Hemoglobin Levels and Dietary Iron in Pubescent Children in a Biracial Community

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DIFFERENCES IN HEMOGLOBIN LEVELS between U.S. blacks and whites (*1–4*) may not be due largely to differences in dietary iron intake. Some authors have concluded from this observation that clinical standards for treatment of anemia should differ for blacks and whites (*4,5*). To elucidate this question, we examined girls and boys at different stages of puberty in an entire biracial community. A community such as this permits a description of the consequences of iron loss after menarche in both white and black girls. The racial comparison was complemented by observations on boys, whose increasing hemoglobin levels during adolescence coincide with their increasing anabolic androgens. Nutrient intakes were quantitated by a 24-hour dietary recall (*6,7*).

Study Population and Methods

All children residing in Ward 4 (Bogalusa) of Washington Parish, La., were eligible for the study. The community had a total population of 22,371 (1970 U.S. Census)—29.5 percent black and 70.4 percent white (26 persons were classed as "other race"). Bogalusa is a semirural, one-industry (paper and chemical) community, typical of many small southern towns. Based on the 1970 census, the annual per capita income of Bogalusa blacks ($1,199) was 55 percent less than that of whites ($2,673). Furthermore, almost one-half (45.3 percent) of all black families earned less than the U.S. Census poverty level, in contrast to 15.5 percent of all white families.

During the 1976–77 school year, 87.8 percent of 4,639 Ward-4 children, ages 5 to 17 years, were screened for cardiovascular disease risk factors. The racial composition of those children studied was 64.6 percent white and 35.4 percent black. Appropriate written permission was obtained from a parent or guardian of each child. Hemoglobin levels were not obtained on 85 (2 percent) of the 4,074 examined school children. All determinations were made in our Core Laboratory in New Orleans by use of a cyanmethemoglobin method (Hycel Inc., Houston, Tex., provides a pamphlet: "Cyanmethemoglobin Reagent"). Duplicate blood samples were collected randomly throughout the study from 430 school children. All samples were labeled (blind controls were given a blind identification number at the venipuncture station) and analyzed independently in a blind manner for assessment of pos-

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sible human errors in all procedural steps in the entire chain of events from brachial vein puncture to computer printout. No resulting hemoglobin values were rejected. The standard deviation for the measurement error ($SD = \sqrt{\frac{(X_1 - X_2)^2}{n}}$ where X_1 = sample, X_2 = blind duplicate, and n = number of these pairs) assessed in this manner was 0.36 g/dl, and the coefficient of variation ($SD/\overline{X}$, where $\overline{X}$ is the mean of all samples) was 2.62 percent.

Nutrient intake was determined for a 50 percent random subsample of 185 Bogalusa children representing all 10-year-olds in 1973–74 (*6*) and for 148 of those children age 13 in 1976–77. A 24-hour dietary recall method adapted for children was used (*7*). The methodology includes the use of graduated food models, visual aids, actual home and school lunch recipes, and probing questions to enhance complete and accurate recall. Dietary recalls for each child were analyzed by use of a computerized food composition table, "Extended Table of Nutrient Values" (*8*), for nutrient composition. We present here only results indicative of iron intake. More extensive analyses of the diets were published earlier (*6*).

Results

The means and standard error for hemoglobin levels by race and sex are shown in the chart. White children had significantly higher levels of hemoglobin at every age level, except age 13 boys. For this analysis, the children were divided into three age groups: before (5–9), during (10–13), and after (14–17) pubescence. The difference in hemoglobin levels between the races increased by 0.2 g/dl in boys and 0.6 g/dl in girls from ages 10–13 to 14–17, as shown in table 1 (*9*). Clinical anemia (hemoglobin $<$ 11 g/dl) occurred mostly in younger black boys and older black girls.

