Mother-Infant Interactions and Infant Development Are Altered by Maternal Iron Deficiency Anemia

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ABSTRACT The aim of this study was to determine whether iron deficiency anemia (IDA) in young South African mothers alters mother-infant interactions and the infant’s development. The study was a prospective, randomized, controlled intervention trial with 3 groups of mothers: nonanemic controls and anemic mothers administered either placebo (25 mg ascorbic acid and 10 μg folate) or daily iron treatment (125 mg FeSO₄ plus ascorbate and folate). Mothers of full-term, normal birth weight infants (n = 81) were followed from 10 wk to 9 mo postpartum. Maternal iron status, socioeconomic level, mother-infant interaction [Parent/Caregiver Involvement Scale (PCIS scale)], and infant development (Griffiths scale) were assessed. At baseline, anemic mothers tended (P < 0.10) to be less responsive to, and more controlling of, their infants. Infants of anemic mothers were developmentally delayed at 10 wk in hand-eye movement and overall quotient. Despite normalization of maternal iron status with supplementation in some mothers, the developmental delays were not diminished at 9 mo. At 9 mo, anemic mothers were significantly more "negative" towards their babies, engaged less in goal setting, and were less “responsive” than control mothers. In contrast, the behavior of anemic mothers given iron treatment toward their children was similar to that of the control mothers on all 11 scales of the PCIS. In conclusion, IDA altered mother-child interactions at both 10 wk and 9 mo postpartum. Additionally, infants whose mothers were anemic in the early postpartum scored worse on developmental tests at 10 wk and 9 mo of age. J. Nutr. 135: 850–855, 2005.

KEY WORDS: • iron • postpartum • infant • cognition • behavior • development

Iron deficiency is the most common single nutrient deficiency in the world with an estimated prevalence of >50% for women of reproductive age (1). Although research on infants and young children has shown cognitive, behavioral, and anthropometric effects of iron deficiency (2–5), no studies have focused on the effects of iron deficiency in mothers with regard to the potential negative effect of poor maternal functioning on infant development. Malaise, fatigue, and depression are symptoms often associated with iron deficiency but not with regard to mother-child interactions, which may in turn affect the development of their infants (6). Fatigue and depression in the early part of the postpartum period can be related to anemia (7–9), whereas maternal depression affects mother-child interactions and the developmental trajectory of infants (10–12).

We utilize the cumulative risk model of infant development within the conceptual framework that coexisting environmental risk factors as well as cumulative risk factors affect maternal and infant functioning and infant development (13). It is not simply one risk factor that predicts poor outcomes, but multiple risk factors that in combination can multiply many times the risk for poor outcomes. Our previous work with this group demonstrated a significant relation between iron deficiency anemia (IDA) and maternal depression and anxiety over the course of the study (14). The current research hypothesis is based on this cumulative risk model of child development with the specific hypothesis that mothers experiencing poverty with IDA will be different from mothers with the same limited economic resources but without IDA. Mothers with clearly defined clinical depression and anxiety have infants with developmental delays and some psychologists assert that attachment and other aspects of the mother-child interaction are likely paths of mediation of association (10–12).

The aim of the study was to determine whether IDA in mothers alters her interactions with her infant and also influences her infant’s development. The effects of IDA on mater-

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3 Abbreviations used: CN, control; GQ, general quotient; IDA, iron deficiency anemia; EPDS, Edinburgh Postnatal Depression Scale; ID, iron deficiency; IDA-PL, iron deficient anemic receiving placebo; IDA-Fe, iron deficient anemic receiving iron; MCH, mean corpuscular hemoglobin; MCV, mean corpuscular volume; PCIS scale, Parent/Caregiver Involvement Scale; RDW, RBC distribution width; WHp, weight-for-height percentile.
nal cognitive and behavioral performance were reported elsewhere (14).

