Iron Deficiency Anemia and Depleted Body Iron Reserves Are Prevalent among Pregnant African-American Adolescents[1]

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ABSTRACT Anemia is prevalent among pregnant adolescents, but few data exist on biochemical indicators of iron status in this group. We hypothesized that among an at-risk population of African-American, pregnant adolescents, the degree of iron depletion and deficiency would be marked, and that iron deficiency anemia would comprise the majority of the observed anemia. To examine this, blood samples were collected from 80 girls ($\leq$18 y old) attending an inner city maternity clinic, 23 of whom were studied longitudinally in the 2nd and 3rd trimesters depending on contact at the clinic. Sample sizes for the biomarkers varied according to the blood volume available at the time the assays were completed. Descriptive statistics were applied to characterize iron status, and multivariate regression and logistic analyses were used to identify significant determinants of iron status. Depleted iron stores (ferritin $\leq$ 15 μg/L) were indicated for 25% (n = 44) and 61% (n = 59) of adolescents during the 2nd and 3rd trimesters, respectively. Serum folate (39.3 ± 15.4 nmol/L, n = 60), RBC folate (2378 ± 971 nmol/L, n = 60), and serum vitamin B-12 concentrations (313 ± 163 pmol/L, n = 60) were within normal ranges. Adolescents with serum transferrin receptor:serum ferritin ratios (R:F ratio) $>$ 300 during the 2nd trimester were 12.5 times (95% CI 2.83, 55.25) more likely to be classified with iron deficiency anemia during the 3rd trimester (P = 0.0002) than those with lower ratios. Estimates of body iron were lower in those tested after wk 26 of gestation ($P < 0.0001$), and reserves were depleted in 5.0% vs. 31.3% of the 2nd (n = 40) and 3rd (n = 48) trimester cohorts, respectively. In conclusion, iron-deficiency anemia was prevalent among these pregnant minority adolescents. Targeted screening and interventions to improve diet and compliance with prenatal iron supplementation are warranted for this at-risk group. J. Nutr. 135: 2572–2577, 2005.

KEY WORDS: • *minority* • *anemia* • *adolescents* • *pregnancy* • *folate*

Although the prevalence of iron deficiency is highest in developing and low-income countries, several vulnerable subgroups also exist within the U.S. population. Risk of anemia increases in infants, young children, and adolescents undergoing rapid growth periods as well as in pregnant and lactating women. Although minority youth are at greatest risk for early childbearing (1), and pregnant minority youth have several risk factors associated with increased risk of anemia (2), few biochemical studies of iron status are available among this group.

Pregnancy heightens iron needs to accommodate the ~40% increase in blood volume, and to supply the iron demands required for the growth of the fetus, placenta, and other maternal tissues (3). Iron absorption increases during pregnancy, although the majority of women are still unable to meet their iron needs without supplementation especially during the 2nd and 3rd trimesters of pregnancy (4,5).

Adolescence, like pregnancy, increases iron requirements in girls to accommodate the demands of growth and iron losses due to the onset of menstruation. A national study from 1994 to 1996 found that only 27.7% of girls ages 12–19 y met the RDA requirements during this period for iron (6). Pregnant adolescents may also be at increased risk for related nutritional deficiencies such as folate and vitamin B-12 (7,8). Emphasis on folic acid status during pregnancy has focused primarily on the prevention of neural tube defects; however, there is increasing interest in its effect on elevated homocysteine levels that may result in spontaneous abortions and other poor health and cognitive outcomes (9,10). Low maternal intake of vitamin B-12 during pregnancy was shown to strongly influence fetal storage of the vitamin (11).

The health risks for both mother and child when maternal anemia is present are well established, including low birth weight, preterm birth, and maternal morbidity and mortality (12–17). Evidence shows that when maternal iron stores are depleted, the transfer of dietary iron to the fetus is upregulated,

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but the extent of this increase is limited (18). Moreover, maternal iron deficiency in pregnancy can reduce fetal iron stores and predispose infants for iron deficiency during y 1 of life with its related consequences of developmental delays, behavioral disturbances, and poor cognitive outcomes (19–22).