Iron intakes according to 24-hour dietary recalls for the 185 children age 10 in 1973–74 were 12.5 ± 0.7 mg (mean ± 2 SE) for white boys, 11.3 ± 0.9 mg for white girls, 13.5 ± 1.3 mg for black boys, and 13.4 ± 1.3 mg for black girls. The recommended dietary allowance (RDA) for iron (*10*) was not achieved by 49 percent of the girls. Similar recalls for 148 of the same children at age 13 in 1976–77 reflected lower iron intakes for black girls, 12.0 ± 1.8 mg, than for the other groups—17.5 ± 2.8, white boys; 17.3 ± 9.8 mg, white girls; and 17.4 ± 3.7 mg, black boys (much higher than the median for black boys because of a high reading for 1 boy). Iron intakes for the sample of 13-year-olds were compared with the RDA, and the children were categorized into two race-sex groups: group A, those achieving RDA ($\geq$ 18 mg per day) and group B, those not achieving RDA ($<$ 18 mg), as shown in table 2.

Table 1. Hemoglobin levels (g/dl, mean ± 2 SE) and occurrence of anemia before, during, and after pubescence, by race and sex, Bogalusa Heart Study, 1976–77

Race and sex	Age group (years)		
	5–9	10–13	14–17
	Number examined		
White boys	520	420	398
Black boys	232	244	240
White girls	517	355	374
Black girls	248	215	226
	Hemoglobin levels		
White boys	13.4 ± 0.1	14.1 ± 0.1	15.5 ± 0.1
Black boys	12.7 ± 0.1	13.3 ± 0.2	14.5 ± 0.2
White girls	13.4 ± 0.1	13.9 ± 0.1	14.1 ± 0.1
Black girls	12.8 ± 0.1	13.4 ± 0.2	13.0 ± 0.2
	Number anemic [1]		
White boys	1	1	0
Black boys	9	6	0
White girls	1	0	2
Black girls	5	0	10

[1] Less than 11 g/dl hemoglobin, adapted from O'Neal and associates (*9*).

The mean intakes of animal and vegetable protein, lactose, and ascorbic acid were also observed for each group. Animal protein was higher than vegetable protein intake for all children. Animal protein intakes for group A were approximately twice as high as the animal protein intakes of group B. In addition, for each sex-race category, group B children had less vegetable protein and ascorbic acid than children in group A. The proportion of lactose (indicating milk as a source of low-iron animal protein) to animal protein was greater for children not achieving the iron RDA than for children achieving it.

The iron RDA was not achieved by 89 percent of the black girls and 86 percent of the white girls. However, the mean hemoglobin levels of children who achieved the RDA were only slightly lower than those of children who did not.

Black girls had a median iron intake of 11 mg over the 24 hours compared to 10 mg for white girls and 15 mg for boys of both races. As an index of the availability of dietary iron (*11*), we used the median amount of animal protein minus the median amount of lactose ingested during the 24-hour period. We assumed that lactose intake indicates an equal amount of milk pro-

Table 2. Hemoglobin levels and 24-hour intake of nutrients indicative of iron absorption in children age 13, by race, sex, and iron intake status according to RDA [1] (mean ± 2 SE), Bogalusa Heart Study, 1976–77