MATERIALS AND METHODS

All methods were reviewed and approved by the Institutional Review Boards at The Pennsylvania State University and The University of Cape Town and were in accordance with the Helsinki Declaration of 1975 as revised in 1983. The study was conducted in Khayelitsha, South Africa. The details of the design and subject criteria are elaborated elsewhere but are also summarized below.

**Design.** The study was a prospective randomized, controlled, double-blind intervention trial involving 3 groups of mothers: IDA-PL: iron-deficient anemic mothers provided a daily low dose of vitamin C (25 mg) and 10 μg of folic acid daily; IDA-Fe: iron-deficient anemic mothers provided a daily dose of 125 mg of FeSO₄, 25 mg of vitamin C, and 10 mg of folic acid; and CN: nonanemic control mothers who received no supplementation. Mothers were enrolled in the study at a well-baby clinic visit at 6–8 wk after delivery of their infants.

The inclusion criteria were as follows: for identification of IDA, hemoglobin (Hb) between 90 and 115 g/L, and at least 2 of the following indices of iron deficiency: mean corpuscular volume (MCV) < 80 fl, transferrin saturation (TSAT) < 15%, serum ferritin (Fr) < 12 μg/L. These clinical criteria were in accordance with diagnostic evaluations established by the Hematology Department at the Cape Town University Hospital and were chosen to clearly define IDA. We used C-reactive protein (CRP) as an indicator of immune system activation; when the values were >5.0 mg/L, ferritin was no longer used as a criterion of IDA because it can be falsely elevated during inflammation. For the identification of controls, we used Hb > 135 g/L, MCV > 80 fl, TSAT > 15%, and Fr > 12 μg/L. Any woman with an Hb < 90 g/L was excluded from the study as being too anemic; she was referred to treatment and provided iron supplements. Other inclusion criteria were as follows: mothers had to be between 18 and 30 y old, primary caregivers, and breastfeeding for the duration of the study, have no chronic diseases, and be apparently healthy at the physical health screening. The infants had to be >38 wk of gestational age, have a birth weight >2500 g, have no hospitalization during the neonatal period, and have Apgar scores consistent with normal intrauterine growth and development.

**Subject enrollment.** We employed an opportunistic sampling approach by reviewing the monthly birth statistics of women who delivered in the birthing clinics in the settlement community. Based on the reported type of delivery, Apgar scores, birth weight, and residence of the mothers, we then contacted the mothers as potential subjects and requested that they be screened for inclusion into the study. The first direct contact with the mothers was at 6 wk postpartum when the mothers returned to the clinics for well baby visits. At that time, mothers were provided the informed consent and were screened using a HemoCue. If the Hb value was between 90 and 119 g/L and the woman consented to participate, a venous blood sample was drawn; a Ravens test and a sociodemographic questionnaire were administered, and home follow-up and follow-up clinic visits were scheduled. Once the hematological results were determined by the clinical laboratory and examined by the project hematologists, the mothers were allocated (randomly in the case of the anemic mothers) to their groups and each mother was given a code. Control mothers were matched for age, parity, and level of maternal education to the mothers in the anemic intervention groups. Home field visits were conducted by field workers at the scheduled times indicated, but also once every 2 wk as time permitted to reaffirm the need for the mothers to take their supplements, to conduct dietary intake evaluations, and to maintain contact.

**Measures.** A number of variables with a focus on maternal behavior and cognition were measured in mothers over the course of the study; these are detailed elsewhere (14). Our evaluation of mother-child interactions and infant development was performed at 10 wk and 9 mo postpartum. Mother-child interactions were studied through 20 min of free play recorded on videotape. During these sessions, mothers were given no instructions other than being told that they should not allow their child to sleep during the 20 min of filming and that they should try to interact with their infant in a fashion that was typical of their daily interactions. There were no other persons in the room during the videotaping sessions. Each videotape was viewed and coded independently by a trained field worker who had no knowledge of group assignment. The assessment used the Parent/Caregiver Involvement Scale (PCIS scale), which reflects the affective status of the mother and child as well as the responsiveness of the mother to the infant’s needs and initiations (15). It has 11 scales that assess physical and verbal interaction, responsiveness, play, teaching, control of activities, directives-demands, relationship, positive and negative statements, and goal setting. For each scale, the amount, quality, and appropriateness were determined and a score between 1 and 5 was assigned. The PCIS is a scale that has been used in a number of child development paradigms to evaluate specific characteristics of the interaction in a nonstructured setting. A subset of infants were evaluated by a pediatrician (E.M.P.) using the Griffiths scale of infant development (16). This set of scales focuses on 5 areas of development: locomotor, personal-social, verbal, hand and eye co-ordination, performance, and for older children another scale on practical reasoning. This test was utilized previously among different cultural groups of South Africa to establish cross-cultural validity (17).

