) daily for 2 months, and 56 children received vitamin C only (10 mg daily) for the same period. Levels of hemoglobin and related hematological indices (mean corpuscular volume and mean corpuscular hemoglobin) as well as biochemical measures of iron nutriture (serum iron, transferrin saturation, and ferritin) all improved in the infants treated with iron but not in those treated with vitamin C alone. The

Raven Press, Ltd., l

Iron Nutrition: Growth in Infancy

George M. Owen

Medical Director, Bristol-Myers International Group, New York, New York 10154

ating iron nutrition and growth in infancy and earl
ables should be taken into account: iron endowment
gain. blood loss. the level and bioavailability of iron

0 3 10 25 50 75 90 97 100

Weight (Percentile)

FIG. 4. Frequency distribution of weights of 88 iron-deficient children in whom follow-up data permitted comparison before and after iron therapy. (Reproduced from ref. 12 with permission from *Pediatrics,* © 1966.)

rate of weight gain in the children who received iron and vitamin C was 10 g/day, significantly greater than in those who received vitamin C only (7 g/day) (Fig. 5).

Chwang et al. (17) demonstrated improved growth in anemic (< 11.0 g/dl) and iron-deficient (transferrin saturation < 15%) school children who were treated with iron (2 mg/kg/day) for 12 weeks. Treatment effects were demonstrable for weight, height, and arm circumference in the anemic group but not in the nonanemic control group. Within the control group, no significant differences were seen between those who were treated with iron and those who received placebo.

In a longitudinal study of 276 full-term infants, all of whom stopped breast feeding by age 3 months, one-half received milk fortified with 3 mg of iron and 20 mg of ascorbic acid/100 kcal, and one-half received unfortified milk (18). Hematological data were comparable in the two groups at age 3 months. By age 9 months, the control group had significantly lower mean hemoglobin, transferrin saturation, serum ferritin, and elevated erythrocyte protoporphyrin (Fig. 6). Differences also existed at age 15 months (Fig. 7), although there were no differences in growth.

In a study of breast-fed and formula-fed infants, we examined iron nutriture and growth (19,20). Nearly equal numbers of male and female infants were present in each of four feeding groups: breast (*N* = 26), breast plus 10 mg/day of supplementary iron (*N* = 27), formula (*N* = 41), and iron-

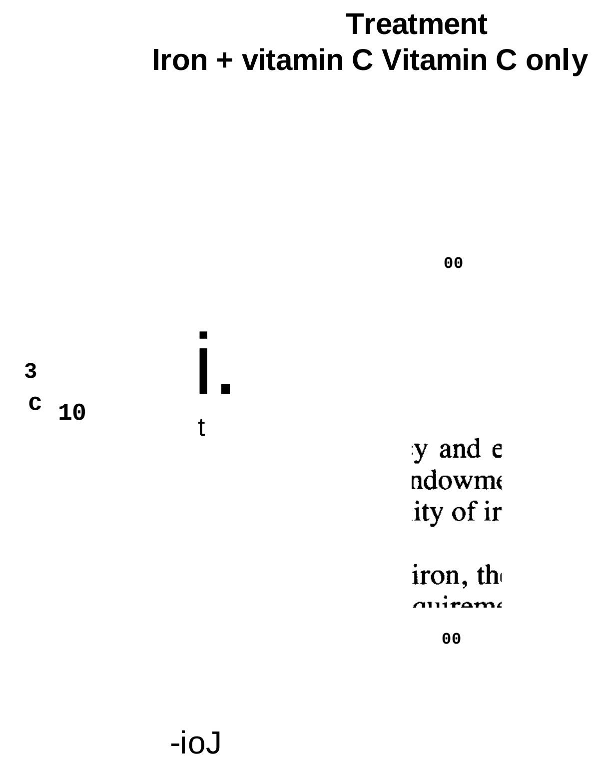

FIG. 5. Weight gain according to treatment group (p = 0.001). (Reproduced from ref 16with permission from the *British Medical Journal,* © 1986.)

fortified formula (N = 45) estimated to provide an intake of 10 mg of iron/day. Use of iron supplement or iron-fortified formula began when infants were 1 month of age. Formula-fed infants gained an average of 23.5 g/day, and breast-fed infants gained 19.3 g/day between 1 and 178 days of age! Within the breast-fed and formula-fed groups, there were no apparent differences in weight gain during the first 6 months to reflect iron supplementation (Table 5). The decrease in body storage iron (BSI) was greatest in the infants receiving formula and lowest in the infants in the breast plus supplementary iron group. The decrease in BSI was comparable in the other two groups, although infants in the group receiving iron-fortified formula gained weight at a significantly greater rate.

