Results and Discussion

Chapter IV

RESULTS AND DISCUSSION

This chapter presents the findings of this research in accordance with the *major objective:* to study the impact of daily and. intermittent (once and twice weekly) iron folic acid supplementation on hemoglobin levels, pubertal growth, food and nutrient intake, cognitive function and physical work capacity among underprivileged primary school going girls in early adolescence (9 –13 years) of Vadodara.

Prior to studying impact, the baseline profile of the girls was studied which is presented in Section I. The intervention has been described in the previous chapter. Section II presents the process evaluation data and section III, the impact evaluation of the intervention and discusses the findings. Thus, this chapter presents the results organized in three major sections as below:

Section I: Baseline Survey

- Socio-economic characteristics of the girls
- Nutritional status of the girls
  - Prevalence of anemia
  - Weight-for-age, Height-for-age and BMI
  - Morbidity profile
  - Food and nutrient intake
- Perception of the girls regarding anemia
- Cognitive abilities of the girls
- Physical work capacity of the girls

Section II: Process Evaluation

- Distribution of IFA and compliance with iron folic acid supplementation: comparison between daily, once weekly and twice weekly regimens
- Benefits and side effects experienced by the girls with the three intervention regimens
- Spot observations in school: involvement and interest of teachers and principal

Section III: Impact of the Iron-Folic Acid Supplementation Intervention On:

- Hemoglobin levels and prevalence of anemia
- Growth: Weight-for-age, Height-for-age and Body Mass Index
- Food and nutrient Intake
- Cognitive abilities
- Physical work capacity

Section I: Baseline Survey

Before initiating the interventions a baseline survey was done to assess the present nutritional status of schoolgirls in early adolescence and to measure specific aspects of physical work capacity and cognitive function. The perceptions of the girls regarding anemia: its causes, adverse effects and prevention-control were also determined. To compare the girls with their affluent counterparts from high income group (HIG) families, baseline nutritional status was also assessed of the girls of similar age from one HIG school. This section thus presents the results of the baseline survey conducted on the low income group (LIG) schoolgirls and high income group (HIG) schoolgirls.

Socio-Economic Profile of the School Girls

An overview of the study school girl's socio-economic characteristics (LIG) is given in **Table 4.1.1.** A majority of the girls followed Hindu religion; some also followed Muslim religion. The girls predominantly came from nuclear families with an average family size of five to eight members. Nearly half of the parents were educated only till primary level. A higher percentage of mothers were illiterate than were fathers. Most of the fathers of the girls were employed in low-income generating services such as peons or drivers in banks, hospitals, university, or as helpers in hotels. Almost half of the mothers were housewives or were employed as maids.

Table 4.1.1: Socio-Economic Profile of the Schoolgirls

Primary School Girls (N=358)					
Characteristics	**N**	**%**	**Characteristics**	**N**	**%**
1. Type of Family			**2. Family Size**		
• Nuclear	282	78.8	• ≤ 4 members	56	15.6
• Joint	72	20.1	• 5 - 8 Members	261	72.9
• Extended	4	1.1	• ≥ 9 Members	41	11.5
3. Father's Education			**4. Mother's Education**		
• Uneducated	38	10.6	• Uneducated	131	36.6
• Primary School	195	54.5	• Primary School	190	53.1
• Secondary/Higher School	123	34.4	• Secondary/Higher School	37	10.3
• Graduate/Above	4	1.1	• Graduate/Above	0	0.0
5. Father's Occupation			**6. Mother's Occupation**		
• Service	206	57.5	• Housewife	185	51.7
• Business / Self Employed	94	26.2	• Service	155	43.3
• Daily wage Labourer	53	14.8	• Business/ Self Employed	14	3.9
• Unemployed	5	1.5	• Daily wage Labourer	4	1.1
7. Type of House			**8. Total No. Of Rooms** (including Kitchen)		
• Pucca	217	60.6	• ≤ 2 rooms	266	74.3
• Semi-Pucca	106	29.6	• 3 – 4 rooms	89	24.9
• Kaccha	35	9.8	• ≥ 5 rooms	3	0.9
9. Access to Toilet Facilities			**10. Access to Drinking Water Facilities**		
• Independent at Home	167	46.7	• Own Tap at Home	174	48.6
• Community Toilet	135	37.7	• Common Tap	165	46.1
• Open defecation	56	15.6	• Hand Pump	19	5.3
11. Religion					
• Hindu	311	86.9			
• Muslim	45	12.6			
• Christian	2	0.6			

No Significant difference was found with regards to the above socio economic characteristics profile of the LIG girls studying in the four study schools (p>0.05).

As regards housing conditions, a majority of the girls lived in semi-pucca or pucca houses with less than three rooms. The defecation and drinking water facilities were less than adequate with only about 50% having their own toilet facility at home and the remaining were either using the common toilet or went to open fields in the area. There were drinking water taps within the house only in about half of the subjects while others collected water from the common municipal tap.

The overall socio-economic profile was not significantly different among the study girls of the four schools.

In the HIG girls, 97% were Hindu and were from nuclear families with less than five family members. Most parents had completed côllege graduation and had their own business or had jobs with private or government companies. All houses were pucca with more than five rooms, and had drinking water taps and independent toilets at home. In brief, their socio-economic environment was favorable with a better quality of life than the LIG girls.

Nutritional Status of the Study Girls

Prevalence of Anemia

Overall, the mean hemoglobin (Hb) was 11.32 g/dl in the LIG girls of the four schools (**Table 4.1.2**), with more than two-third (68.3%) of the girls being anemic (Hb <12 g/dl). The mean Hb and prevalence of anemia was similar in younger and older girls. The mean Hb of the anemic girls was 10.69 g/dl and that of non-anemics was 12.68 g/dl.

On the other hand, the mean Hb in HIG girls was 12.88 g/dl, with a low prevalence of anemia (18.6%).

Table 4.1.2: Mean Hemoglobin and Prevalence of Anemia[1] In the Girls

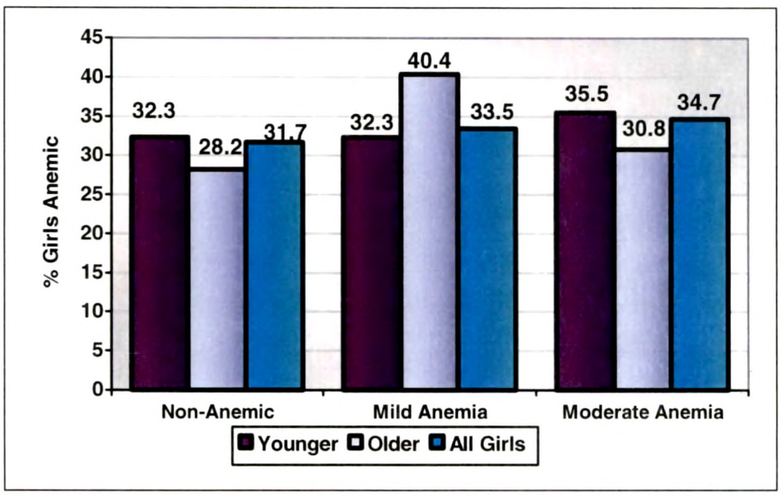
Age (Years)	LIG					HIG				
	N	Hemoglobin (g/dl)		% Anemic subjects		N	Hemoglobin (g/dl)		Anemic subjects	
		Mean	± SD	n	%		Mean	± SD	n	%
Younger and Older Girls										
9.0 - 11.9	282	11.32	± 1.29	191	67.7	41	12.89	± 0.95	7	17.5
12.0 – 13.9	52	11.33	± 1.30	37	71.2	20	12.87	± 0.86	4	21.1
All girls	334	11.32	± 1.29	228	68.3	61	12.88	± 0.91	11	18.6
Anemic and Non-Anemic Girls										
Anemic	228	10.69	± 1.01	-	-	11	11.69	± 0.66	-	-
Non-anemic	106	12.68	± 0.57	-	-	50	13.18	± 0.72	-	-
t value LIG anemic vs. non-anemics: 22.87***, HIG anemic vs. non-anemics: 6.40***										

[1]Hb < 12 g/dl, ***Significant at p<0.001

How Severe Was The Anemia Among The Present Study Girls?