To date, the prevalence of iron deficiency and iron-deficiency anemia during pregnancy has been documented only among select populations of adolescents (23–26). Previously, we documented high rates of anemia and increased risks of adverse birth outcomes from a retrospective medical chart review of 1100 minority adolescents (27). This study was undertaken to investigate further the causes of anemia and to identify potential risk factors associated with low concentrations of iron status indicators among this cohort of pregnant African-American adolescents.

SUBJECTS AND METHODS

Study design and subject recruitment. Blood samples were taken from 80 pregnant African-American adolescents attending an inner-city maternity clinic, Maternity Center East (MCE),[3] affiliated with Johns Hopkins Hospital. To assess longitudinal changes in iron status, 23 adolescents were studied during both the 2nd and 3rd trimesters. Different sample numbers appear for the various biomarkers depending on the blood volume available. All adolescents attending this clinic were eligible for this study if they self-reported their racial group as African American and were carrying a singleton pregnancy. All adolescents attending the clinic were asked if they would like to participate in this study when they were having blood drawn for clinically indicated prenatal tests. Of the adolescents approached, >90% agreed to volunteer to participate in this research study. The study was approved by the Joint Committee of Clinical Investigation at Johns Hopkins Hospital and written consent was obtained from each adolescent.

A standard prenatal hematological screen that included hemoglobin (Hb), hematocrit, and other measures was used as part of routine pregnancy tests. At the time of these blood draws, if there was consent, an additional 10 mL of blood was collected from the non-fasting adolescent and used for the assessment of iron status and related indicators including serum ferritin, transferrin receptor, erythropoietin, leptin, folate and vitamin B-12 concentrations. Because the samples were also utilized for other laboratory studies, in some instances, there was inadequate sample volume for all analyses. Data on variables of interest including age, smoking status, parity, infections, education, and other self-reported anthropometric data were collected from each subject.

Screening for genitourinary infections, including bacterial vaginosis, Chlamydia, gonorrhea, trichomonas, monilia, and urine culture and sensitivity were routinely undertaken throughout prenatal care. A positive test at any stage of the pregnancy was classified as positive.

Biochemical analyses. Hb, hematocrit, and mean corpuscular volume were determined at the core laboratory using a standard hematological screen at Johns Hopkins Hospital. Commercially available ELISA assays were used for the determination of concentrations of serum soluble transferrin receptors (sTfRs) ferritin (Ramco Laboratory), erythropoietin (R&D), and serum leptin (Linco Research). From Ramco Laboratories, the ferritin intra-assay CV was 5.8%, and the interassay CV was 6.8%.

Serum folic acid and vitamin B-12 concentrations were measured in samples collected from 60 of the 80 adolescents. The samples selected for this analysis were stratified by gestational age and proportionally selected, ensuring that only one sample was assessed per client. A chemiluminescent competitive immunoassay was utilized for folic acid and vitamin B-12 analyses (Immulite 1000 Analyzer, Diagnostic Products). Instrument precision was within instrument specifications as determined by regular replication of 3 levels of control serums. Pooled samples were included in each assay for folate and vitamin B-12 to ensure the accuracy of the methods. The intra-assay CV was 2.38% for serum folate and 6.35% for vitamin B-12 analyses.

Anemia and iron classifications. The CDC criteria were used to define anemia and high Hb concentrations during pregnancy. Cutoff values were selected on the basis of gestational age of the adolescents: Hb concentrations < 110 g/L or hematocrits < 0.33 during the 1st and 3rd trimesters, and Hb < 105 g/L and hematocrit < 0.32 during the 2nd trimester. In adolescents that self-reported a history of current cigarette smoking (13%), the Hb cutoff value was increased by +3 g/L (28). We defined elevated Hb concentrations as those >120 g/L throughout pregnancy based on our previous data on Hb concentrations and adverse birth outcomes in the larger clinic population (12). Adolescents were classified as having iron deficiency anemia if the serum ferritin concentration was ≤ 15 μg/L and the Hb concentration was <110 g/L (1st and 3rd trimesters) or <105 g/L (2nd trimester) (28).

