Supplementation with Iron and Folic Acid Enhances Growth in Adolescent Indian Girls[1,2]

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ABSTRACT The prevalence of anemia is high in adolescent girls in India, with over 70% anemic. Iron-folic acid (IFA) supplements have been shown to enhance adolescent growth elsewhere in the world. To confirm these results in India, a study was conducted in urban areas of Vadodora, India to investigate the effect of IFA supplements on hemoglobin, hunger and growth in adolescent girls 10–18 y of age. Results show that there was a high demand for IFA supplements and >90% of the girls consumed 85 out of 90 tablets provided. There was an increment of 17.3 g/L hemoglobin in the group of girls receiving IFA supplements, whereas hemoglobin decreased slightly in girls in the control group. Girls and parents reported that girls increased their food intake. A significant weight gain of 0.83 kg was seen in the intervention group, whereas girls in the control group showed little weight gain. The growth increment was greater in the 10- to 14-y-old age group than in the 15- to18-y-old group, as expected, due to rapid growth during the adolescent spurt. IFA supplementation is recommended for growth promotion among adolescents who are underweight. J. Nutr. 130: 452S–455S, 2000.

KEY WORDS: • *adolescent girls* • *growth* • *iron* • *folic acid* • *India*

Iron deficiency anemia is a widespread deficiency in adolescents of developing countries. In an 11-country study >40% of adolescents were anemic [hemoglobin (Hb)[4] < 115 g/L] in the Asian countries including Nepal and India (Kurz 1996). A review of Indian studies on anemia in adolescent girls revealed that >70% of adolescent girls in low income communities had Hb levels <110 g/L. When the WHO cutoff of 120 g/L was applied, the prevalence was even higher (80–90%) (Kanani and Ghanekar 1997).

Iron requirements are increased during adolescence, reaching a maximum at peak growth, and remaining almost as high in girls after menarche to replace menstrual losses. Adolescent iron requirements are even higher in developing countries because of infectious diseases and parasitic infestations that cause iron loss, and because of low bioavailability of iron from diets limited in heme iron. Low iron status among adolescents may limit their growth spurt (Brabin and Brabin 1992). Anemic girls are at risk of compromised physical and mental functions, and they may also be at increased obstetric risk, once pregnant. In India, to combat the pervasive problem of anemia, initiation of iron supplementation early in the adolescent years has been recommended (Gopalan 1989), but is not yet being implemented.

According to Gillespie (1998), iron and folic acid supplementation is one of the most important nutritional interventions for adolescent girls. Folic acid is included within the iron supplement to prevent folate deficiency, which is implicated in the etiology of anemia and associated with neural tube defects of the newborn. Supplementation with folic acid before pregnancy offers a better chance of preventing neural tube defects than if given during pregnancy (Gillespie 1997).

Iron-folic acid (IFA) supplementation has been shown to enhance adolescent growth. In Kenya, Lawless et al. (1994) supplemented 87 primary school children with 55 mg elemental iron per day for 14 wk and reported a positive effect on growth and appetite that was significantly better than that in children receiving the placebo. The positive effect of iron supplementation on growth of their subjects was likely due to their improved appetite and increased food intake. If iron does enhance growth, it can be promoted in programs instead of food supplementation, which is more expensive and less feasible.

To confirm the results of Lawless et al. (1994) in the South Asian context, we undertook an intervention study to investigate the feasibility, compliance and effect of giving daily IFA supplements for 3 mo on Hb levels, perceived hunger and growth of unmarried, urban, low income adolescent girls in Vadodara (Baroda), Gujarat, India.

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[4] Abbreviations used: BMI, body mass index; Hb, hemoglobin; IFA, iron-folic acid.

Measuring Hunger
Checklist of questions

1. Do you feel hungry at mealtime? Yes = 2 No = 1
2. Do you feel hungry at times other than mealtime? Yes = 2 No = 1
3. Do your family members (specify) feel that you eat as much as you ought to? Yes = 2 No = 1
4. Do you think you eat as much as you did earlier? (For example a month back?) Yes = 2 No = 1

Rating Scale

Circle the number, which indicates your level of hunger: the lower the score, the less hungry you feel.