**Informed consent.** All of the requirements for participation in the study were explained to the potential subject in her native language, Xhosa. If she agreed to participate, she was asked to sign, or make a symbol of affirmation, in the appropriate place on the informed consent form.

**Statistical analysis.** All data were analyzed with SAS (version 8.1) software. The general statistical approach was ANOVA with repeated measures; significant covariates were entered into the model statement if necessary to control for nonrandom distributions of baseline variables. Data were checked for normality of distribution and log transformed, if necessary, before ANOVA. Log transformation was necessary for ferritin as well as all of the cognitive and behavioral variables. Post hoc Tukey comparisons were considered significant at P < 0.05. Analyses at baseline for group differences were analyzed both with and without the inclusion of subjects who later failed to return to the clinic for the final evaluation. We utilized the PROC-GLM program within SAS and stepwise linear regression to determine strengths of association.

**RESULTS**

**Maternal selection and sociodemographic data.** We initially contacted and screened 500 women; venous blood was taken from 280 mothers [Fig. 1 in (14)]. The characteristics of the 95 mothers we enrolled in the study are presented in the earlier article [Tables 2 and 3 in (14)]. Of these, 81 mothers remained for the entire study and are included in this report: 21 in the IDA-PL group, 30 in the IDA-Fe group and 30 in the CN group. Iron treatment for 7.5 mo significantly improved the iron status of women in the IDA-Fe group, whereas women in the IDA-PL group largely remained iron deficient, although a substantial proportion did show a restoration in hemoglobin concentration (14).

**Mother-child interactions.** At the 10-wk visit, the mean scores for the 11 scales of mother-child interaction did not differ among the groups (Fig. 1). Anemic mothers tended (P < 0.10) to provide fewer positive and negative statements, were less responsive, exerted more control over their infant’s behavior, and related less well with their infants. The relations between indices of maternal iron status and these subscales of the PCIS were tested using both correlation and regression analyses. Goal setting and directives were correlated with mean corpuscular hemoglobin (MCH) concentration (r = 0.314, P < 0.002 and r = -0.254, P < 0.03, respectively).

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4 HIV was not present in any mothers; this testing was done as part of a government project and was not a part of our exclusion or inclusion criteria.
and with RBC distribution width (RDW) \( r = -0.378, P < 0.001 \) and \( r = -0.231, P < 0.05 \), respectively). Hemoglobin, MCV, and other hematological variables were similarly related (data not shown). Combinations of these variables typically explained 28–40% of the variance when stepwise regression was performed. Hunger and age were the only noniron biological variables to also enter in the regression models but, although significant, their contribution to the variance was generally <5%. No other PCIS variables were related to maternal iron status measures.