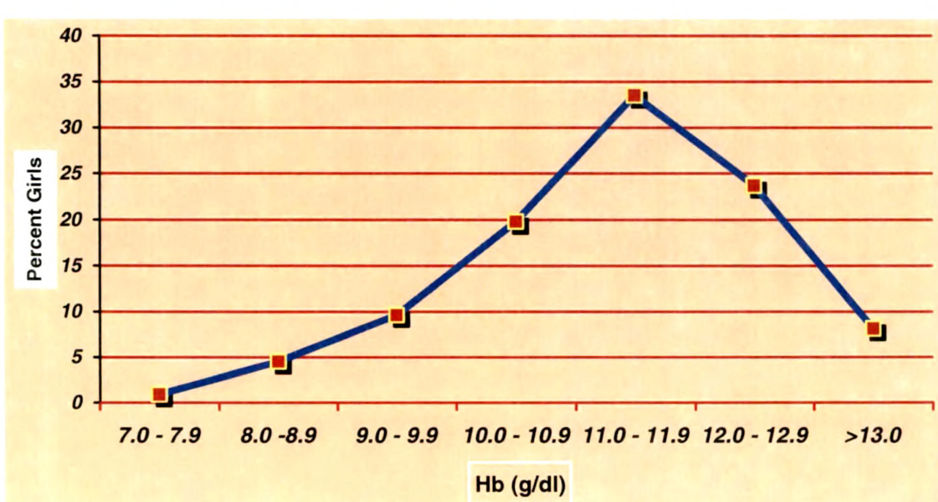
One-third of the girls were mildly anemic and another one-third moderately anemic (**Figure 4.1.1**). None of the girls was severely anemic (Hb <7 g/dl). The frequency distribution curve of the Hb levels among the girls clearly illustrates the high prevalence of anemia (**Figure 4.1.2**).

Figure 4.1.1 Severity of Anemia[1] In the Present Study Group Girls



Non-anemic: Hb ≥12 g/dl; Mild anemia: Hb=11.0 - 11.99 g/dl; Moderate anemia: Hb 7.0 - 10.9 g/dl. None of the girls was severely anemic i.e. Hb <7.0 g/dl
Younger girls: 9.0 to 11.9 yrs, Older girls: 12.0 to 13.9 yrs.

Figure 4.1.2: Frequency Distribution Curve of Hemoglobin Levels of Girls



Stunting and Undernutrition among the Girls

Table 4.1.3 gives the mean and median height-for-age, weight-for-age and body mass index (BMI) values of the LIG school girls, as well as these indices as percentage of the reference standards.

A) **Height:** The mean height of the girls was 135.3 cm; i.e. 93% of CDC standards. Prevalence of stunting was higher among older girls (47%) than younger girls (32%). **Figure 4.1.3 [a]** illustrates the height profile of the school girls compared to the reference standards (CDC 2000), Indian affluent children (Agarwal et al 1992) and Vadodara girls belonging to high income group. The present LIG girls lagged behind the CDC standards and Agarwal values as well as local HIG girls, except that present study younger girls (9-11 years) showed similar height as Indian affluent children.

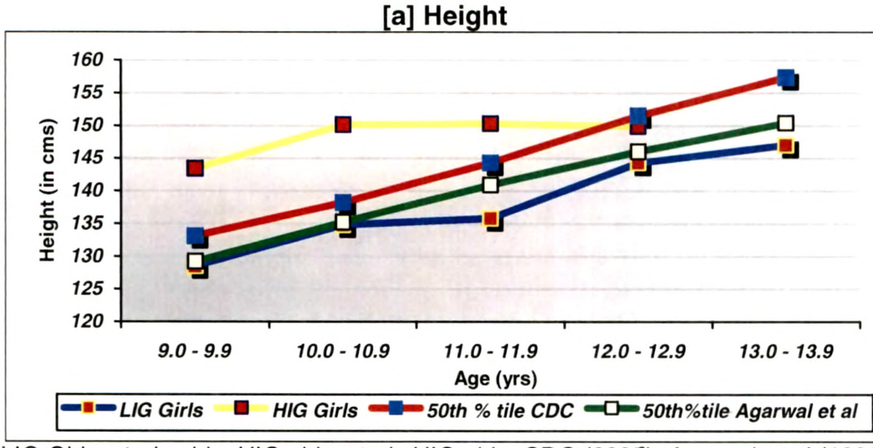
Table 4.1.3: Mean Height, Weight and BMI of the Girls Compared with Reference Standards

Age (Years)	N	Anthropometric Measurements			% Standard [1,2]			Girls < 5^{th} %tile Std[1,2]	
		Mean	± SD	Median	Mean	± SD	Median	N	%
Height (cm)									
Younger Girls (9-11yrs)	298	133.7	± 8.00	133.9	94.42	± 5.30	94.16	96	32.2
Older Girls (12-13 yrs)	60	143.0	± 8.19	144.8	91.55	± 5.49	93.01	28	46.7
All Girls	358	135.3	± 8.73	135.1	93.94	± 5.43	94.00	124	34.6
Weight (Kg)									
Younger Girls (9-11yr)	298	25.9	± 4.89	24.9	73.38	± 13.6	70.89	179	60.1
Older Girls (12-13 yrs)	60	31.4	± 5.36	31.5	69.02	± 12.0	68.47	42	70.0
All Girls	358	26.8	± 5.37	25.7	72.65	± 13.4	70.28	221	61.7
BMI (Kg/m^2)									
Younger Girls (9-11yrs)	298	14.4	± 1.65	14.2	84.46	± 9.96	82.90	166	55.7
Older Girls (12-13 yr)	60	15.3	± 1.82	15.1	81.88	± 9.47	80.25	39	65.0
All Girls	358	14.5	± 1.71	14.3	84.03	± 9.92	82.35	205	57.3

[1]Reference Standard for Height and Weight: CDC (2000), [2] Reference Standard for BMI: Must et al (1991)

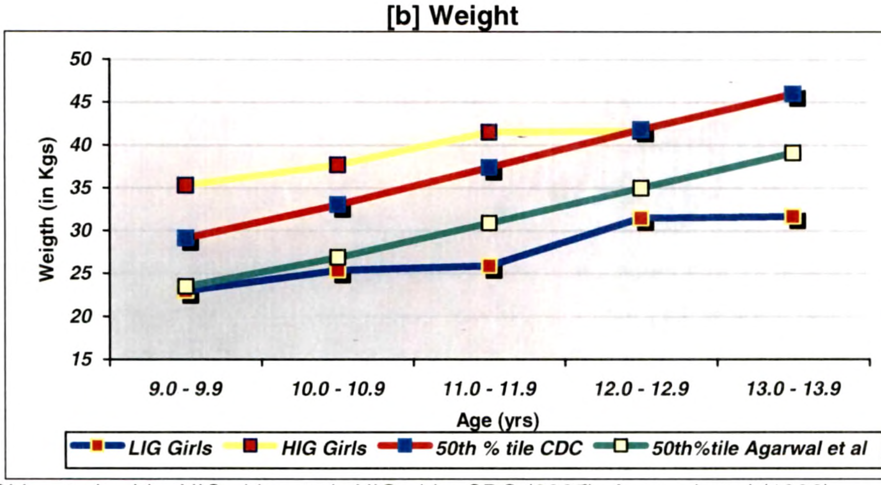
Figure 4.1.3: Height, Weight and BMI Profile of the Girls Compared to HIG Girls and Other Reference Standards