In general, the distributions of Hb concentrations are lower for African Americans and are unrelated to iron deficiency indicators, creating the possibility of false positive for iron deficiency. Several studies showed that relative to Caucasian groups, African-Americans have a mean 8 g/L lower Hb concentration (29). In our previous study with a similar population, the reference range was decreased to 90–105 g/L, and a U-shaped distribution between Hb and adverse birth outcomes was found in the 3rd trimester cohort (30). In this study, we similarly examined risk factors associated with a lower cutoff value for the African-American adolescents, but have reported values applying the CDC and WHO recommended Hb cutoff values for defining anemia and iron-deficiency anemia for all pregnant women. This is in concordance with the CDC stated rationale that no reason for the differences has yet been identified.

A number of other iron status markers were employed to gain further specificity and sensitivity. Serum ferritin concentrations ≤ 15 μg/L were used as an indicator of depleted iron stores (23). Tissue iron deficiency was defined when sTfR concentrations exceeded 8.5 mg/L (31). A sTfR:serum ferritin ratio (R:F ratio; both indicators expressed in units of μg/L) > 300 was also used as an indicator of depleted iron stores. This cutoff point was found to give a sensitivity of 85% and a specificity of 79% when used in pregnant women (32). A measure of body iron reserves was calculated using the formula: body iron (mg/kg) $= -[\log(\text{sTfR:ferritin ratio}) - 2.8229]/0.1207$ (33). Negative values correspond to deficiency of body iron reserves. To convert the body iron concentrations from mg/kg to mmol/kg, divide values by 55.847.

Folate and vitamin B-12 classification. Serum folate concentrations < 6.80 nmol/L were used to classify any of the stages of folate depletion or deficiency (34). To provide a more accurate measure of longer-term folate status, RBC folate status was calculated as follows: RBC folate (μg/L) $= 21R \times (100/H)$ where $R =$ result, $H =$ hematocrit as a percentage. A value > 453.2 nmol/L was considered normal or possibly indicative of early negative folate balance; values < 271.9 nmol/L were indicative of folate deficient erythropoiesis and anemia (35). The corresponding cutoff levels used to indicate vitamin B-12 depletion or vitamin B-12 deficiency were <111 pmol/L or 74 pmol/L, respectively (36).

Statistical analyses. Statistical analyses were performed using the Stata software package (Stata 8.0) (37). Descriptive data analysis was carried out to characterize iron status and related indicators. Normality tests and transformations were applied. Student t and χ^2 tests were used to examine the significance of differences in risk characteristics associated with Hb concentrations and iron status markers, and linear and logistic regression analyses to examine associations between maternal characteristics (maternal age, parity, prepregnancy BMI, weight gain during pregnancy, leptin concentrations, infant birth weight, genitourinary infections, number of prenatal care visits, and self-reported smoking status) and iron status indicators. Paired t tests were used to assess differences in adolescents for whom longitudinal changes were evaluated. Differences were

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[3] Abbreviations used: Hb, hemoglobin; MCE, Maternity Center East; 5-MTHFA, 5-methyltetrahydrofolic acid; STD, sexually transmitted disease; sTfR, soluble transferrin receptor; R:F ratio, sTfR:serum ferritin ratio, both units expressed as μg/L.

TABLE 1

Characteristics of pregnant African-American adolescents[1]

Characteristic	
Maternal age, *y*	16.5 ± 1.1 (13.5–18.2)
Prepregnancy BMI, *kg/m^2*	24.3 ± 4.96 (16.9–36.9)
Birth weight, *g*	3198 ± 471 (1648–4275)
Parity, %	
Primagravida	72.5
Gravida 2	20
Gravida 3	6.3
Gravida 4	1.3
Infection, %	
STD	21.3
Bacterial vaginosis	28.7
Chlamydia	10
Trichomonas	12.5
Monilia	3.8
Currently smoking, %	12.5

[1] Values are means ± SD (range) or %, $n = 80$.

considered significant at $P < 0.05$. Values in the text are means ± SD.

RESULTS

Subject characteristics. Adolescents involved in this study ($n = 80$) ranged from 13 to 18 y of age, with 31% < 16 y old (**Table 1**). Gynecological age was 4.9 ± 1.8 y. Of the 80 teens recruited, 22 had ≥ 1 prior pregnancy before entering the study. Prepregnancy BMI of the adolescents ($n = 57$) indicated that 52.5% were overweight (BMI > 26.1 kg/m^2), 38.7% were normal weight (BMI 19.8–26.0 kg/m^2), and 8.7% were classified as underweight (BMI < 19.8 kg/m^2) at entry into prenatal care (Table 1). Body weight gain in subjects whose weight was recorded at delivery ($n = 26$) was 13 ± 5.4 kg, but ranged from a loss of 0.68 kg to a gain of 25.2 kg. The prevalence of genitourinary infections was high in this population. Among the adolescents for whom infant birth information was available ($n = 67$), 6% had babies born with low birth weight (<2500 g).