At the 9-mo follow-up visit, the amount of individual variation increased dramatically from that observed at the 10-wk videotape session (Fig. 2). Mothers in the IDA-PL group scored less well than those in either the CN group or the IDA-Fe group with respect to the overall summation of scales \( P < 0.05 \). The overall scale is the unweighted summation of all of the scales and can be viewed as indicative of overall mothering performance. The anemic mothers in the IDA-PL group had more negative statements and less goal setting than mothers in the CN group \( P < 0.05 \). The iron-replete mothers in the IDA-Fe group resembled placebo mothers in some aspects of behavior (e.g., positive scales) but the overlap was not complete. In many scales, the iron-supplemented mothers were in between the characteristics of anemic and control mothers. Stepwise regression was again performed to assess the contribution of various iron status and maternal characteristics to the scores on the PCIS. Age, RDW, and MCH were all significant independent contributors to the amount, quality, and appropriateness of goal setting \( f = 5.14, 8.78, \) and \( 10.45, P < 0.002 \) in each case). Similarly, hunger and MCH were related to Directives and Control scales \( f = 4.03 \) and \( 3.47, P < 0.04 \) for each). Many of the other subscales had at least 1 iron status variable that was significantly related to the score on that subscale but the explained variance was generally <10% (data not presented).

**Anthropometric status of infants.** Birth weights were (mean ± SD) 3200 ± 510, 3210 ± 440, and 3280 ± 415 g for infants in the IDA-PL, IDA-Fe, and CN groups, respectively. At 10 wk of age the mean weight-for-age Z-scores for infants in the IDA-PL, IDA-Fe, and CN groups were 0.9, 1.4 and 1.4; the mean height-for-age Z-scores were 0.2, 0.7 and 1.1; the mean weight-for-height Z-scores were 0.8, 1.4 and 1.8, respectively. None of these Z-scores differed among the 3 groups. The Apgar scores done at 1 and 5 min after birth also did not differ. The physical characteristics of infants in all groups were similar.

At the 9-mo follow-up visit, infants in the IDA-PL, IDA-Fe, and CN groups, had mean weight-for-age Z-scores of 0.7, 0.2, and 0.1; mean height-for-age Z-scores of 0.4, −0.7, and −0.3; and mean weight-for-height Z-scores of 1.0, 0.9, and 0.4, respectively. Infant growth rates were marginal in all 3 groups, especially for the IDA-Fe and CN groups compared with the IDA-PL group. Mean head circumference did not differ at this time. Breast-feeding was maintained similarly in all groups with >70% of the infants still breast-feeding at 9 mo of age. None of these changes in anthropometry were related to the mothers’ iron status variables.

**Development of infants.** At the 10-wk visit, the Griffiths developmental test was performed on 50 infants: 11 from the IDA-PL group of mothers, 18 from the IDA-Fe group of mothers and 21 from the CN mothers \(^5\) (Table 1). The infants born to CN mothers performed significantly better \( P < 0.05 \) on the hand-eye co-ordination scale and for the general quotient (GQ) scale. None of the scales differed between infants from mothers in the IDA-PL and IDA-Fe groups at the 10-wk visit. There was no correlation between the 10-wk maternal hematological variables and the Griffiths results at 10 wk.

Of the original 50 infants who completed the Griffiths at 10 wk, 45 completed the Griffiths test at 9 mo: 10 from the IDA-PL group, 16 from the IDA-Fe group and 19 from the CN group (Table 1). The CN infants scored better than did infants from the IDA-PL and IDA-Fe groups \( P < 0.05 \) on the locomotor scale and tended to score better \( P < 0.07 \) on the GQ scale but the groups did not differ on the other subscales.

\(^5\) Infants that participated in the Griffiths developmental score did not differ from the total sample in any physical characteristic nor did the mothers of these infants differ from the larger cohort of mothers in each treatment group. All infants that participated in the Griffiths developmental score also participated in the PCIS evaluation.

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**FIGURE 1** Scores of mother-child interaction from videotaped session at 10 wks postpartum in infants whose mothers were not anemic (CN) or who were anemic and were assigned to placebo (IDA-PL) or iron (IDA-Fe). Values are means ± SEM, \( n = 81 \). *IDA-PL mothers and CN mothers differ, \( P < 0.05 \).”