COMMENT

The Committee on Nutrition of the American Academy of Pediatrics suggests that determination of weight gain is the single most valuable component of the clinical evaluation of nutritional adequacy of the infant diet. A feeding-

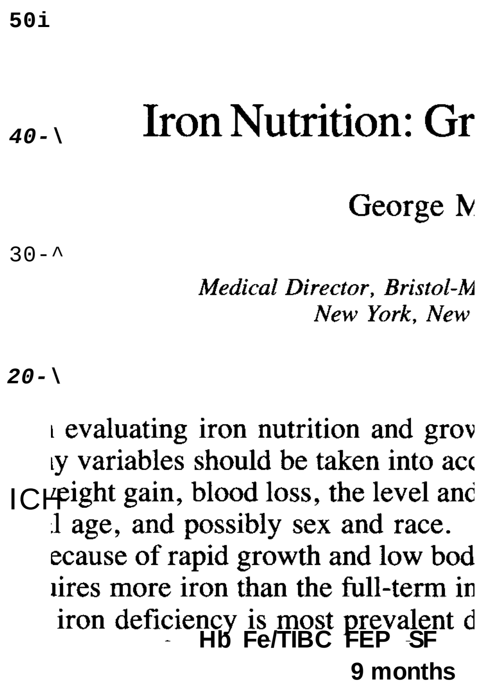

FIG. 6. Percentage of infants at 9 months of age with Mb < 110 g/liter, FemBC < 9%, FEP > 120 ug/dl (2.12 limol/liter) of red blood cells, and SF < 10 Hg/liter. (Reproduced from ref. 18 with permission from the *American Journal of Clinical Nutrition,* © 1988.)

related difference in weight gain of more than 3 g/day over a 3-month period during early infancy should be considered of nutritional significance.

If a sufficiently large group of infants were followed between 6 and 18 months of age, it is likely that slight changes in weight gain would be detected if biochemical changes indicative of iron depletion were found. It is reasonably certain that the rate of gain will decrease when the iron deficiency becomes severe and anemia is latent or actually developing. It is not possible to conclude whether the early phases of iron depletion are associated with an initial increase in rate of gain; this seems possible as the infant consumes more food than necessary, presumably in an effort to achieve an adequate iron intake.

TABLE 5. *Gain in body weight and decrease in body storage iron (BSI) from birth to 6 months in infants in four feeding groups*

Feeding group	Gain in weight (g/day)	Decrease in BSI (mg/kg)
Formula	+24.1	-21.5
Iron-fortified formula	+23.0	-18.9
Breast	+19.5	-18.4
Breast + iron supplementation (10 mg/day)	+19.0	-13.5

Iron Nutrition: Growt

George M. Ow

Medical Director, Bristol-Myers In
New York, New York 1

FIG. 7. Percentage of infants at 15 months of age with Hb < 110 g/liter, Fe/TIBC < 9%, FEP > 100 ug/dl (1.77 limol/liter) of red blood cells, and SF < 10 ug/liter. (Reproduced from ref. 18 with permission from the *American Journal of Clinical Nutrition,* © 1988.)

In evaluating iron nutrition and growth in
any variables should be taken into account:
weight gain, blood loss, the level and bioav
ital age, and possibly sex and race.
Because of rapid growth and low body cont
quires more iron than the full-term infant.
id iron deficiency is most prevalent during