[a] Height



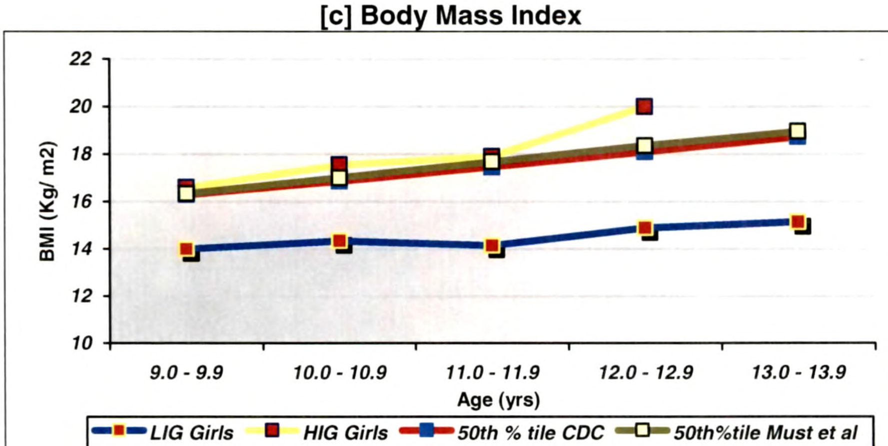
LIG Girls: study girls, HIG girls: study HIG girls, CDC (2000), Agarwal et al (1992)

[b] Weight



LIG Girls: study girls, HIG girls: study HIG girls, CDC (2000), Agarwal et al (1992)

[c] Body Mass Index



The mean height of HIG girls was 148.2 cm which was almost the same as the CDC standard for this age group (100.8%). Only 8.6% of the girls were stunted among these girls from higher income group families.

B) Weight: Mean weight of the girls was 26.8 KGS and the mean weight (as % CDC) was only 72.6% (**Table 4.1.3**). About two-third (61.7%) of the girls had weight deficits compared to the CDC standards for weight-for-age. The older girls had lower mean weight values (as % Std.) and more girls were below the 5th percentile of CDC standard than younger girls. The gap in weight of the present study girls and the standards increased with increase in age of the girls (**Figure 4.1.3 [b]**).

The HIG girls had mean weight-for-age slightly above the CDC standard (106%) and their mean weight was 41.03 Kgs. Only 9% girls had weight less than 5th percentile of CDC standard.

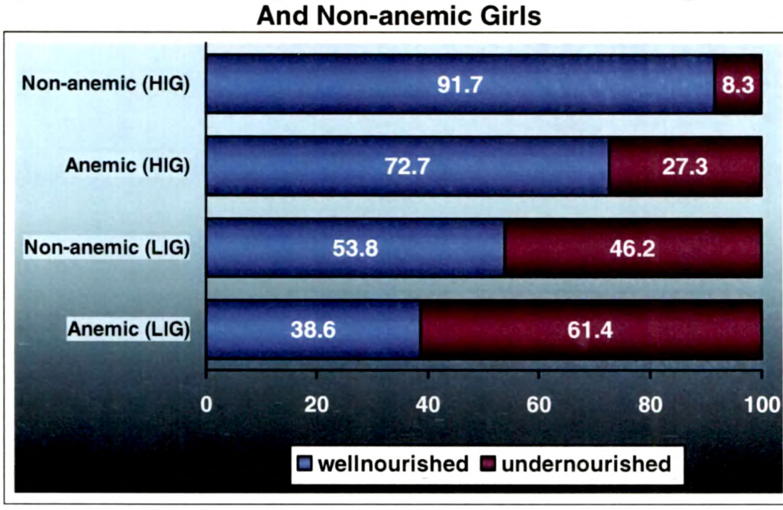
C) Body Mass Index: More than half of the girls had BMI <5th percentile of the standards (**Table 4.1.3**). The mean BMI was 14.5 (Kg/m^2); and was 84.03% of the Must et al standard. Among younger and older girls, again more of the older girls had BMI deficits, i.e. BMI <5th percentile standard (65%), compared to younger girls (56%). **Figure 4.1.3 [c]** clearly depicts the wide BMI deficits compared to the standards for these young girls in early adolescence.

The mean BMI of HIG girls (18.62 Kg/m^2) was higher than LIG girls; and when expressed as Must et al standard, the mean was more than 100% of the standard. Ten percent of the girls had below normal BMI.

Did Undernutrition In Terms BMI Differ Between Anemics And Non-Anemics?

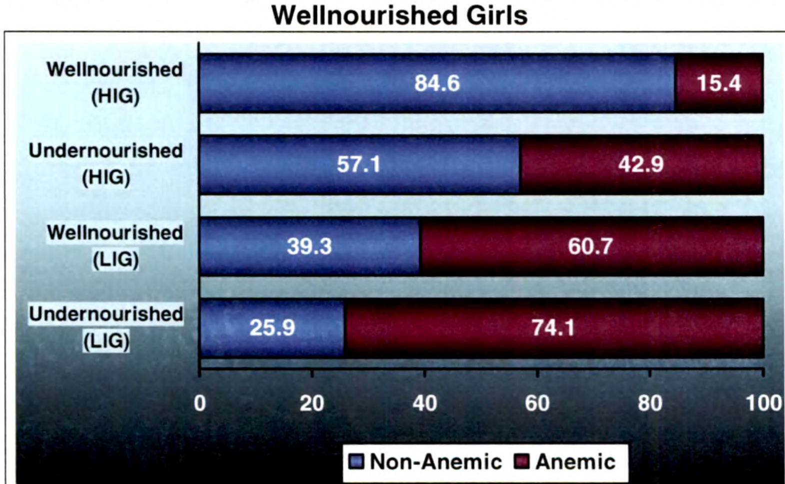
Figure 4.1.4 indicates that the percentage of girls who were undernourished was significantly higher in anemics than among non-anemic, both in HIG and LIG schools with difference being more marked in LIG girls. Almost two-third of the anemic girls were undernourished in LIG compared to less than half among non-anemics (61% vs. 46%). In HIG also, about one-fourth of the anemic girls were undernourished. Therefore, anemic status appears to aggravate undernutrition in girls entering puberty.

Figure 4.1.4: Percentage Girls Undernourished[1] Among Anemic[2] And Non-anemic Girls



[1]Undernourished: BMI <5th percentile Must et al (1991), [2] Anemic: Hb <12 g/dl,
Chi-Sq test anemic (LIG) vs non-anemic (LIG): $p < 0.05$

Figure 4.1.5: Percentage Girls Anemic[1] Among Undernourished[2] and Wellnourished Girls



[1] Anemic: Hb <12 g/dl, [2]Undernourished: BMI <5th percentile Must et al (1991),
Wellnourished (LIG) vs Undernourished (LIG): Chi-Sq test: $p<0.05$

Does Being Undernourished In Terms BMI Means Higher Chances Of Being Anemic?

Being undernourished in terms of BMI <5th percentile of Must et al standards, increases the chances of being anemic, especially among girls from lower economic background (LIG). The percentage of girls anemic was significantly higher among those who were undernourished than those who were wellnourished in LIG girls (**Figure 4.1.5**). Undernourished HIG girls also had higher percentage of anemics than wellnourished girls. In other words, anemia coexists with undernutrition.