**FIGURE 2** Scores of mother-child interaction from videotaped session at 9 mos postpartum in infants whose mothers were not anemic (CN) or who were anemic and were assigned to placebo (IDA-PL) or iron (IDA-Fe). Values are means ± SEM, \( n = 81 \). *IDA-PL mothers and CN mothers differ, \( P < 0.05 \).”
The improvement in the scores of the Griffiths development test was greater for the CN infants than for those of mothers who had been anemic at the 10-wk visit. That is, the "change in score" between 10 wk and 9 mo for the GQ aggregate was greater in the CN infants (+17.4) compared with either the IDA-PL (+15.7) or IDA-Fe infants (+8.6) (P < 0.001). Infants from IDA-PL mothers improved in the hearing/speech and hand-eye co-ordination task (P < 0.05). Infants from IDA-Fe mothers improved in the locomotor scale (P < 0.05).

We performed multiple regression analysis to evaluate the relation of individual variables of iron status to each of the subscales as well as to the GQ aggregate at both 10 wk and 9 mo. The only significant regression at 10 wk was between eye-hand coordination and hemoglobin and MCV (f = 4.84, P < 0.01, R² = 0.203). At 9 mo however, RDW and age were powerful and consistent variables related to locomotion, personal-social, and speech subscales (R² = 0.453–0.396, f = 12.7–6.56, P < 0.001 for each equation, respectively). Eye and hand coordination were again related to baseline Hb and joined RDW and age as significant predictor variables (P < 0.005, total R² = 0.496). The GQ aggregate was very strongly related to RDW (f = 46.0, R² = 0.622, P < 0.0001), with baseline Hb providing an additional significant 6.8% to the explained variance. No other iron status or sociodemographic variables were significant predictors.

Other factors affecting mother-child interaction and the development of infants. We examined other factors that could have affected mothers and infants and analyzed the influence of income, age, and educational level of the mother, and relation to the partner (evaluated based on trust, reliability, and practical support). Mothers with household incomes >$350/mo had infants who were heavier at 10 wk [mean weight-for-height percentile (WHP) 76.23] than those of mothers with incomes <$350/mo (WHP 51.8) (P < 0.001); the Griffiths scores of infants with higher-income mothers did not differ from those of infants from poorer households. Mothers with less income did not differ from those with a higher income on the PCIS scales. The educational level of the mothers never entered into any of the regression models nor did income independently of more proximate variables such as hunger. Infants whose mothers had a good relationship with their partner had higher scores in the locomotor scale (112.9 vs. 93.1, P < 0.05) than infants whose mothers who did not have a good relationship with their partner. This influence of partner on locomotion was not seen at 9 mo. In contrast, the quality of the relationship to the mother’s partner correlated positively (r = 0.24–0.93, P < 0.05) with 6 of the 9 aspects of mother-child interaction (verbal, responsiveness, play, teaching, control and negative statements) at 9 mo but not at the 10-wk evaluation.

Maternal age correlated positively at 10 wk with the hand-eye coordination and speech scales of the Griffiths test (r = 0.28–0.32, P < 0.05), and at 9 mo with GQ, locomotor, social, and speech scales. As with the Griffiths test, there was a negative correlation at this stage between maternal age and the verbal, responsiveness, play, teaching, negative statements and goal setting scales of the PCIS (r = −0.25–0.70, P < 0.05). Including iron status variables in these regression models did not affect these relations.

**DISCUSSION**

Two important observations result from this study of iron deficiency during the postpartum period. The first is the novel observation that maternal iron status affects mother-child interactions. At 9 mo, anemic mothers were more negative, less adept at setting appropriate goals for their infants, and less responsive than were mothers who were not anemic or once-anemic mothers who had been successfully treated with ferrous sulfate. Anemic mothers given iron treatment generally related to their infants in a more positive manner and did not exhibit the "negative mothering" characteristics observed in anemic mothers at 9 mo although the differences between the groups were not significant. No previously published literature exists that directly compares with our investigation. However, Lozoff et al. (2) noted years ago in her Costa Rican studies that adult caregivers “interacted” differently with iron-deficient anemic infants but the nutritional status of the caregivers, or mothers, was unknown. Importantly, our results demonstrate that the iron status of the mother, or primary caregiver, may have an influence on this interaction between mothers and their infants. Several previous studies noted that postpartum anemia negatively affects self-reported quality of life (8–12) and worsens symptoms of fatigue, irritability, and poor concentration (18). A study in Tanzania showed a large amount of overlap between postpartum depression and anemia (19). However, Lozoff and colleagues (20) did not find an association between maternal iron status and depression symptoms at 1 y postpartum in a large sample of mothers from Chile and Costa Rica. In upper-middle class American women, we demonstrated a significant relation between anemia and depression symptoms in the postpartum period (7). None of these studies, however, links these maternal behavioral characteristics to the development of their infants and the potential mediating role that maternal behavior may have on that process. The significant association that we observed between maternal iron