W:TIBC FEP

15 months

REFERENCES

1. Lukens, J. N. (1985): Nutritional anemias in childhood. In: *Practice of Pediatrics* revised ed edited by V. C. Kelley. Harper and Row, Philadelphia.
2. Siimes, M A (1981): Pathogenesis of iron deficiency in infancy. In: *Iron Nutrition Revisited-Infancy. Childhood, Adolescence: Report of the 82nd Ross Conference on Pediatric Research,* edited by F. A. Oski and H. A. Pearson. Ross Laboratories, Columbus, pp. 96-108
3. Owen, G. M., and Lubin, A. H. (1973): Anthropometric differences between black and white preschool children. *Am. J. Dis. Child.,* 126:168-169.
4. Owen, G. M., Lubin, A. H., and Garry, P. J. (1973): Hemoglobin levels according to age race and transfemn saturation in preschool children of comparable socioeconomic status. *J. Pediatr.,* 82:850—851.
5. Oski, F. A., and Pearson, H. A., eds. (1981): *Iron Nutrition Revisited-Infancy, Childhood Adolescence: Report of the 82nd Ross Conference on Pediatric Research.* Ross Laboratories Columbus, p. 42.
6. Reeves, J. D., Driggers, D. A., Lo, E. Y. T., and Dallman, P. R. (1981): Screening for anemia in infants: evidence in favor of using identical hemoglobin criteria for blacks and Caucasians *Am J. Clin. Nutr.,* 34:2154-2157.
7. Naiman, J. L., Oski, F. A., and Diamond, L. K. (1964): The gastrointestinal effects of iron deficiency anemia. *Pediatrics,* 33:83-99.
8. Oski, F. A. (1979): The non-hematologic manifestation of iron deficiency. *Am. J. Dis. Child.,*
9. Morton,R.E.,Nysenbaum,A.,andPrice,K.(1988):Ironstatusinthefirstyearoflife *J Pediatr Gastroenterol. Nutr.,* 7:707-712.
10. Grindulis, H., Scott, P. H., Belton, N. R., and Wharton, B. A. (1986): Combined deficiency of iron and vitamin D in Asian toddlers. *Arch. Dis. Child.,* 61:843-848.
11. Owen, G. M., Lubin, A. **H.,** and Garry, P. J. (1971): Preschool children in the United States- who has iron deficiency? *J. Pediatr.,* 79:563-568.

12. Judisch, J. M., Naiman, J. F., and Oski, F. A. (1966): The fallacy of the fat iron-deficient child. *Pediatrics,* 37:987-990.
13. Dommergues, J. P., Breton, M. P., Ducat, **B.,** Yuart, J., Rossignol, **C.,** and Tchemia, G. (1984): Carence en fer chez le nourrisson: etude des facteurs de risque. *Arch. Fr. Pediatr.,* 41:623-627.
14. Burman, D. (1972): Haemoglobin levels in normal infants aged 3-24 months, and the effect of iron. *Arch. Dis. Child.,* 47:261-271.
15. Burman, D. (1982): Iron deficiency in infancy and childhood, *din. Haematol.,* 11:339-351.
16. Aukett, M. A., Parks, Y. A., Scott, P. H., and Wharton, B. A. (1986): Treatment with iron increases weight gain and psychomotor development. *Arch. Dis. Child.,* 61:849-857.
17. Chwang, L., Soemantri, A. G., and Pollitt, E. (1988). Iron supplementation and physical growth of rural Indonesian children. *Am. J. din. Nutr.,* 47:496-501.
18. Stekel, A., Olivares, M., Cayazzo, M., Chadud, P., Llaguno, S., and Pizarro, F. (1988): Prevention of iron deficiency by milk fortification. U. A field trial with a full-fat acidified milk. *Am. J. Clin. Nutr.,* 47:265-269.
19. Garry, P. J., Owen, G. M., Hooper, E. M., and Gilbert, B. A. (1981): Iron absorption from human milk and formula with and without iron supplementation. *Pediatr. Res.,* 15:822-828.
20. Owen, G. M., Garry, P. J., and Hooper, E. M. (1984): Feeding and growth of infants. *Nutr. Res.,* 4:727-731.
21. Roche, A. P., and Himes, J. H. (1980): Incremental growth charts. *Am. J. Clin. Nutr.,* 33:2041-2052.

Dietary Iron: Birth to Two Years,
edited by L. J. Filer, Jr.
Raven Press, Ltd., New York © 1989.

Discussion

Dr. Filer: In the Albuquerque study, were there any differences in body length after 12 months?

Dr. Owen: I have only examined the weight data. There may be some subtle sex differences that affect nutritional needs for later growth. In the study by Walravens and Hambidge, there was a growth effect of zinc supplementation in male but not in female infants.

Dr. Filer: Do you have any information about the zinc status of these infants?

Dr. Owen: No.

Dr. Walravens: Individual variability makes it difficult to do studies of this type. Did you control for parental size? If you have many short parents, you will have many little children by age 9 to 12 months when the growth rate is slowing down due to influence on genetic growth potential.

Dr. Owen: The altitude in Albuquerque is about 5,500 ft (1,700 m) above sea level. Approximately 70% of the children were Hispanic. We do have height information for the mothers; however, I do not know if we have paternal heights. All infants were full-term and all were enrolled in the study prenatally. Parents were contacted sometime during the second or third trimester of pregnancy.

Dr. Oski: We have observed that as many children became iron-deficient, they begin to show a pattern of "failure to thrive."