Morbidity Profile of the Girls

The morbidity profile of the girls was collected by asking them to report any illness suffered during last 15 days for which they had to go to a doctor. Only 28.5% girls reported to have suffered mainly from fever, cold and cough which lasted only for two – three days (**Table 4.1.4**). A few suffered from diarrhea and only one girl had fallen ill due to malaria. More than 60% of the girls, who fell ill, recovered in less than four days.

Table 4.1.4: Morbidity Profile of The Present LIG Subjects

Characteristics	All Girls	
	n	%
1. Morbidity		
• Yes	102	28.5
• No	256	71.5
2. Type of Illness		
• Fever	49	48.0
• Cough/cold	35	34.3
• Diarrhea	7	6.9
• Malaria	1	1.0
• Others	10	9.8
3. Number of Days of Illness		
• ≤3	62	60.8
• 4 – 6	34	33.3
• ≥7	6	5.9

Note: No Significant difference was found with regards to above morbidity profile of the girls studying in the four study schools (p<0.05)

In HIG girls, 25% suffered from illness, mainly cold and cough and recovered within three days.

Dietary and Nutrient Intake of the Girls

Quantitative estimation of intake of various food groups and nutrient intake from the 24-hour dietary recall are presented below.

Mean Food Intake

The mean dietary intake of various food groups as % RDA, among the younger, older and all girls are presented in **Table 4.1.5**. The intake of various food groups met less than 50% of the RDA, except for pulses and fat intake (**Figure 4.1.6**). Cereal intake was just about 50% RDA and pulses intake was about three-fourth of the RDA. Among vegetables, intake of green leafy vegetables (GLVs) was very low (10%) compared to intake of other vegetables and roots-tubers. The intake of milk was very low, less than 10% of RDA (**Figure 4.1.6**). The intake of fats and oils was very high among these girls. The consumption of '*bhajiyas*', 'fried *papad*', giving empty calories, was common. Sugar intake was less than 50% of the daily allowances.

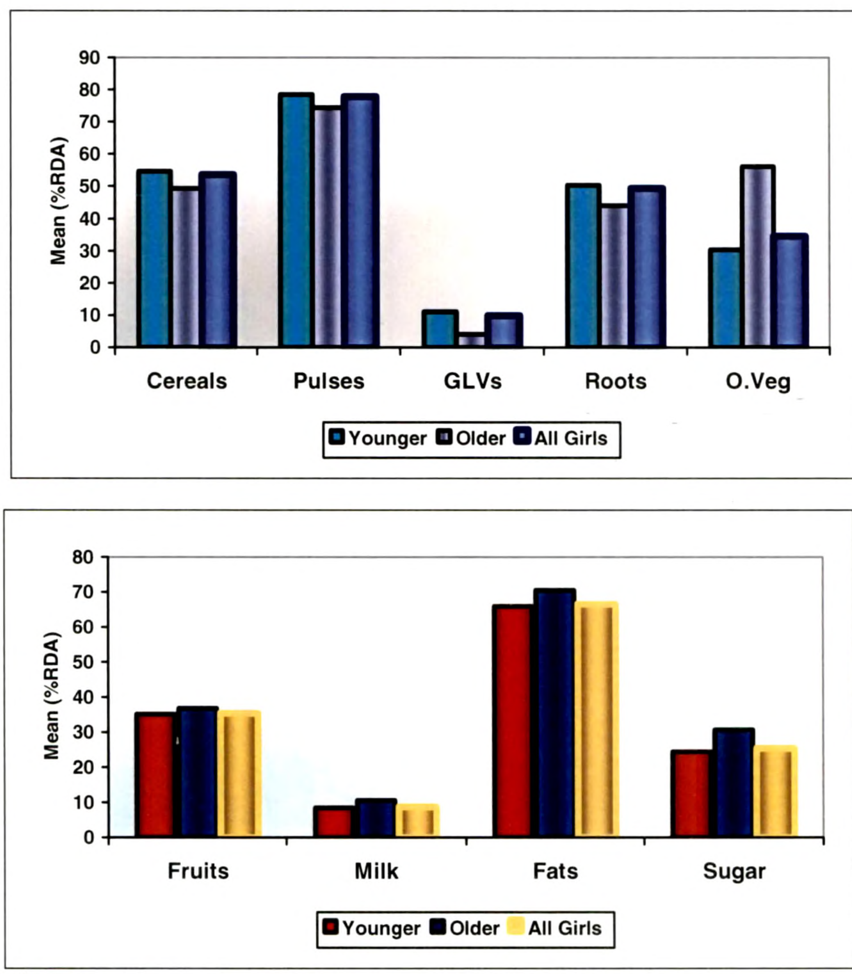
Table 4.1.5: Mean Food Intake (% RDA[1]) of the Younger and Older Girls

Food Groups	Younger Girls (n=134)			Older Girls (n=26)			All Girls (n=160)		
	Mean	± SD	Median	Mean	± SD	Median	Mean	± SD	Median
Cereals	54.65	18.29	51.85	49.27	20.42	46.30	53.77	18.69	51.85
Pulses	78.61	51.39	69.17	74.49	51.76	72.50	77.94	51.31	70.83
GLVs	11.16	12.23	0.00	4.04	3.70	0.00	10.00	10.75	0.00
Fruits	35.10	10.90	0.00	36.73	12.40	0.00	35.36	12.46	0.00
Milk	8.42	7.82	5.00	10.48	11.18	5.00	8.76	8.45	5.00
Roots-Tubers	50.45	48.98	40.00	44.23	43.97	40.00	49.44	45.69	40.00
Other-Veg	30.49	27.55	15.00	56.15	55.07	50.00	34.66	32.43	20.00
Fats	65.89	43.15	55.00	70.53	45.10	65.00	66.65	43.36	55.50
Sugar	24.38	21.56	16.67	30.71	28.00	16.67	25.41	24.93	16.67

Younger girls: 9 – 11 years, Older girls: 12 – 13 years, [1]NIN (1998)

Comparing the age groups, the intake of cereals, pulses, GLVs, and roots-tubers was slightly lower among the older girls compared to younger girls. However, intake of fruits, milk, fats and sugar was slightly higher among older girls than their younger counterparts (as % RDA).

Figure 4.1.6: Mean Food Intake (% RDA[1]) in Younger, Older and All Girls



[1]Recommended Dietary Allowances: NIN (1998)

Frequency of Intake

The frequency of intake of those foods reported to be consumed by the girls (energy giving and foods rich in iron and Vitamin C) is presented in **Table 4.1.6** and the quantity consumed is presented in **Table 4.1.7**.