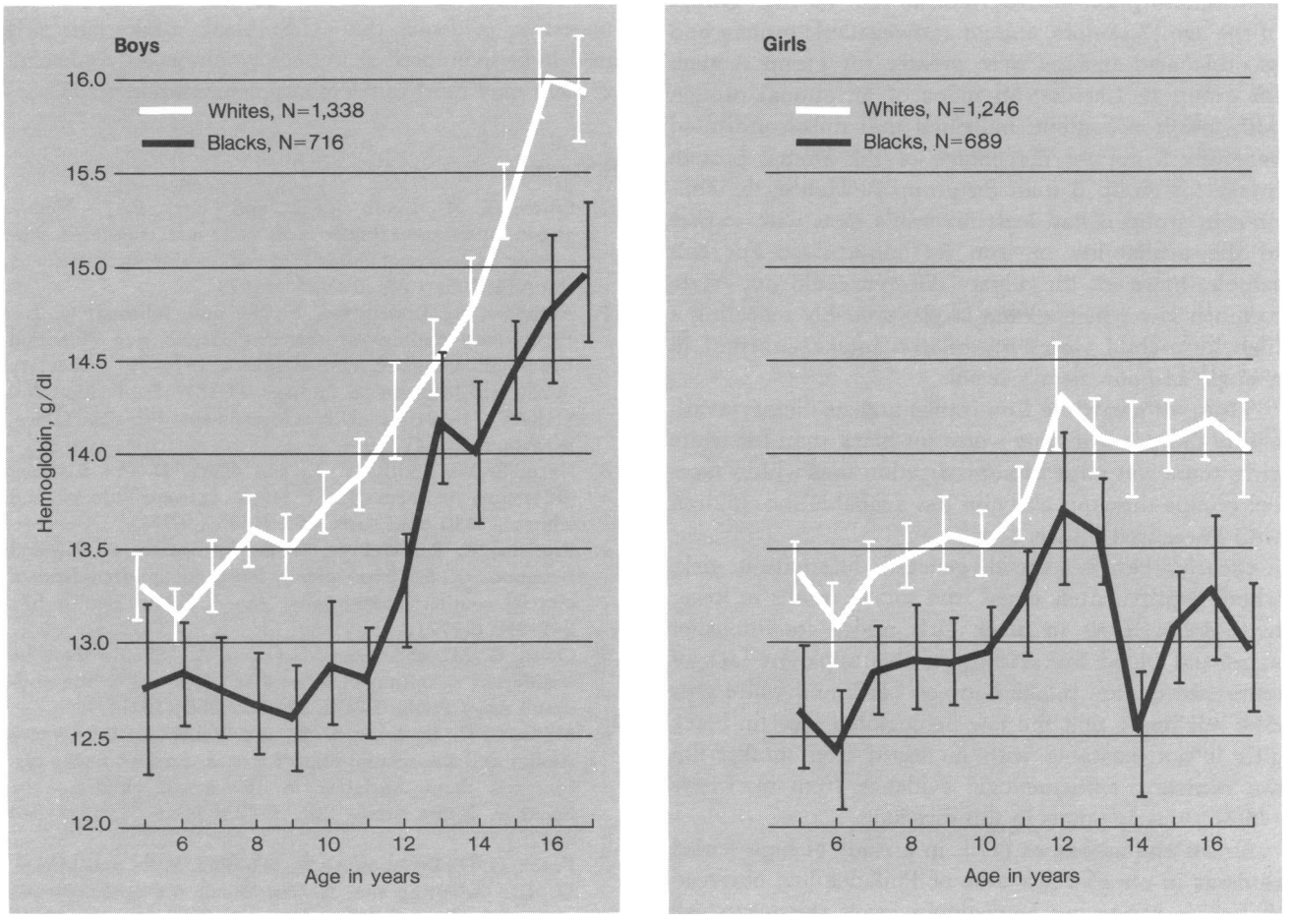
Achievement of iron RDA [2]	Number	Animal protein (g)	Vegetable protein (g)	Lactose (g)	Ascorbic acid (mg)	Hemoglobin (g/dl)
White boys:						
Group A, yes	20	103 ± 27	36 ± 13	31 ± 10	161 ± 138	14.8 ± 0.5
Group B, no	29	45 ± 7	18 ± 3	17 ± 4	40 ± 17	14.5 ± 0.4
Black boys:						
Group A, yes	10	81 ± 25	32 ± 9	28 ± 12	136 ± 74	14.8 ± 0.6
Group B, no	19	37 ± 7	24 ± 4	20 ± 7	30 ± 19	14.3 ± 0.3
White girls:						
Group A, yes	6	78 ± 34	25 ± 4	20 ± 10	142 ± 123	13.6 ± 1.1
Group B, no	[3] 36(34)	39 ± 8	16 ± 2	16 ± 4	60 ± 25	14.3 ± 0.6
Black girls:						
Group A, yes	3	52 ± 37	27 ± 15	22 ± 17	120 ± 95	13.9 ± 1.0
Group B, no	[3] 25(24)	37 ± 8	20 ± 4	13 ± 5	94 ± 41	13.5 ± 0.4

[1] Recommended dietary allowance (*10*). The marked deficiency in iron intake among girls recorded here was not noted when they were 10 years old (see text).

[2] Group A, ≥ 18 mg per day; group B, < 18 mg per day.

[3] Sample size for hemoglobin in parentheses, if different from that of dietary intake sample size.