**TABLE 1**

Griffiths scores at 10 wk and 9 mo postpartum of infants whose mothers were not anemic (CN) or who were anemic and were assigned to placebo (IDA-PL) or iron (IDA-Fe)

<table>
<thead>
<tr>
<th>Test</th>
<th>IDA-PL 10 wk (n = 11)</th>
<th>9 mo (n = 10)</th>
<th>IDA-Fe 10 wk (n = 18)</th>
<th>9 mo (n = 16)</th>
<th>CN 10 wk (n = 21)</th>
<th>9 mo (n = 19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Locomotor</td>
<td>111.8 ± 22.5</td>
<td>124.8 ± 21.9*</td>
<td>103.2 ± 23.0</td>
<td>118.2 ± 21.9*</td>
<td>114.1 ± 17.6</td>
<td>136.4 ± 19.8</td>
</tr>
<tr>
<td>Social</td>
<td>109.4 ± 25.5</td>
<td>124.9 ± 20.5</td>
<td>116.1 ± 18.0</td>
<td>121.5 ± 18.1</td>
<td>121.6 ± 14.1</td>
<td>137.2 ± 22.1</td>
</tr>
<tr>
<td>Hear/speech</td>
<td>91.3 ± 22.2</td>
<td>115.4 ± 18.9</td>
<td>101.0 ± 11.5</td>
<td>111.6 ± 23.3</td>
<td>108.1 ± 30.1</td>
<td>135.8 ± 24.4</td>
</tr>
<tr>
<td>Hand-eye</td>
<td>81.9 ± 25.0*</td>
<td>107.7 ± 17.1</td>
<td>90.1 ± 29.3*</td>
<td>101.2 ± 17.5</td>
<td>100.7 ± 17.1</td>
<td>115.4 ± 17.6</td>
</tr>
<tr>
<td>Performance</td>
<td>90.2 ± 17.2</td>
<td>97.2 ± 15.7</td>
<td>97.7 ± 18.3</td>
<td>101.7 ± 14.1</td>
<td>104.1 ± 17.4</td>
<td>107.0 ± 13.8</td>
</tr>
<tr>
<td>GQ</td>
<td>98.3 ± 17.5*</td>
<td>114.0 ± 14.4</td>
<td>101.9 ± 15.2*</td>
<td>110.5 ± 15.6</td>
<td>109.7 ± 13.7</td>
<td>127.1 ± 17.7</td>
</tr>
</tbody>
</table>

1 Values are means ± SD.
* Different from CN at that age, P < 0.05.
deficiency and emotion scores (14) and between maternal iron status and mother-child interactions and infant development are intriguing. Nevertheless, our small sample size is insufficient to actually test the hypothesis of a causal link. It is our contention that the more iron-deficient and depressed mothers were actually less “effective” mothers of infants who were already “at risk” due to poorer iron stores, and this may have resulted in the lower developmental scores of the infants at 9 mo. Our hypothesis was that poor iron status was only one risk in the multiple risk factor–laden environment in which these young women were raising their infants (13). The iron-deficient mothers in the current study of socially and economically disadvantaged women were not interacting with their infants in the same way as mothers who were never iron deficient or were treated for IDA. The study cannot answer the next logical question: what are the long-term developmental consequences of this altered mother-child interaction as posed by Lozoff et al. (2,13). Subsequent studies, however, may begin to account for the influence of maternal nutritional status on developmental patterns of infants. 