Table 4.1.6: Frequency of Intake of Selected Iron and Vitamin C Rich Foods

Food Groups	Frequency of Consumption (Percentage Girls)				
	Daily	*3-5 d/wk*	*1-2 d/wk*	*Occasionally*	*Rarely*
Cereals					
Wheat flour	100.0	0.0	0.0	0.0	0.0
Rice	88.8	11.3	0.0	0.0	0.0
Bajra	3.1	1.9	10.0	28.8	56.3
Pulses					
Red gram dhal	42.5	45.0	12.5	0.0	0.0
Green gram	10.0	26.3	51.3	12.5	0.0
GLVs					
Spinach	0.0	9.4	32.5	10.0	48.1
Fenugreek leaves	0.0	0.0	34.4	56.9	8.8
Drumstick leaves	0.0	0.0	15.6	23.1	61.3
Fruits					
Amla	63.8	21.9	8.1	6.3	0.0
Custard apple	5.0	7.5	53.1	14.4	20.0
Ber	4.4	13.1	46.3	32.5	3.8
Oranges	3.8	11.3	76.3	3.8	5.0

Table 4.1.7: Quantity of Intake of Selected Iron And Vitamin C Rich Foods

Food Groups	Frequency of Consumption (Percentage Girls)			
	< ¼ Cup	*¼ to ½ Cup*	*½ to 1 Cup*	*> 1 Cup*
Cereals				
Wheat flour	0.00	0.00	22.50	77.50
Rice	5.00	8.75	74.38	11.88
Bajra	21.43	58.57	15.71	4.29
Pulses				
Red gram, dhal	3.13	53.75	41.25	1.88
Green gram	3.13	53.13	43.75	0.00
Sprouts	46.48	52.11	1.41	0.00
GLVs				
Spinach	42.17	51.81	6.02	0.00
Fenugreek leaves	56.16	30.14	6.85	0.00
Drumstick leaves	54.84	38.71	6.45	0.00
Fruits				
Amla	78.13	21.88	0.00	0.00
Custard apple	11.72	53.91	30.47	3.91
Ber	5.19	10.39	40.26	44.16
Oranges	13.16	83.55	3.29	0.00

Wheat flour and rice was most commonly consumed amongst all cereals, by almost all the girls daily. Most of the girls consumed 2-3 *chappaties* and ½ to 1 cup rice. Among the pulses, red gram *dal* was most frequently consumed (daily or 3-5 times /week) by more than 80% girls and the quantity consumed ranged from ¼ th cup to 1 cup. Other pulses and legumes like green gram *dal* and bengal gram dal were consumed less frequently i.e. 1-2 times a week by about 40% to 50% of the girls. Sprouts were consumed by less than half of the girls and that too occasionally. A majority of the girls did not consume green leafy vegetables regularly, though a few green leafy vegetables like spinach and fenugreek leaves were consumed 1-2 times a week during winter by about one-third of the girls. However the quantity consumed was very low (1/4 th to 1/2 cup).

Amla was consumed by all the girls during the season. Other citrus fruits like lemon, pineapple and orange were mainly consumed 1-2 times a week. Girls consuming non-vegetarian foods were very few (13%). Overall the girls did not frequently consume iron and vitamin C rich foods and those that did consumed inadequate amounts. This is reflected in poor nutrient intakes reported subsequently.

Mean Nutrient Intake

Tables 4.1.8 summarize the mean intake of selected nutrients. The mean intake of calories and proteins was found low (just about 50% of RDA) suggesting inadequate quantity of food consumed. However the fat intake was very high because the girls regularly had deep fried snack foods in school like 'Tasty' (a fried snack made from rice flour). The mean intake of iron was low, meeting less than one-third the RDA, and β-carotene intake was the most deficient (only 12% of RDA). Vitamin C intake was high due to higher intake of tomatoes in their diets and also fruits consumption especially in winter due to easy availability and low cost of a variety of fruits. With exception of fat and vitamin C, which met more than 50% of RDA, all the other nutrients were less than 50% of RDA.

The nutrient intake (as % RDA) among younger girls and the older girls was similar.

Table 4.1.8: Mean Nutrient Intake of the Younger and Older Girls

Nutrients	Younger Girls (n=134)			Older Girls (n=26)			All Girls (n=160)		
	Mean	SD	Median	Mean	SD	Median	Mean	SD	Median
Energy (Kcal)	1026	±319	1010	1013	±329	1000	1024	±320	1010
Protein (gm)	28.0	±9.5	27.4	27.1	±8.7	28.2	27.9	±9.3	27.5
Fat (gm)	24.8	±13.6	22.0	27.7	±17.0	23.4	25.2	±14.2	22.6
Fiber (gm)	3.9	±3.1	3.2	3.6	±1.6	3.4	3.9	±2.9	3.2
Carbohydrates (gms)	168.2	±53.4	165.4	159.3	±51.8	169.4	166.7	±53.1	165.4
Calcium (mg)	231.4	±135	191.0	254.0	±180	197.3	235.1	±143.0	193.6
Iron (mg)	6.3	±3.1	6.0	6.2	±2.9	5.9	6.3	±3.1	6.0
β-Carotene (µg)	273.7	±174	224	307.4	±179.3	244.5	279.3	±175.5	227.9
Vitamin C (mg)	29.5	±29.5	21.3	32.8	±25.7	29.4	30.1	±28.8	23.0
Mean Nutrient Intake (as % RDA[1]) of the Younger and Older Girls									
Energy	52.3	±16.2	51.7	50.8	±16.5	49.6	52.0	±16.2	51.5
Protein	54.9	±20.3	54.4	46.1	±15.2	46.4	53.5	±19.8	51.6
Fat	108.7	±61.0	98.0	125.8	±77.4	106.4	111.5	±64.0	100.6
Calcium	44.1	±27.3	39.0	42.3	±30.1	32.9	43.8	±27.7	36.5
Iron	30.6	±16.7	27.3	30.0	±15.5	28.3	30.5	±16.5	27.3
β-Carotene	11.4	±7.2	9.3	12.8	±7.7	10.2	11.63	±7.3	9.5
Vitamin C	73.8	±73.8	58.3	82.1	±64.4	73.5	75.3	±72.1	56.9

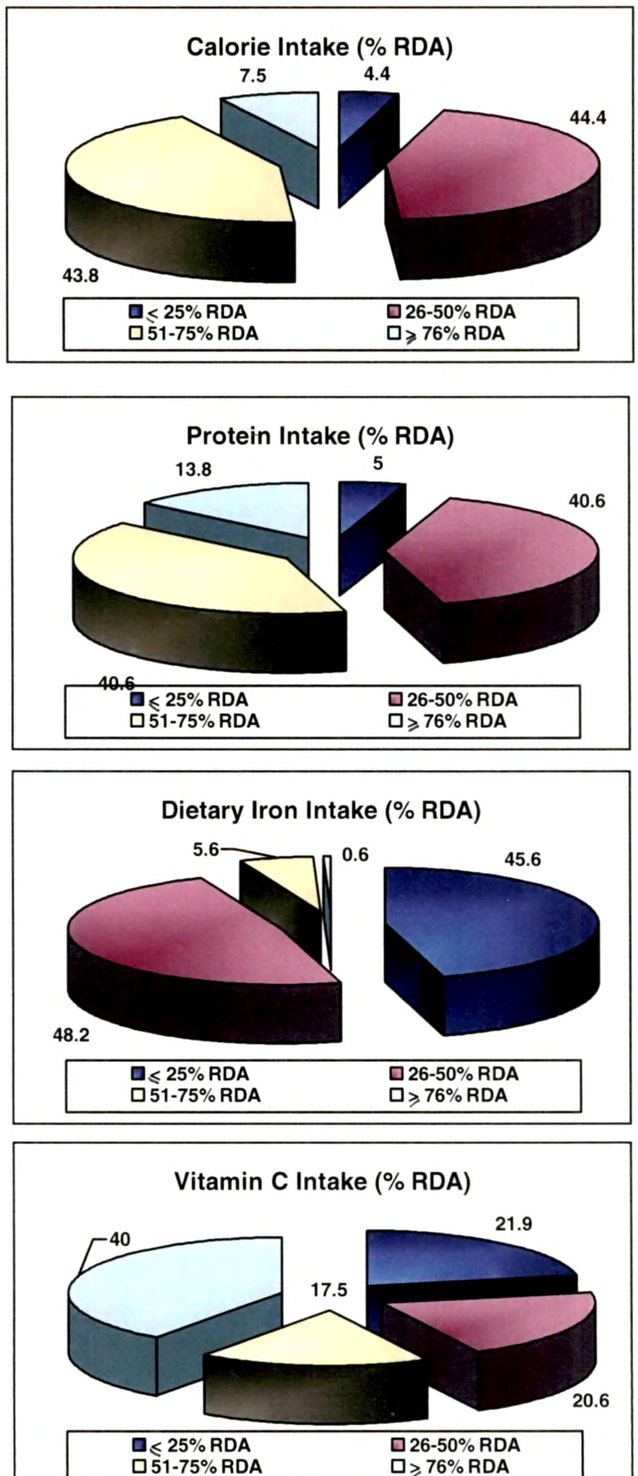
[1] Recommended Dietary Allowances, ICMR (1991)

The Nutrient Intake at Various Levels of Recommended Dietary Allowances

Figure 4.1.7 presents the intake of various nutrients at various levels of RDA. The calorie and protein intake of majority girls was between 26 – 75% RDA. Moreover, nearly half of the girls (45%) had dietary iron intake below 25% RDA and another half had iron intake of 26% to 50% of RDA.