The biomarkers assessed (**Table 2**) indicated falling concentrations of Hb and serum ferritin concomitant with rising concentrations of sTfR and erythropoietin throughout pregnancy. Lower concentrations of body iron were evident among the 3rd trimester cohort relative to that in the 2nd trimester cohort (**Fig. 1**). Among the 23 adolescents studied longitudinally, body iron ($P < 0.0001$) and ferritin ($P < 0.0001$) were lower during the 3rd trimester compared with the 2nd trimester. Iron status markers did not differ between those studied longitudinally compared with cross sectionally, with the exception of higher sTfR concentrations during the 3rd trimester for adolescents contributing blood once (5.9 ± 1.8 mg/L, $n = 34$) compared with those contributing twice (4.6 ± 0.65 mg/L, $n = 14$, $P < 0.001$).

High Hb concentrations were prevalent, 55.8% among the 1st trimester cohort ($n = 43$), falling to 25.6% among the 2nd trimester cohort ($n = 39$), and 14.3% in the last trimester cohort ($n = 70$). The highest proportion in the normal range was found during the 2nd trimester, 43.6% compared with 34.9 and 22.9% in the normal range during the 1st and 3rd trimesters, respectively.

The prevalences of iron depletion, deficiency, and anemia based on different indicators were determined by trimester (**Table 3**). For all indicators, there was a rise in the prevalence of compromised iron status during the 3rd trimester. Possible determinants of iron deficiency and iron-deficiency anemia were explored using multiple regression and logistic regression analyses. Age and parity significantly predicted Hb levels during 1st trimester only ($P = 0.004$, $r = 0.50$). Increasing age and primagravida classification had a significant protective effect against low Hb concentrations. The iron status indicators, serum folate and vitamin B-12 concentrations, and Hb concentrations were not associated with the presence of sexually transmitted diseases (STDs), smoking status, total number of prenatal visits, BMI, or serum leptin concentrations. To assess the relation between iron status indicators, infection, and inflammation, a number of analyses were conducted using the variables of white blood cell counts, the presence of sexually transmitted infections, and various iron status indicators, with no significant correlations found.

Iron status indicators were examined in relation to each other for their predictive performance in determining iron depletion and iron deficiency anemia throughout pregnancy. Hb concentrations were inversely associated with the sTfR:ferritin concentration ratio during the 2nd trimester ($P = 0.015$, $r = -0.59$). Among the study cohort with longitudinal data available, adolescents with depleted iron stores (R:F > 300) during the 2nd trimester were 12 times more likely to be classified with iron deficiency anemia during their 3rd trimester (odds ratio 12.5, 95% CI 2.83, 55.25, $P = 0.0002$, $n = 23$). Applying logistic regression, no associations were found between iron repletion and high Hb status during the 2nd and 3rd trimesters.

TABLE 2

Iron status indicators for pregnant African-American adolescents[1]

	n	2nd Trimester	*n*	3rd Trimester
Hb, *g/L*	35	111.2 ± 11.4 (78, 130)	70	107.2 ± 12.1 (81, 138)
Hematocrit	35	0.33 ± 0.03 (0.27, 0.38)	70	0.32 ± 0.03 (0.26, 0.40)
Erythropoietin, *IU/L*	44	18.03 ± 12.31 (7.77, 86.84)	59	33.89 ± 21.36 (7.13, 128.58)
Serum ferritin,[2] *μg/L*	44	33.7 ± 23.3 (6.7, 124.0)	59	15.2 ± 10.1 (3.9, 42.9)
Serum sTfR,[2] *mg/L*	40	4.32 ± 0.90 (2.71, 7.67)	48	5.52 ± 1.65 (3.7, 10.57)
sTfR:ferritin ratio	40	192.4 ± 169.5 (30.9, 852.1)	48	569.5 ± 435.8 (93.2, 1779.2)
Body iron,[3] *mg/kg*	40	5.46 ± 2.62 (−0.89, 11.05)	48	1.56 ± 2.78 (−3.54, 7.07)
Serum leptin, *μg/L*	44	18.46 ± 9.87 (3.95, 5.62)	55	21.37 ± 12.25 (3.41, 6.28)

[1] Data are presented as the mean ± SD (95% CI) unless otherwise indicated.

