Iron Deficiency Anemia Among Three Groups of Adolescents and Young Adults

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This study was initiated in order to estimate and compare the occurrence of nutritional anemia in three groups of adolescents and young adults. The first group comprised 159 individuals aged 14–21, who had been previously screened for thalassemia in three Connecticut cities. The second group was made up of 163 Derby High School students, aged 14–18, who had also been previously screened for thalassemia. The third group consisted of 118 Yale undergraduate students, aged 16–21, who were monitored for nutritional anemia while undergoing routine physical examinations at the Yale University Health Service.

The prevalence of nutritional anemia varied from 0.0 percent to 5.5 percent among the three male groups, and from 4.4 percent to 17.9 percent among the three female groups. Only the Yale undergraduate male group was found to be free from this condition. The Yale undergraduate females were discovered to have the highest prevalence. Mean hemoglobin levels of the male and female groups were also compared.

INTRODUCTION

Iron deficiency anemia, as a term, is almost interchangeable with nutritional anemia and represents the most prevalent deficiency of early childhood in the United States [1,2]. Its frequency has even prompted the suggestion that it is the most frequent disorder seen in clinical medicine [3]. Although usually considered benign, iron deficiency anemia may have serious debilitating effects. These include: a decreased resistance to infection [4–7], an impaired immune response [8], symptoms of irritability and fatigue [9], a diminished capacity for work and activity, and lowered intellectual motivation and performance [10,11].

While its frequency of occurrence has been well documented in infants and preschool age groups of children, there has been relatively little study of this condition among older adolescents and young adults. Undoubtedly, the most reliable population data are those collected in the Health and Nutrition Examination Survey (HANES) of the National Center for Health Statistics [12]. These data, based on blood specimens collected primarily by venipuncture from a national probability sample, indicate that in the age groups 12–17 and 18–19, mean hemoglobin levels of males are consistently higher than females. A thorough examination of the mean differences among females of reproductive age found that they could not have been due to differences in iron nutriture, as measured by transferrin saturator values [13]. Furthermore, white males and females have higher mean hemoglobin values than blacks at all ages; reasons for this have been explored elsewhere [14–18].

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The purpose of this report is to present the prevalence of iron deficiency as found in three groups of adolescents and young adults, and also to relate these findings to socioeconomic status as measured by a residential indicator. Such estimates may help determine whether nutritional anemia is a public health problem among high school and college age groups.

METHODS

The first group studied in this investigation was composed of 159 persons, 14–21 years of age, who participated in a thalassemia minor screening program at three Greek Orthodox churches in Connecticut sponsored by the Connecticut Campaign Against Cooley's Anemia, a lay and professional volunteer organization. The second group included 163 students from one high school in Derby, Connecticut, who were also screened for thalassemia minor by this organization. Thalassemia may be described simply as an inherited inability to produce adequate quantities of either the α or β types of polypeptide chain of normal adult hemoglobin. Persons with thalassemia minor exhibit the heterozygous form of this condition, which is inherited singly as a trait, and may exhibit mild clinical symptoms of anemia or no symptoms whatsoever. Any individual found to have thalassemia trait in either of these groups was excluded from the present investigation. The third study group was composed of 118 Yale University undergraduates 21 years of age and under who underwent a general physical examination, without any presenting medical problem, at the Yale University Health Services over an uninterrupted two-month period (November–December 1977). In all three groups, venous blood was drawn and analyzed with a Coulter Model S electronic counter. Blacks were excluded from the study since hemoglobin levels are known to vary by race, and the numbers of blacks in each group were too small to be able to analyze separately.

Criteria used to diagnose iron deficiency anemia were a hemoglobin level of less than 12.5 gm/dl and a mean corpuscular volume (MCV) level of less than 80 μ3 in males, and a hemoglobin level of less than 12.0 gm/dl and a mean corpuscular volume level of less than 80 μ3 in females. These are the limits suggested by Wintrobe [19] and often used to characterize iron deficiency and microcytosis. While no differential diagnosis for low MCV values was made, and microcytosis may certainly result from other conditions, it is reasonable to assume that in the populations studied iron deficiency is the major cause of microcytosis.