The second important observation is that infants of the anemic mothers appeared to develop less rapidly than those of mothers without current or prior IDA. The lower mean Griffith's developmental scores exemplify this at both 10 wk and 9 mo of age. The Griffith scores are not culturally bound variables as noted in a recent study comparison of South African Xhosa, whites, mixed-race, and Indian with the British standards (17). There was high construct validity within each racial group that did not vary significantly among racial groups. The clinical relevance of deviations in infant development scales as predictive of later development is still being debated (2,13). The 95% CI of scores from normal children translates into a variation of ~5 points in 18-mo-old children (21). These authors conclude that a poor score on the Griffiths scale at 1 or 2 y of age is a good predictor of impairment at school age especially for the movement scale for which the sensitivity was 70% and the specificity at age 5 y was 100%. The observation of a relation between IDA and infant development persisted after controlling for possible confounding variables such as income, maternal education, age, and other socioeconomic variables. Unfortunately, funding restrictions prevented us from measuring the iron status of the infants in this study. Thus the growth faltering in infants of anemic mothers might have been the result of their own iron deficiency, which developed between birth and 10 mo of age, or may have also been the result of a preexisting condition of iron deficiency in utero that subsequently altered growth (22). Anemic mothers at entry into the study were randomly assigned to treatment or placebo group, and no difference existed in the distribution of severity of IDA between the placebo and iron-treated mothers. This suggests that preexisting neonatal iron deficiency was not responsible for the attenuated development in IDA-PL infants. Until recently, infants were believed to behave as true parasites with respect to sequestering iron from their mothers. Oski in 1985 is quoted as saying that “unless extreme, the presence of maternal iron deficiency does not appear to compromise the iron endowment of the fetus” (22). This concept is changing slowly; a number of studies have revealed that when appropriate measurements for iron deficiency are used, mild and moderate iron deficiency in the mother does contribute to lower iron reserves, if not frank iron depletion in the fetus (23–27). In a longitudinal follow-up study of 91 healthy term Danish infants, it was found that a major part of the variation in serum ferritin values among the infants at 9 mo could be explained by the ferritin values at 2 mo of age, the diet, and the growth velocity (28). On the basis of these studies, we could assume that infants from the iron-deficient anemic mothers had lower iron stores than infants of the nonanemic mothers. This lack of body iron during the first 6–9 mo of life could have affected their development. However, the very short time frame for evaluation of the infants in this study precludes us from any large commentary regarding the effect of iron deficiency on infant development over a longer period.

Although there is some controversy concerning the interaction between IDA and impaired development (29), it is certain that iron is an essential component of brain growth. When IDA manifests early in life, its deleterious effects on development may be irreversible (2,3). Although all infants in the current study were of similar birth weight, length, Apgar scores, and gestational age, we cannot ensure that the infants were not anemic in utero or during the first 10 wk of life. All children experienced growth failure relative to population anthropometric variables between the time of entry into the study and the end. Stunting is associated with adverse cognitive and behavioral outcomes in infancy and childhood (30). The short time frame of the current study does not, however, necessarily imply consistent growth faltering. Although it is tempting to speculate that growth failure may have a separate and additional effect on infant development apart from the influence of iron status, our design and limited resources prevent us from exploring this question.

In conclusion, this study demonstrates a relation between iron status and mother-child interactions with mothers who had a normal iron status scoring significantly better than those mothers who had reduced iron-deficient status. This study also shows that developmental test scores are significantly worse at 10 wk and 9 mo of age in infants whose mothers were anemic in the early postpartum period. The functional linkage between maternal nutritional status and behavior and the infant’s nutrition status and growth may very well be the mother-child interaction. These data suggest that future studies of iron deficiency during pregnancy and the postpartum period examine the potential influence of this behavioral linkage.

LITERATURE CITED