[2] Geometric means.

[3] Body iron, (mg/kg) = −[log(sTfR:ferritin) − 2.8229]/0.1207. To convert body iron concentrations from mg/kg to mmol/kg, divide by 55.847.

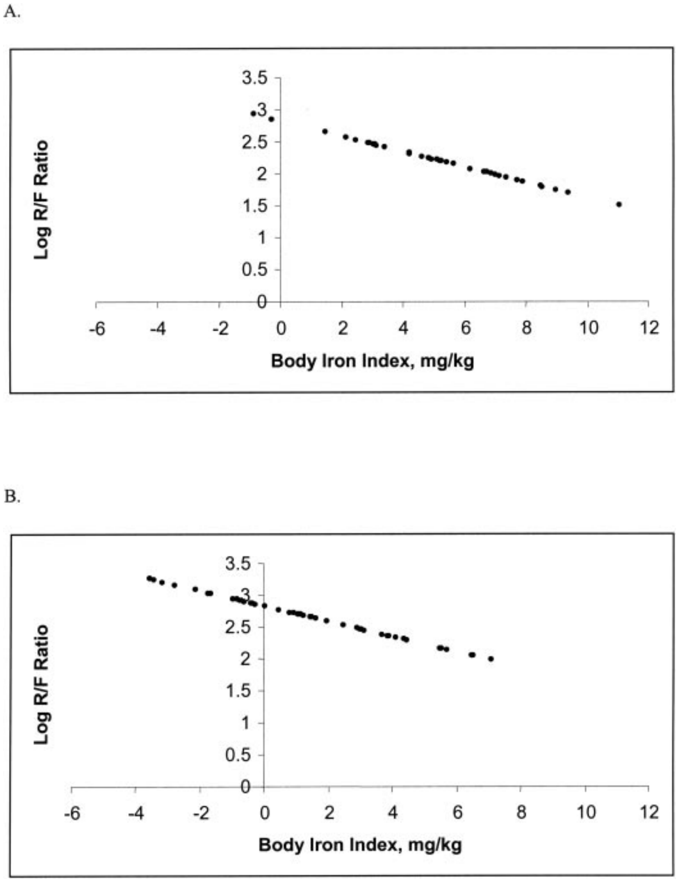

FIGURE 1 Estimated body iron reserves [log (sTfr:ferritin ratio) − 2.8229]/0.1207] (33) and the log of the sTfR:serum ferritin ratio (R:F ratio) for the 2nd trimester cohort (18.1 ± 2.0 wk gestation, $n = 40$; *panel A*) and the 3rd trimester cohort (28.3 ± 2.3 wk gestation, $n = 48$; *panel B*). Negative values are indicative of depleted body iron reserves. During the 2nd trimester, 5% of the cohort studied had depleted body iron, increasing to 31.3% among the 3rd trimester cohort ($P < 0.01$ by χ^2 test). To convert body iron concentrations from mg/kg to mmol/kg, divide by 55.847.

A number of covariates were examined in relation to the body iron indicators in both univariate and multivariate regression and logistic analyses. Body iron was positively associated with Hb concentrations during the 2nd ($P = 0.02$, $r = 0.57$) and 3rd trimesters ($P = 0.01$, $r = 0.35$). Adolescents were predicted to fall below body iron = 0, the cutoff value for depleted iron reserves, when Hb concentrations were 95.5 g/L during the 2nd trimester and 105.1 g/L during the 3rd trimester. Body iron and serum erythropoietin were not correlated. Body iron concentration was not associated with age, smoking status, infection, or parity.