Hemoglobin levels (mean ± 2 SE) in white and black children 5–17 years old, Bogalusa Heart Study, 1976–77



NOTE: After age 13 a gap in hemoglobin levels between white and black children becomes apparent. Although all frequency distributions are skewed to the higher levels, the means of untransformed data are reported here for reasons of simplicity and uniformity.

tein intake. For black girls this index was 24 g, for white girls 19 g, for black boys 25 g, and for white boys 34 g. Thus, for black girls not only the amount of iron intake but also its availability was not unfavorable compared to that of the white girls. Also, median ascorbic acid intake by the black girls was 74 mg, more than for any other group.

Discussion

The hemoglobin patterns presented here are in close agreement with the hematocrit patterns from the National Health Examination Survey (*12*). The greater racial difference noted in black girls, ages 13–17, may relate to borderline iron intake inadequate for loss related to menstruation (*13*). Remedial iron intake may be especially urgent when the girls enter the childbearing age. Our previous studies have shown slightly higher birth weights for black and white infants born in private hospitals than for those born in State-supported hospitals in the community (*14*).

Iron absorption varies for foods of animal (10–30 percent) and vegetable (2–10 percent) sources; however, a mixed diet also adequate in ascorbic acid enhances absorption (*15,16*). For all four race-sex groups of the age 13 sample, animal and vegetable protein and ascorbic acid intakes were greater for group A than for group B. Lactose, an index of an animal protein with low iron content, indicated that milk constituted generally a greater percentage of the animal protein intake for group B than for group A. Hence, the children in group B had least favorable diets with respect to the availability of iron for absorption. For this sample, however, the dietary difference did not relate to much lower hemoglobin levels, probably reflecting a high intra-child variability of iron intake, inherent in a single 24-hour dietary recall.

Thus, although the iron intake and its dietary availability did not seem any worse for black than for white girls, there was some broad indication that within race-sex groups this iron was also less available for children with lower iron intake.

Clearly, there is a racial (genetic) difference in girls, where approximately equal iron intake results in lower hemoglobin levels in black girls under conditions of menstrual blood loss. However, this apparent lack of difference in iron intake between black and white girls does not imply that the low hemoglobin level in black girls is not treatable with increased iron intake. On the contrary, epidemiologic evidence from elsewhere (*16,17*) clearly points in this direction.

Brown and associates (*17*), in a study of high school students in an all-black area of Philadelphia, observed that with decreasing hemoglobin levels the mean cell volume as well as the mean corpuscular hemoglobin decreased. Thus, in the hemoglobin range of 10.0–11.5 g/dl, there were signs of iron deficiency. Data from the National Health Survey (*12*) showed that in children aged 12–17, including age 13 black girls, the hematocrit tended to decrease with decreasing socioeconomic class.

The increasing hemoglobin levels with age in boys during adolescence (see chart) point to the likely involvement of anabolic androgens in this age period (*18*).

Practical questions remain to be answered. What is the critical level of hemoglobin in childbearing women below which iron should be supplemented? Are eating patterns analyzed to plan the most complementary diet? The apparent racial difference in genetic determinants does not necessarily indicate that hemoglobin criteria for treatment or dietary intervention should be determined solely by (*a*) the level at which the deleterious effects of anemia become apparent and (*b*) the magnitude of response to iron therapy. Subtle differences in folic acid intake have to be explored, and the influences of improved dietary practices on childbearing women (*19*) should be documented. In spite of these caveats, however, the present data add to the suggestive evidence that U.S. black adolescent girls need to be monitored as to hemoglobin levels, and some of them may need nutrient supplementation.

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SYNOPSIS

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Although differences in hemoglobin levels between blacks and whites may be due in part to genetic influences, low hemoglobin levels in black girls of childbearing age may nevertheless constitute a health hazard. To study this problem, hemoglobin levels were examined in children of a biracial community not only before but also during and after puberty and menarche. At the same time, 24-hour dietary recalls of a representative group of 13-year-olds in the same population were examined with respect to the intake of iron and nutrients influencing iron absorption.

In black girls, hemoglobin levels dropped after menarche, accompanied by a diet marginal in iron and in iron-absorption-promoting nutrients. Questions as to hemoglobin levels compatible with optimum health remain, and racial differences and genetic influences on levels should not be an excuse for failure to address this problem. More investigational studies are also needed to observe responses to an optimum dietary iron intake.