1 2 3 4 5 6 7 8 9 10

Analysis

Category	Score by checklist	Score by rating scale
Less hungry	4, 5, 6	1–4
More hungry	7, 8	5–10

FIGURE 1 Measuring hunger: checklist of questions, rating scale and analysis.

SUBJECTS AND METHODS

Sample. This study was conducted in three low income communities of Vadodara, a community in which the first author has worked closely with adolescent girls for 7 y on community-based youth projects implemented by a voluntary organization, the Baroda Citizens Council. Because many girls marry before the age of 18, and this study enrolled only unmarried girls, the sample of 15- to 18-y-old girls was considerably smaller than the sample of 10- to 14-y-old girls. For feasibility reasons and to ensure similar sample sizes, the two smaller communities were combined with respect to the intervention. Through random allocation, the larger community became the experimental group and the two smaller ones became the control group. All unmarried girls 10–18 y of age, residing in the three communities, were considered eligible for the study and agreed to participate ($n = 210$). Pre- and postintervention data were available for 203 girls for anthropometry and 180 for hemoglobin.

Study design. This was an experimental placebo control study. Girls in the experimental group received iron folic acid tablets for 3 mo (60 mg of elemental iron + 0.5 mg folic acid per day); the control group received a similar-looking placebo tablet according to the same protocol. Girls were given 15 tablets in a sachet and asked to consume one tablet daily after the evening meal. Every 15 d, the leftover tablets, if any, were counted and the balance replenished for the next 15 d. If a girl was irregular in consumption, she was counseled on the importance of the tablets and (if needed) on how to cope with side effects.

Data collection. Weight and height were measured before and after the intervention with the use of standard techniques (Gibson 1989), and body mass index (BMI) was calculated. Blood hemoglobin was estimated by the cyanmethemoglobin method (Oser 1979) before and after intervention.

How the girls perceived their own hunger was assessed as a proxy for anorexia, which causes poor food intakes and therefore poor growth, and is associated with iron deficiency anemia. One objective of this study was to explore whether improving the iron status of adolescent girls would lead to their improved appetite and increased growth. Improved appetite is likely to induce a feeling of increased hunger as perceived by the girls, which, if satisfied through increased food intake, could lead to a more favorable energy balance, thus contributing to better weight and height gains. Because assessment of appetite in terms of increased food intake was not possible, two scales were developed to evaluate perceived hunger as reported by the girls before and after intervention (see **Fig. 1**). Methodological development of the scales was based on the visual analog scale for the perception of pain (Mottola 1993, Stratton et al. 1998). Data for the two scales were as follows: a checklist of questions regarding hunger, from which the answers were scored and added into a composite score; and a rating scale (1–10) of the degree of hunger as perceived by the subject, i.e., the lower the score, the lower the feeling of hunger (Fig. 1).

RESULTS

Baseline socioeconomic status, housing conditions, water supply and sanitation, and health facilities were similar in both communities. Similarly, baseline Hb and BMI did not differ (**Table 1**).

A high level of compliance with the supplements was achieved, i.e., 90% of the girls consumed >85 of the 90 tablets provided. Contributing factors could include the rapport with the girls through previous programs and the semimonthly monitoring. After the intervention, the girls requested that the tablets be continued, saying they felt an improved sense of well-being and were hungrier and more energetic. Baroda Citizens Council complied with this request by continuing to implement the supplementation program for girls who continued to be anemic.