Serum folate concentration was 39.3 ± 15.4 nmol/L, RBC folate was 2378 ± 971 nmol/L, and serum vitamin B-12 concentration was 313 ± 163 pmol/L; 88% of the teenagers had folate levels indicative of positive folate balance (>22.7 nmol/L). Only 1 study participant had a serum folate concentration < 6.8 nmol/L, an indication of early folate depletion, and no participants had vitamin B-12 depletion (<111 pmol/L) or deficiency (<74 pmol/L). Serum folate and vitamin B-12 concentrations were not correlated with any of the iron status indicators measured.

DISCUSSION

Although there are data for Hb concentrations in pregnant adolescents, few studies have reported on other iron status indicators among this group. A recently published analysis by the CDC of the 3rd National Health and Nutrition Examination Survey (38) found mean Hb concentrations in nonpregnant, African-American girls to be 125 ± 8.9 g/L at 12–14 y and 123 ± 10 g/L at 15–19 y. This is comparatively higher than those found for our cohort during the 2nd and 3rd trimesters, 111 ± 11.4 and 107 ± 12.1 g/L, respectively.

To characterize the degree of iron depletion and deficiency apparent in these adolescents, our study employed a broad range of biomarkers in addition to Hb and hematocrit markers. We found significant drops in serum ferritin concentrations coincident with increasing concentrations of sTfR and erythropoietin in later trimester cohorts. This was consistent with other studies among pregnant adults showing similar trends (39). Measured erythropoietin concentrations during the 2nd (18.03 ± 12.31 IU/L) and 3rd trimesters (33.89 ± 21.36 IU/L) were slightly elevated compared with those found in older pregnant populations, 17.12 ± 4.7 and 31.43 ± 14.13 IU/L, respectively (40). Moreover, the R:F ratio was significantly correlated with Hb concentrations and, when used with the cutoff value (>300), was highly predictive of 3rd trimester iron deficiency anemia. Parity and age were both risk factors

TABLE 3

Prevalence of iron depletion, deficiency, and anemia in pregnant African-American adolescents

		Depleted Fe stores (Ferritin)[1]	Depleted Fe stores (sTfR:Ferritin)[2]	Tissue Fe deficiency (sTfR)[3]	Depleted Fe reserves (body iron)[4] (Hb + ferritin)[5]	Iron deficiency anemia	Anemia (Hb)[6]
2nd Trimester	*n*	44	40	40	40	61	39
	%	25.0	12.5	0	5.0	3.3	30.8
3rd Trimester	*n*	59	48	48	48	46	70
	%	61.0	29.2	6.3	31.3	50.0	62.9

[1] Depleted iron stores defined by serum ferritin (μg/L) ≤15.0.
[2] Depleted iron stores defined by sTfR:ferritin ratio >300.
[3] Tissue iron deficiency defined by sTfR > 8.5 mg/L.
[4] Body iron deficiency defined by body iron < 0; body iron, mg/kg = −[log(sTfR:Fer) − 2.8229]/0.1207.
[5] Iron deficiency anemia defined as Hb < 110 g/L for 1st/3rd trimester; <105 g/L 2nd trimester and serum ferritin concentration ≤15 μg/L.
[6] Anemia defined as Hb (g/L) < 110 1st/3rd trimester; <105 g/L 2nd trimester.

for anemia during the 1st trimester and should also be part of screening and targeting considerations.

The prevalence of iron depletion and deficiency was markedly high during the 3rd trimester in these African-American adolescents. Our study uniquely applied a new method for estimating body iron, (41) in a pregnant adolescent cohort. We were able to assess differences across gestation and across different populations in spite of the possible limitations of this method yet to be fully explored in pregnant women. In a study of anemic, pregnant Jamaican women at a mean age of 23 y, body iron was 0.085 ± 4.48 mg/kg (0.0015 ± 0.0802 mmol/kg) during the 2nd trimester (42). Results from a study in Bolivia among mothers of young children showed body iron to be 3.88 ± 4.31 mg/kg, (0.069 ± 0.077 mmol/kg) with 15% exhibiting body iron deficiency (43). The African-American adolescents in our study had a body iron concentration of 5.46 ± 2.62 mg/kg (0.098 ± 0.047 mmol/kg) in the 2nd trimester cohort, which fell to 1.56 ± 2.78 mg/kg (0.028 ± 0.050 mmol/kg) in the 3rd trimester cohort, i.e., 5 and 31.4%, respectively, exhibited depleted body iron reserves.