It was not possible to conduct an individualized socioeconomic work-up on every person tested in this study. Alternatively, the first two groups were rated as entities according to the Groff-Wright Scale [20,21], a socioeconomic index which ranks geographic areas (both census tracts and towns) in Connecticut. The formula used for this ranking accounts for educational, occupational, and family income levels of the residents in each area. Geographic localities are designated into one of five social rank areas (1 = highest, 5 = lowest). Addresses of individuals who participated in this study were matched to social rank areas in order to categorize their socioeconomic status. Over 90 percent of the first study group comprised individuals residing in areas classified as social rank 1; the remainder resided in areas classified as social rank 2. The second study group consisted entirely of residents of social rank 4 areas.

Since Yale undergraduates tend to come from a variety of socioeconomic and geographic backgrounds, a single composite of the group could not be attained. The group was, however, divided into these living on campus (in dormitories) and off-campus to see if there existed a different prevalence of nutritional anemia between these groups.
RESULTS

Mean hemoglobin and mean MCV values are presented for the three groups, by sex, in Table 1. There were no overall significant differences in the mean MCV levels among the three groups of males when compared through an analysis of variance. (The assumption of homoskedasticity was previously shown to be satisfied by using Bartlett's test [22].) While no significant overall difference was noted, certain more specific comparisons of mean hemoglobin values were made as suggested by the data. Results of the specific contrasts tested, by using Scheffe's test, are presented in Table 2. This test has the advantageous property of allowing any number of comparisons, selected by inspection of the data, while protecting the intended level of statistical significance [22]. Among males it can be observed that the only significant pairwise comparison is that which compares the Derby High School males with the Yale undergraduate males. Furthermore, when the mean hemoglobin level of Yale undergraduate males is contrasted against the church-screen male group and Derby High School male group, a statistically significant difference is still observed (Table 2).

An analysis of variance for the comparison of the mean hemoglobin levels of the three female groups showed a significant overall difference (F = 13.58, p < 0.05). Specific contrasts done by Scheffe's test are given in Table 3. The Yale undergraduate females had a significantly lower mean hemoglobin level than both the church-screen females and the Derby High School females.

The mean ages of the males and females in the three study groups are presented in Table 4, and it is evident that the Yale undergraduates were somewhat older, on average, than the other two groups. In order to take into account the effect of age on hemoglobin status, mean hemoglobin levels found in this study were compared with age-specific means from the U.S. Health and Nutrition Examination Survey which are presented in Table 5. As can be seen, mean hemoglobin levels are 1.2 gm/dl higher among males over 18 years of age relative to males of ages 12-17. This would tend to underscore the finding of a lower mean hemoglobin value of the Yale undergraduate males, who were older, on average, than the other two groups. Among females, the national data depict no meaningful differences between the three age groups listed in Table 5. The differences found in mean hemoglobin levels between the three female groups, therefore, could not be explained by the somewhat older mean age of the Yale undergraduates. The mean hemoglobin levels of the church-

| Group* | Sex | Number Studied | Mean Hb (gm/dl) | S.E. | Mean MCV (µl) | S.E. |
|--------|-----|----------------|-----------------|------|---------------|------|
| 1      | Male| 65             | 14.8            | 0.94 | 87.7          | 4.10 |
|        | Female| 94         | 13.5            | 1.24 | 88.9          | 4.25 |
| 2      | Male| 73             | 15.1            | 0.80 | 84.2          | 3.12 |
|        | Female| 90         | 13.9            | 0.68 | 85.2          | 3.10 |
| 3      | Male| 62             | 14.5            | 0.69 | 87.3          | 3.53 |
|        | Female| 56         | 12.8            | 0.87 | 86.6          | 3.76 |

*Group 1 = Church-screen
Group 2 = Derby High School
Group 3 = Yale undergraduates
screen and Derby High School females are quite similar to those found in the national probability sample, while the Yale undergraduates had a lower mean level.

The prevalence of iron deficiency anemia as found among the three groups studied is shown in Table 6. As can be seen, the prevalence varied from 0.0 percent to 5.5 percent among the males, and from 4.4 percent to 17.9 percent among the females. A chi-square test for difference on proportions showed no significant difference in the proportion of males with nutritional anemia between the groups ($x^2 = 2.79; p > 0.05$). However a significant difference in the proportion of females with nutritional anemia was noted between the three groups ($x^2 = 8.36; p < 0.05$).