About 60% girls met above 50% of RDA for vitamin C intake. The girls (81.9%) had very low (<25% RDA) intakes of β-carotene.

Figure 4.1.7: Percent Girls Who Met Various Level of % RDA[1]



[1]Recommended Dietary Allowances, ICMR (1991)

Discussion

Summing up, overall the nutritional status of the girls from low income families was very poor, and their food intake was not sufficient to meet their daily nutrient demands. More than two-third (68.3%) of the girls were anemic (Hb <12 g/dl). Prevalence of undernutrition was also high as below normal BMI was seen in 57.3% girls. Further, the percentage of girls who were undernourished was high in anemic compared to those non-anemic (61.4% vs. 46.2%). HIG girls had significantly better nutritional status in terms of lower proportion of anemia and undernutrition compared to LIG girls.

Literature reviewed shows a high prevalence of anemia and undernutrition among younger and older adolescent girls, especially in developing countries. A study in Kazakhstan on Muslim school children (6 -15 years) reported a fairly high prevalence of anemia (49.8%) and 11- 12% of stunting and wasting (Hashisume et al 2003). Tiwari and Seshadri (2000) reported a similar prevalence (60.3%) of anemia (Hb <12 g/dl) amongst Nepali schoolgirls (10-18 years). Almost one-third (31%) had BMI <16 Kg/m^2 and 50% had BMI between 16 and 17 Kg/m^2.

In a national study in 18 states of India, the prevalence of anemia (Hb <11 g/dl) among unmarried adolescent girls (90.1%) was very high (ICMR 2001). In the NNMB-MND survey (2003), the pooled data on prevalence of anemia among young adolescent girls (12-14 years) in eight states of India, (WB, Orissa, AP, MP, Karnataka, Maharashtra, Kerala and TN) was reported as 68.7%.

In this region, using hemoglobin cut offs of 11 g/dl or 12 g/dl, anemia prevalence is reported to 55-75% in most studies reviewed in Gujarat. Further, undernutrition is highly prevalent in this age-group. In Ahmedabad, Gujarat, 81.8% of school children (6-18 years) were reported anemic (Hb <12 g/dl) (Verma et al 2004). The prevalence of anemia was significantly higher among those having BMI <18.5 vs. those with higher BMI; also among those having the habit of consuming tea/coffee vs. those who did not habitually drink tea/coffee. The prevalence of anemia was significantly lower in girls consuming green leafy vegetables.

A survey conducted in Vadodara district on 2860 secondary school girls in rural, tribal and urban areas under Gujarat Government's Adolescent Anemia Control Program (UNICEF supported) reported as many as 75% girls to be anemic (Hb < 12 g/dl) (Kotecha et al 2000). Undernutrition was present in 33.6% adolescent girls. Research done in our department from 1990 to 2005 clearly highlights that above 75% urban poor adolescent girls were found anemic in Vadodara. Undernutrition is also prevalent in more than half of these girls (Agarwal and Kanani 1998, Kanani and Poojara 2000, Kanani and Sen 2001). There appears to be no decline in the prevalence of anemia and undernutrition in the vulnerable section of the community during the last 50 years.

Thus anemia is a widely prevalent nutritional disorder in adolescent girls requiring urgent attention. Further, undernutrition in adolescent girls, who are the future mothers, contributes significantly to the intergenerational cycle of malnutrition. Thus, programs need to be urgently implemented for improving the nutritional status as well as the iron status of adolescent girls.

Inadequate food and nutrient intake

In the present study, the intake of cereals and pulses was less than 50% of the RDA, The intake of green leafy vegetables and milk was very low (<10% RDA). A majority of the girls did not frequently consume iron and vitamin C rich foods and those that did consumed them in inadequate amounts. This inadequacy was reflected in the nutrient intakes where the mean intake of calories and proteins was found low (just about 50% of RDA) and dietary iron and β-carotene intake was even lower (<30 % of RDA).

Most of the studies reported corroborate the poor food and nutrient intakes in girls. Soodh and Sharada (2002) reported that school age (9-11 years) children in Andhra

Pradesh consumed inadequate amounts of green leafy vegetables, fruits, milk and milk products, fats and oil less than 30% RDA. The iron intake was only 30-35% of RDA. Agarwal and Kanani (1998) reported that primary school girls (8-13 years) in Vadodara, had low frequency of consumption of iron, vitamin A and vitamin C rich foods and mean intakes of all the nutrients were less than 50% RDA.

According to Ananthakrishnan et al (2001), dietary deficiency may be an important factor contributing to the suboptimal growth, anemia and other nutritional deficiencies.

Thus, these girls entering their pubertal growth spurt urgently need intervention to improve their existing nutritional status as well as lay down stores for future increased requirements for adolescent growth and development, and lay the foundation for future reproductive health.

Perceptions of the Girls Regarding Anemia: Causes, Consequences and Treatment

As this was an IFA intervention study for anemia control, the perceptions of the young schoolgirls regarding anemia, its causes, consequences and treatment were assessed. Further, their awareness regarding iron tablets and willingness to consume these tablets was determined. Data is presented in **Table 4.1.9**. A majority of the girls had not heard of anemia or '*pandurog*' and many more did not know about the causes and consequences of anemia. Only a few mentioned, feeling tired (20%) and paleness of eyes, nails and face (10%) as symptoms and effects of 'pale blood'. Among those who gave causes of 'pale blood', they mentioned inadequate diet (10%) and poor intake of green leafy vegetables (2.5%). To quote:

- "*Lohi na rang phiku padi jay ane moda pan phika dekhay che.*" (Colour of the blood becomes pale and the face also looks pale.)
- "*Nakh phiku hoi, aanko pilli hoi.*" (Nails and eyes become pale.)
- "*Khorak ocha hoy ane sak bhaji na khata hoy to lohi phiku padi jay.*" (If the diet is poor and if one does not eat green leafy vegetables, then blood becomes pale.)