Table 2 summarizes the effect of the intervention on Hb levels, hunger scores, weight gains and BMI in the experimen-

TABLE 1

Baseline mean hemoglobin level and body mass index (BMI) of experimental and control groups

Indicator	Age range, *y*	Experimental group (A)		Control group (B)		Chi-square
		n	%	*n*	%	
Mothers literate	10–18	101	56	102	53	NS[1]
House has individual toilet	10–18	101	46	102	40	NS
		n	Mean ± SEM	*n*	Mean ± SEM	Student's *t* test A vs. B
Age of girls	10–18	101	12.4	102	12.0	NS
Family size	10–18	101	6.1	102	5.8	NS
Hemoglobin, *g/DL*	10–14	75	10.80 ± 1.2	78	10.93 ± 1.3	NS
	15–18	16	11.16 ± 0.29	11	10.75 ± 0.34	NS
Body mass index	10–14	81	14.10 ± 0.20	89	14.08 ± 0.22	NS
	15–18	20	17.09 ± 0.51	13	17.48 ± 0.91	NS

[1] NS, values are nonsignificant ($P > 0.05$).

TABLE 2

Changes in hemoglobin levels, perceived hunger scores, weight and body mass index BMI after the iron-folic acid intervention (10–18 y)

Indicator	Experimental group[1]				Control group[1]				Students t value A vs. B
	n	Initial	Final	Change (A)	n	Initial	Final	Change (B)	
Hemoglobin, g/dL	91	10.87 ± 0.11	12.61 ± 0.08	1.73 ± 0.11	89	10.91 ± 0.12	10.82 ± 0.11	−0.08 ± 0.03	14.47
Hunger score									
Checklist	101	6.01 ± 0.11	6.90 ± 0.06	0.89 ± 0.11	102	6.16 ± 0.10	6.54 ± 0.08	0.37 ± 0.07	3.79
Rating scale	101	4.47 ± 0.20	6.03 ± 0.14	1.55 ± 0.12	102	5.76 ± 0.23	6.23 ± 0.19	0.49 ± 0.08	7.31
Weight kg	101	28.54 ± 0.77	29.39 ± 0.77	0.83 ± 0.09	102	27.19 ± 0.86	27.22 ± 0.85	0.04 ± 0.06	7.22
BMI	101	14.69 ± 0.22	14.70 ± 0.23	0.00 ± 0.05	102	14.51 ± 0.25	14.16 ± 0.26	−0.35 ± 0.03	5.39

[1] Values are means ± SEM; significant at $P < 0.001$.

tal compared with the control group. There was an increment of 17.3 g/L Hb in the group that received IFA supplementation, whereas the controls showed a slight decrease in Hb levels. Increase in perceived level of hunger was consistently and significantly higher in the experimental group after intervention compared with the control group. Spontaneous responses from several experimental group subjects as well as their parents indicated that the food intake of the girls had increased during the study period. Some girls specifically stated that they ate more food than before the study. A significant weight gain of 0.83 kg was seen in the experimental group, whereas the controls showed little weight gain. The experimental group also had a significantly better BMI response to supplementation than the control group. In the case of BMI, however, the experimental group exhibited no change, whereas the control showed a decrease. This may have occurred because the m^2 term (denominator of BMI) was increasing at a faster rate than weight (numerator). Differences in the change in height-for-age were not analyzed because they were not expected to be significant, although height gains in both groups were anticipated.

The differential effect of the intervention on nutritional status between the younger (10–14 y) and older (15–18 y) girls was compared because the rate of pubertal growth was expected to be greatest in early adolescence (**Table 3**). Among the experimental subjects, the increments in mean Hb levels and weight-for-age were more pronounced in the younger than in the older girls, and they were also significantly higher than the increments of the controls. In addition, at postintervention, there was a more pronounced increase in the hunger scores in the younger girls by the checklist compared with the older girls (+0.92 vs. + 0.75). This is perhaps because the younger girls were more anemic and were less hungry than the older girls before the intervention (Hb 108 vs. 112 g/L, respectively). Among the older girls, although Hb levels and hunger scores improved significantly compared with the controls, the weight and BMI changes were not significantly higher than controls. This could also be because of the smaller sample size of the older girls. Thus, the effect on growth in the overall group was explained by the significant difference seen in the younger age group. The age-related trends in Hb levels, perceived hunger and weight-for-age were not seen in the control group, with the initial and final values being similar in both age groups.