A number of more specific comparisons were conducted within the overall group of females. First, a comparison between the first two groups of females showed no significant difference in the proportion with nutritional anemia ($x^2 = 0.36; p > 0.05$). These two female groups were then combined and tested against the Yale undergraduate females. Another chi-square test was done and this did indicate a significant difference in the proportion of females with nutritional anemia ($x^2 = 7.73; p < 0.05$).

Sixty percent of the males and 71.4 percent of the females studied resided on

### Table 2
Specific Mean Contrasts Among Males, Using Scheffé's Test*

| Contrast * | L' | S.E. (L) | Degrees of Freedom | F-Ratio |
|------------|----|----------|-------------------|--------|
| A vs. B   | 0.300 | 0.180     | (2,197)          | 1.67 not significant; $p > 0.05$ |
| A vs. C   | 0.400 | 0.192     | (2,197)          | 2.08 not significant; $p > 0.05$ |
| B vs. C   | 0.700 | 0.187     | (2,197)          | 3.74 significant; $p < 0.05$ |
| B vs. A,C | 0.500 | 0.155     | (2,197)          | 3.23 significant; $p < 0.05$ |
| C vs. A,B | 0.500 | 0.161     | (2,197)          | 3.11 significant; $p < 0.05$ |

* L = linear combination of mean hemoglobin values; $L = \lambda_1 \bar{x}_1 + \lambda_2 \bar{x}_2 + \ldots + \lambda_n \bar{x}_n$ where $\lambda$'s are fixed numbers.

S.E. (L) = Standard error of $L$, which is $\sqrt{\sum \lambda^2 / \sigma / \sqrt{n}}$

F-Ratio = $L / S.E. (L)$

For a fuller explanation of Scheffé's Test, see [22].

*A = Church screen group
B = Derby High School group
C = Yale undergraduates

### Table 3
Specific Mean Contrasts Among Females, Using Scheffé's Test*

| Contrast * | L | S.E. (L) | Degrees of Freedom | F-Ratio |
|------------|---|----------|-------------------|--------|
| A vs. B   | 0.400 | 0.148     | (2,237)          | 2.70 not significant; $p > 0.05$ |
| A vs. C   | 0.700 | 0.198     | (2,237)          | 3.54 significant; $p < 0.05$ |
| B vs. C   | 0.900 | 0.199     | (2,237)          | 4.50 significant; $p < 0.05$ |
| C vs. A,B | 0.900 | 0.179     | (2,237)          | 5.03 significant; $p < 0.05$ |

* L = linear combination of mean hemoglobin values; $L = \lambda_1 \bar{x}_1 + \lambda_2 \bar{x}_2 + \ldots + \lambda_n \bar{x}_n$ where $\lambda$'s are fixed numbers.

S.E. (L) = Standard error of $L$, which is $\sqrt{\sum \lambda^2 / \sigma / \sqrt{n}}$

F-Ratio = $L / S.E. (L)$

For a fuller explanation of Scheffé's Test, see [22].

*A = Church screen group
B = Derby High School group
C = Yale undergraduates
campus. Although there was a slightly higher prevalence of iron deficiency among males and females who resided on campus, differences were not statistically significant.

DISCUSSION

It is well documented that children from lower socioeconomic class groups have a greater prevalence of iron-deficiency anemia than other children [14–18]. This study, however, did not find differences between two groups of adolescents and young adults with dissimilar socioeconomic status, but did find rates which were of an important magnitude. This tends to confirm the results of the Ten-State Nutrition Survey, 1968–1970 [22], which discovered anemia in all the population subgroups studied regardless of socioeconomic status. Other surveys have also reported significant rates of anemia in populations which were deemed to be of “middle class” or higher status [23, 24].

The results in the Yale undergraduate group were somewhat surprising. The most important finding was a 17.9 percent prevalence of iron-deficiency anemia among the females, which was significantly greater than the prevalence in either of the other two female groups. The reasons for this are not readily apparent, although menstrual iron losses may have a greater effect on this group in light of their being of a greater mean age than the other female groups.