Table 4.1.9: Major Perceptions of Girls Regarding Anemia: Its Causes, Consequences and Treatment

Description	N = 80	%
Awareness about "paleness of blood"		
o Yes	13	16.3
o No	67	83.7
Description of the state of "pale blood"		
o Paleness (eyes, nails, face)	14	17.5
o Body becomes dry and black	3	3.6
o Decrease in hemoglobin	2	2.5
o White patches on body	2	2.5
o No Response	61	76.2
Problems, Symptoms & Effects of "pale blood"		
o Feel weak and tired	16	20.0
o Pale hands, nails and body	8	10.0
o Lack of concentration	3	3.6
o Not aware	53	66.2
Reasons for having "pale blood"		
o Inadequate diet	8	10.0
o Less Intake of GLV's	2	2.5
o Poor hygiene	1	1.3
o No response	69	86.2
Do you think that you have "pale blood"		
o No	63	78.8
o Yes	13	16.2
o Don't Know	4	5.0
• If yes, why		
o Feel tired and weak	7	53.8
o Fall ill regularly	6	46.2
• If no, why		
o Not weak and don't feel tired	19	30.2
o Feel healthy and strong	14	22.2
o Drink milk and eat fruits	5	7.9
o Body, nails and eyes are not pale	3	4.7
o Don't eat too many chocolates and sweets	3	4.7
o No Response	42	66.7
Foods which make "blood red"		
o Vegetables (carrot, tomatoes, beetroot)	28	34.0
o Green leafy vegetables	9	11.2
o Watermelon	3	3.8
o No response	43	53.8

Continued...

Description	N = 80	%
Foods which contain iron		
o Vegetables (Beetroot, tomato, carrots)	20	25.0
o Green leafy vegetables	11	13.8
o Fruits (Orange, Lemon)	2	2.5
o No response	51	63.8
Foods which contain Vitamin C		
o Fruits (orange, lemon, amla)	11	13.8
o Tomatoes	4	5.0
o Green leafy vegetables	2	2.5
o Fruits (Banana, Apple)	2	2.5
o Potatoes	4	5.0
o No response	65	81.3
Relationship between tea drinking and anemia		
o Blood becomes thin	4	5.0
o No relation	35	43.8
o No response / Don't know	41	51.2
Do you drink tea immediately before/ after meals		
o Yes	79	98.8
o No	1	1.2
Ways to improve pale blood: Treatment		
o Medicines	52	65.0
o Eat GLVs	7	8.8
o Eat fruits like orange, amla	6	7.5
o No response	15	18.8
Ever seen red iron tablets (*shakti nil lal goli*)		
o Yes	3	3.8
o No	77	96.2
Ever consumed Iron tablets		
o Yes	0	0.0
o No	80	100
Do you know the advantages of consuming iron tablets		
o We get energy and eat more	1	1.2
o Eat more	1	1.3
o Blood becomes red	2	2.5
o No response	76	95.0

About 78.8% of the girls believed that they did not have anemia. However, a majority did not respond when asked why they believed so. Others perceived that they did not feel tired and were healthy and strong hence were not anemic. However, one girl who felt she was anemic said that, "*Thoda ma thaki jau chu. School thi ghare jaine thaki jao chu, pachi gharkam nathi thatu.*" (I get tired very easily. After

going back home from school I feel tired and am not able to do the household chores.) A majority of girls did not know which foods were rich in iron or vitamin C. Vegetables such as carrots, beetroot and tomatoes were believed to make their blood red, as they are red in colour. One-fourth of the girls mentioned green leafy vegetables as rich sources of iron and stated that they make the blood red. Similarly knowledge regarding vitamin C, an enhancer of absorption of iron, was very poor. Only a few mentioned fruits like oranges, lemon and amla as vitamin C sources.

When asked how anemia could be cured, more than half of them said taking medicines and a few suggested eating green leafy vegetables and fruits would help.

- *"Manda pade to doctor pase thi goli khaile to saru thai jay."* (When ill, if one goes to a doctor and consume tablets, one will get better.)

The relationship between tea drinking (inhibitor of iron absorption) and anemia, was not known to most of the girls and they stated that they drank tea with meals. This was also evident from their dietary intake, which shows milk was usually consumed in form of tea with morning and evening meals. With regard to knowledge about iron tablets, only three girls had seen them before and they had consumed the tablet earlier. One of them said, *"Mummy shakti ni goli le che, ekdam lal hoyeche. Pela dar athwariye mandi padi jati hati ane kamjor thai gai hati, awe ene ashkti nathi lagti. Doctor khorak ma sak bhaji lewanu kidu che."* (My mother takes energy pills (iron tablets) - its red in colour. Earlier she used to fall ill very frequently and was weak, but now she does not feel weak. Doctor has asked her to eat green leafy vegetables.)

A majority did not know the benefits of consuming iron tablets.

Discussion

To sum up, in the present study young primary school girls had very poor knowledge regarding anemia and its adverse consequences on health. Though a majority had not even heard regarding 'pale blood' and did not know about the symptoms and causes of 'pale blood', they believed that they did not suffer from anemia. Further, the girls did not know regarding the rich sources of dietary iron and Vitamin C. All the girls drank tea immediately before or after regular meals. A majority of the girls had not seen iron tablets and did not know its benefits.

Under the Adolescent Anemia Reduction Program (AARP), formative qualitative research was conducted among secondary school girls of Vadodara district (Kanani 2000). The research elicited KAP of the schoolgirls regarding anemia and its etiology. One-half of the girls associated anemia with pallor and the girls had good knowledge regarding anemia, and food sources of dietary iron and vitamin C. This may be due to inclusion of these topics in their secondary school curriculum. It was interesting to note that a majority of the girls (88%) in the schools believed that they themselves were not anemic. In contrast, hemoglobin data shows about 75% were actually anemic. Schoolgirls were asked to draw things that make blood healthy, strong and those that make blood pale and weak, using drawing and dialogue method. The girls mainly drew fruits and vegetables as foods that make blood healthy. Many girls mentioned red/orange foods like tomatoes, carrots and beetroot and fruits such as apples, orange, grapes and mango. Salt, chocolates, desserts, oily and unhygienic foods and consuming potatoes were mentioned as foods which make blood weak and pale.

A series of studies were conducted in Vadodara among adolescent girls with the Baroda Citizens Council (a NGO). The perceptions of the girls regarding nutrition, health and anemia were obtained from the semi-structured individual interviews (Kanani et al 1998). Another study in the same project compares the perceptions of 10-15 year old girls vs 16-18 year old girls regarding health and nutrition collected using various qualitative and participatory research methods. Majority of the girls believed themselves to be healthy with a higher percentage of 10-15 year girls believing so (94% vs 64%). The main reasons for believing themselves to be healthy was, that they ate well, did not feel tired, did not suffer from illness and could work efficiently. Majority of the older group (94%) were aware about anemia which was commonly known as 'paleness of blood' while less than half of the younger group (44%) was aware about it. The correct cause of anemia was not known by majority of the girls in both groups (>90%). Fruits and green leafy vegetables were stated as health promoting foods by almost half of the subjects, while about one-third felt that milk and ghee or wheat and *dal* make one healthy. About half of the subjects (43%) stated that anemia can be cured by eating fruits, green leafy vegetable, meat, fish and increasing the quantity of food consumed, that is, by dietary modification.

In India, Agarwal and Kanani (1998) studied primary school girls (8-13 years) in Vadodara. Most of the girls were not aware about the concept of health, adolescence period and its importance, anemia and dietary factors responsible for good health. A positive impact on prevalence of anemia was reported after effective nutrition education promoting appropriate dietary habits.

Thus, young girls entering adolescence are not only vulnerable to anemia, undernutrition and have poor food intakes, but in addition, have poor knowledge and awareness regarding anemia and its prevention. These girls in early adolescence need to be included in interventions to control anemia.

Cognitive Abilities of the Girls

This section presents the cognition abilities in terms of cognitive function test scores of the underprivileged schoolgirls in early adolescence. Four tests, namely Digit Span (DS), Visual Memory Test (VMT), Clerical Task (CT) and Maze (MT), were performed by randomly selected sub-samples of girls as described in the earlier chapter. These tests measured various aspects of their cognitive abilities, and the results are presented in the **Table 4.1.10**. They are compared with scores of HIG girls.