The functional consequences of low body iron are yet to be comprehensively described. Serum ferritin in these youth was substantially lower and serum sTfR was higher than those in adult pregnant women (44). When the 2 components of body iron are combined, serum sTfR as a measure of iron available for tissues and the rate of erythropoiesis and serum ferritin as a marker of stores, the accuracy of diagnosing iron deficiency anemia is improved (45). Our study demonstrated important associations between body iron and Hb concentrations.

At the other end of the spectrum, high Hb concentrations (>120 g/L) were also evident among this population. Other studies have reported associations of high Hb concentration with adverse birth outcomes (46). Poor blood volume expansion has been posited as one explanation, although there may be other environmental factors such as indoor smoke (47). Our study found no significant differences in iron status indicators between adolescents classified with high Hb and those below this cutoff point. This supports our contention that the high Hb concentrations are not caused primarily by iron repletion and may be more indicative of failure of the plasma volume to appropriately expand. Additional studies addressing this are warranted.

The status of folate and vitamin B-12 was investigated in this study because of the increased demands for these vitamins during pregnancy and their relation to hematopoiesis and megaloblastic anemia (36), and the potential risk of deficiencies in the study population. Although other international studies assessed pregnant adolescents and identified marginal to negative balance of these nutrients (48,49), we are aware of no other data on folate and vitamin B-12 status in pregnant adolescents from the United States with which to compare our values. A recent study examined plasma 5-methyltetrahydrofolic acid (5-MTHFA) concentrations in 116 pregnant African-American women (24.5 ± 5.4 y) in relation to dietary consumption of folate, smoking, and alcohol consumption (50). Plasma 5-MTHFA concentration was 40.8 ± 16.1 nmol/L compared with a serum folate concentration of 39.3 ± 15.4 nmol/L among pregnant adolescents in our study. A prospective cohort study among low- to middle-income pregnant women ($n = 2026$) residing in North Carolina reported serum folate as 47.8 ± 24.9 nmol/L and RBC folate as 1054.8 ± 450.9 nmol/L (51). Another study involving low-income, pregnant women found that RBC folate levels were assay dependent; by chemiluminescence, the concentration was 1450 ± 32 nmol/L (52). In both of these studies, RBC folate as the indicator of longer-term tissue stores appeared to be lower than the finding from our study (2378 ± 971 nmol/L) although still sufficiently above what is considered normal or early negative folate balance (<453.2 nmol/L).

One potential explanation for the generally higher levels may be the recent fortification requirements for grain products by the FDA in 1998 (53). Ecological studies showed concomitant rises in these markers in similar populations during this period (54). The study assessing folate status in pregnant African Americans found that fortified foods contributed 198 ± 98 μg/d, or >50% of the total dietary folate equivalents. The primary fortified foods consumed were cold cereal, orange juice, milk, French fries, and breads, respectively (55). Other factors found to be significantly associated with folate status included smoking exposure and alcohol consumption, which were not measured comprehensively in our study.

In the United States, there is no one recommended iron supplementation regimen. In 1993 the policy of routine supplementation during pregnancy was redefined. These recommendations specified that pregnant women with Hb concentration either <90 g/L, or between 90 and 109 g/L with serum ferritin < 12 μg/L, are expected to increase normal supplemental oral dose of 30 mg/d to 60–120 mg/d (56). At the MCE clinic, 1 of 2 prenatal multivitamins is prescribed initially, containing either 40 mg of ferrous fumarate or 90 mg of carbonyl iron. If the adolescent's Hb concentration is <110 g/L, an additional 195 mg (65 mg as ferrous sulfate 3 times/d) is recommended with incremental increases in dosage according to tolerance. Although compliance in this study was not carefully observed, there was indication of poor compliance through self-reporting. Insufficient data currently exist on the optimal way to promote and educate this age group about the importance of prenatal diet and supplementation. Moreover, due to limitations in medical resources, nutritional counseling is frequently not adequately supported.

In this population of African-American pregnant adolescents, we found iron stores to be significantly depleted and iron deficiency anemia highly prevalent during the 3rd trimester. Folate and vitamin B-12 status appeared to be sufficient. Targeted screening and improved services including dietary recommendations and iron supplementation are warranted among this at-risk group of adolescents.

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