Dietary habits must be regarded as conceivable causes for the alarming prevalence of nutritional anemia in this group. Although no dietary histories were collected, the

### TABLE 4
Number of Individuals Tested for Nutritional Anemia and Mean Age of the Three Groups Tested

| Group | No. Tested | Mean Age |
|-------|------------|----------|
| 1 Males | 65 | 16.2 |
| Females | 94 | 16.6 |
| 2 Males | 73 | 16.0 |
| Females | 90 | 16.2 |
| 3 Males | 62 | 19.0 |
| Females | 86 | 18.9 |

### TABLE 5
Mean Hemoglobin Levels, Standard Errors, and Selected Percentiles of White Adolescents and Young Adults in the United States, 1971–74, by Age Group and Sex [12]

| Age    | Mean | Standard Error | 5th | 10th | 50th | 95th |
|--------|------|----------------|-----|------|------|------|
|        |      |                |     |      |      |      |
| **Males** |      |                |     |      |      |      |
| 12–17  | 14.7 | .05            | 12.9| 13.2 | 14.6 | 16.7 |
| 18–19  | 15.9 | .06            | 14.2| 14.7 | 15.9 | 17.6 |
| 20–24  | 15.9 | .07            | 14.3| 14.7 | 15.9 | 17.5 |
| **Females** |      |                |     |      |      |      |
| 12–17  | 13.7 | .07            | 12.1| 12.4 | 13.7 | 15.5 |
| 18–19  | 13.8 | .11            | 12.2| 12.6 | 13.7 | 15.4 |
| 20–24  | 13.7 | .06            | 12.1| 12.5 | 13.7 | 15.3 |
The effect of dieting to promote weight-loss might be a contributory factor. Many foods with high caloric content are also good sources of iron (red meats, iron-enriched bread, etc.), therefore, it is plausible to infer that certain reduction regimens may concomitantly limit iron intake.

The absence of iron-deficiency anemia among the male undergraduates may signify better eating habits among this group and/or may underscore the importance of menstrual losses in females.

An awareness of the existence of nutritional anemia can only be the first step in an active effort aimed at dealing with the problems created by it. Nutritional counseling and iron supplementation may be indicated in adolescents and young adults identified as being iron-deficient. In terms of prevention, nutritional counseling can be focused at youths and their families, and should include information on body iron requirements, and iron content of common food items. Emphasis should be placed on the need for well-balanced meals. Female college students would also appear to benefit from a well-focused nutritional counseling program.

The fortification of foods with iron, as a strategy, has both strengths and weaknesses. It cannot be denied that at least some youths would benefit from a generalized enrichment of foodstuffs with iron; however, the extent to which it would alleviate this condition in any population remains in question. Any doubt as to its efficacy persists mainly because of widely differing dietary habits among individuals. There would certainly be some adolescents and young adults missed by such a program and it may be these same individuals who have the poorest eating habits. Also, there is a small group of persons who have disorders of iron metabolism (hemochromatosis, etc.) who might be harmed by a widespread program of iron-fortification.

In summary, nutritional anemia is a significant public health problem among the three groups of adolescents and young adults studied in this work. If the results of this investigation are borne out by other such studies, family physicians, local health and school officials, and university health plans can be made aware that nutritional anemia is of important magnitude.

Nutritional counseling, iron supplementation, and iron-fortification of foods may serve as integrated parts of a program aimed at alleviating the burden of this condition in youths. Such programs might include one or more of these strategies. Furthermore, these programs may encompass different scopes and be directed at specific groups. Their goal, however, should be a common one—to reduce the occurrence of nutritional anemia among adolescents and young adults.

### TABLE 6

Prevalence of Nutritional Anemia as Found Among the Three Groups Studied, by Sex

| Group | Males | No. Tested | No. Anemic | Prevalence (%) |
|-------|-------|------------|------------|----------------|
| 1     | Males | 65         | 3          | 4.6            |
|       | Females | 94         | 6          | 6.4            |
| 2     | Males | 73         | 3          | 5.5            |
|       | Females | 90         | 4          | 4.4            |
| 3     | Males | 62         | 0          | 0.0            |
|       | Females | 86         | 10         | 17.9           |
| Total | Males | 200        | 6          | 3.0            |
|       | Females | 270        | 20         | 7.4            |
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