DISCUSSION

This study demonstrated that daily iron supplements of 60 mg elemental iron and 0.5 mg folic acid for 3 mo improved growth significantly among adolescent girls compared with

TABLE 3

Comparative impact of Iron-Folic Acid Intervention on the Nutritional Status of the younger and the older adolescent girls (10–14 years versus 15–18 years)

Mean change	Age groups (y)	n	Experimental group[1] (A)	n	Control group[1] (B)	Student's t value A vs. B
Hemoglobin, g/dL	10–14	75	1.84 ± 0.11	78	−0.08 ± 0.03	15.48
	15–18	16	1.23 ± 0.05	11	−0.15 ± 0.11	9.16
Hunger score						
Checklist	10–14	81	0.93 ± 0.13	89	0.34 ± 0.08	3.69
	15–18	20	0.75 ± 0.24	13	0.23 ± 0.19	1.67
Rating scale	10–14	81	1.56 ± 0.13	89	0.48 ± 0.09	6.94
	15–18	20	1.55 ± 0.31	13	0.54 ± 0.21	2.71**
Weight (kg)	10–14	81	0.90 ± 0.09	89	0.05 ± 0.07	7.51
	15–18	20	0.53 ± 0.21	13	−0.23 ± 0.22	0.97 (NS)
BMI	10–14	81	−0.03 ± 0.06	89	−0.40 ± 0.04	4.71
	15–18	20	0.14 ± 0.11	13	−0.08 ± 0.06	0.42 (NS)

[1] Values are means ± SEM; *significant at $P < 0.001$; NS, not significant.

controls. A subsequent study showed similar results among 9- to 16-y-old school girls (Kanani et al., unpublished data).

The mechanism by which supplemental iron and folic acid improve growth has not been clearly delineated. Improved appetite and subsequent improvement in food intake could be a factor as suggested by Lawless et al. (1994) and in this study. Although appetite was not assessed (as was done by Lawless and co-workers) with ad libitum intake of food, the indirect measures of improved appetite used in this study, i.e., perceived hunger scores and the feedback from the girls and parents that they consumed greater amounts of food than they had earlier, suggest that appetite had improved after the IFA supplementation.

The younger age group (10–14 y) experienced greater increases in growth in weight and BMI than did the older group (15–18 y). This was expected because the younger ages correspond with the adolescent growth spurt and the highest iron needs (Brabin and Brabin 1992, Srikantia 1989). In addition, the younger adolescents are easier to reach than the older ones because more of them will still be in primary school. IFA supplementation is recommended for girls throughout schools in India, especially for its growth-promoting benefits. It appears to have the potential for maximum benefit at minimum cost.

In addition to improving hematinic status and growth, IFA supplementation to adolescent girls has other added benefits such as improved cognition. This was observed in a study among American adolescent girls who were iron deficient yet not anemic (Bruner et al. 1996). Even in the absence of anemia, oral ferrous sulfate (650 mg twice daily) for 8 wk improved some aspects of cognitive functioning compared with placebo controls. Improved cognition may lead to better academic performance, which may be an incentive for girls to remain in school.

The strong association between anemia and reproductive health is well known and it is being realized increasingly that it is usually too late to begin to address anemia in pregnancy, given the large prepregnancy iron deficits and the added demands of pregnancy for iron. Thus, as Gopalan (1989) suggests, opportunities provided by the precious years of adolescence before marriage and the childbearing that usually follows soon thereafter should not be wasted by the health system. Adolescent girls should be supplied regularly with IFA supplements so that they can enter pregnancy with no serious iron deficiency handicaps.

What about compliance? Our experience with adolescent girls and our compliance data clearly reveal that most adolescent girls are enthusiastic about consuming iron tablets and continue until the necessary supplementation duration, provided they are counseled about the benefits of IFA, are reassured in case of side effects and parental support is sought. Compared with pregnant women, girls are usually less anxious about tablets being "hot" or having deleterious effects, and they are also more willing to consume the tablets.

Thus, iron-folate interventions hold the potential for not only improving Hb levels, but also enhancing growth among disadvantaged adolescent girls. Further epidemiologic and programmatic research is called for to gain understanding of the iron-growth relationships in adolescence and the mechanisms by which iron improves growth.

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