Dr. Walravens: Are these children older?

Dr. Oski: Actually, their growth rate began to decrease at 6 or 7 months of age.

Dr. Walter: We have observed the same thing. However, we think that it is related to zinc status because it also happens in breast-fed infants. Ten years ago, we studied three groups of infants. One group was fed iron-fortified milk that had been acidified and one group was given nonfortified cow's milk. The third group was given 150 mg of iron dextran intramuscularly at birth. These three groups were followed to 3, 9, and 15 months of age. There were large differences in the ferritin levels between the groups. Infants given the iron-fortified milk were not anemic at 3 or 9 months of age, and very few had anemia at 15 months. A difference that we don't know how to interpret, however, is that the infants who were given iron dextran at birth had higher hemoglobin levels than those fed iron-fortified formula by 3 months of age. Very few of the infants in the iron dextran group had anemia at 9 months, and the incidence of anemia was comparable to that of infants fed the iron-fortified milk at 15 months. In the non-iron-fortified milk group, about 25 % had anemia. The body weight of infants fed the non-iron-fortified milk was less than that of infants fed the iron-fortified formula. We believe that this difference has nothing to do with iron. At 3 months of age, all infants were well nourished according to their weight for age, but at 9 and 15 months, their mean growth curve fell off although they remained within the normal range. We believe that this difference in body weight occurred because infants in the iron-fortified formula group drank more milk and grew better. The fortified formula also had additional vitamins A and D that were not added to the nonfortified milk. There was no difference in mean body weight for age between the iron dextran and non-iron-fortified milk groups even though there was a large difference in iron status. These same relationships between groups were observed for length for age. The linear growth curves of the iron-dextran and non-iron-fortified milk groups were the same with linear growth of the iron-fortified milk group somewhat higher than the other two groups. The falloff in the linear growth curve was more marked than the falloff in body weight, which is why we believe it is a zinc-related phenomenon. Also, male infants were more affected than female infants.

Dr. Filer: Why do you say this is a zinc effect?

Dr. Walter: We have serum zinc data and 60% of the infants who were being breast-fed exclusively or were being fed cow's milk have levels lower than 60 pg/dl at 9 months of age. All samples were obtained in the fasting state before 10:00 A.M.

Dr. Filer: How can you conclude that it is zinc that is having an effect?

Dr. Walter: I am only suggesting that. Our current study will provide conclusions.

Dr. Dallman: I find it difficult to come to grips with the topic as a whole because it seems to me that it can be broken down into several issues. For example, we know that birth weight is a major factor and that low-birth-weight infants, with their low iron stores, get iron-deficient early.

Dr. Owen: Of course, and, at the same time, the low-birth-weight infant is growing rapidly.

Dr. Dallman: Exactly. So, growth rate and iron deficiency are going to be linked in that the fastest-growing infants are the ones with the lowest birth weight and are also the ones who will get iron-deficient.

Dr. Oski: No one has ever done a study of iron-deficient infants who remain untreated to see what the rate of growth is.

Dr. Dallman: I agree. If one cancels out the birth weight issue, there may be two different situations going on. What Marty Siimes tried to assess was whether infants who had average birth weights but were very big at 1 year of age would have higher iron requirements than infants who started out larger at birth but did not gain very much during the first year. I believe that he made some hypothetical calculations of the iron requirement during the first year of life for fast- and slow-growing infants. It makes sense to me that the fastest-growing infant who has a higher iron requirement would be more vulnerable for iron deficiency. The other situation—the one that Dr. Oski may have observed—is that those infants who became iron deficient in early life may have a growth deficit at about the same time.

Dr. Oski: Iron-deficient infants actually become anorectic.

Dr. Dallman: It is difficult to pull all of these factors together because there are at least three separate issues. One of them is related to birth weight and the rate of growth due to prematurity; the second issue is that rapid growth is a causative factor in iron deficiency, as observed in adolescents; and the third issue is that an established iron deficiency has an influence on growth. If we could separate these issues, we could probably learn more about the pathophysiology of iron deficiency.

Dr. Oski: One of the best situations to observe the effects of rapid growth is in exclusively breast-fed babies. Those infants who grow most rapidly on human milk are the ones who are most likely to become iron-deficient.

Dr. Walter: I disagree, based on my serum zinc data from breast-fed infants at 9 months of age.

Dr. Filer: Actually, this situation may apply to any mineral deficiency. The faster the infant grows, the more likely it is that the infant will develop a deficiency. For example, this effect has been observed in copper deficiency.