Table 4.1.10: Cognitive Function Test Scores Of The Young Primary School Girls: LIG and HIG Girls

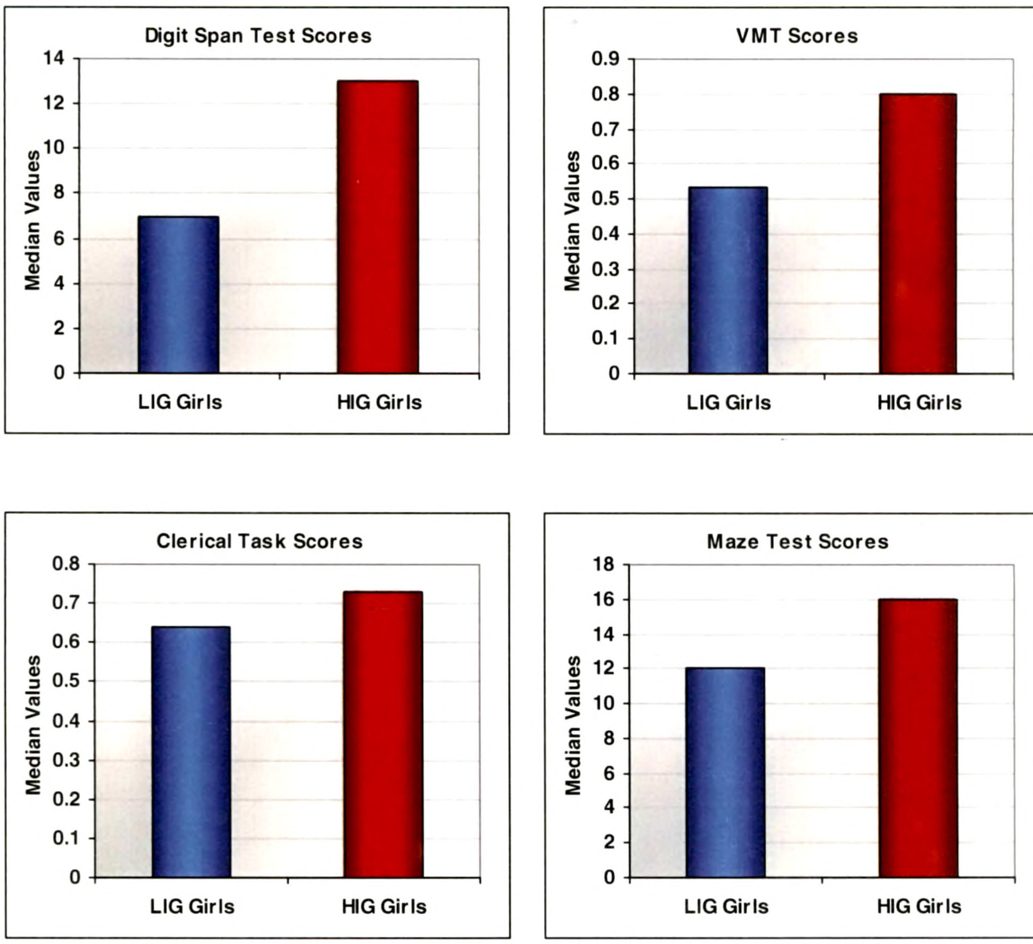
Cognitive Tests	LIG Girls			HIG Girls			t-value (A vs B)
	Younger Girls (9-11yr) n=204	Older Girls (12-13yr) n=36	All Girls (A) N=240	Younger Girls (9-11yr) n=46	Older Girls (12-13yr) n=16	All Girls (A) N=62	
Digit Span Test							
Mean ± SD	6.83 ± 1.93	6.17 ± 2.02	6.73 ± 1.95	12.46 ± 1.05	12.63 ± 0.81	12.50 ± 0.99	6.81***
Median	7.00	6.50	7.00	13.00	13.00	13.00	
Visual Memory Test							
Mean ± SD	0.54 ± 0.22	0.47 ± 0.25	0.54 ± 0.22	0.79 ± 0.11	0.83 ± 0.07	0.80 ± 0.10	9.30***
Median	0.56	0.53	0.53	0.80	0.80	0.80	
Clerical Task							
Mean ± SD	0.62 ± 0.20	0.66 ± 0.21	0.63 ± 0.20	0.75 ± 0.15	0.76 ± 0.08	0.75 ± 0.14	1.77^{NS}
Median	0.64	0.68	0.64	0.73	0.74	0.73	
Maze Test							
Mean ± SD	11.01 ± 4.74	10.93 ± 4.79	10.98 ± 4.74	14.73 ± 2.64	16.25 ± 2.11	15.13 ± 2.59	6.81***
Median	12.0	11.0	12.0	15.5	17.0	16.0	

t test Younger girls vs. older girls: p>0.05, non-significant; except Maze test HIG: p<0.05

Overall, in all the cognitive function tests, the mean scores were significantly higher (p<0.001) in HIG girls compared to LIG girls, except in clerical task. This could be as the clerical task was in Gujarati language, which is the local language more familiar to the LIG girls. Among both LIG and HIG girls, the scores obtained by the younger as well as older girls were similar, except in Maze test which was higher (p<0.05) among older girls than younger girls in HIG.

Figure 4.1.8 compares the median scores obtained by the HIG and LIG girls in the cognition tests. The figures clearly show that the overall performance of LIG girls on various cognitive tests was poor as compared to that of HIG girls.

Figure 4.1.8: Median Cognitive Function Test Scores of Girls



Does Anemia Significantly Influence Cognition?

Table 4.1.11 reveals that when cognitive function test scores were compared between anemic and non-anemic LIG girls, the non-anemic girls scored higher than their anemic counterparts, the difference being significant in digit span and visual memory tests. Though non-anemics scored better in maze test (11.83 vs. 10.72) and clerical task (0.65 vs. 0.63) as well, this difference was not statistically significant. Similar trend was observed among younger and older girls.

Table 4.1.11: Cognition Test Scores Of The Anemic[1] and Non-Anemic[2] Girls

Indicator	Younger Girls (9-11 years)		Older Girls (12-13 years)		All girls (9-13 years)	
	N	Mean ± SD	N	Mean ± SD	N	Mean ± SD
Digit span						
Anemic	146	6.60 ± 1.81	29	5.75 ± 1.99	175	6.49 ± 3.45
Non anemic	53	7.58 ± 2.04	6	7.83 ± 1.17	59	7.61 ± 1.96
t-value		3.27***		2.44*		4.04***
VMT[3]						
Anemic	146	0.53 ± 0.21	29	0.43 ± 0.23	175	0.50 ± 0.21
Non anemic	53	0.61 ± 0.20	6	0.62 ± 0.31	59	0.61 ± 0.22
t-value		2.69**		1.72^{NS}		3.27***
Clerical Task						
Anemic	146	0.62 ± 0.19	29	0.66 ± 0.21	175	0.63 ± 0.20
Non anemic	53	0.64 ± 0.20	6	0.70 ± 0.22	59	0.65 ± 0.20
t-value		0.66^{NS}		0.44^{NS}		0.69^{NS}
Maze Test						
Anemic	146	10.77 ± 4.49	29	10.48 ± 4.78	175	10.72 ± 4.52
Non anemic	53	11.87 ± 4.93	6	11.50 ± 5.05	59	11.83 ± 4.90
t-value		1.48^{NS}		0.47^{NS}		1.59^{NS}

[1] Hb < 12 g/dl, [2] Hb≥ 12 g/dl, [3] VMT- Visual Memory Test, *p < 0.05, **p < 0.01, ***p < 0.001

Table 4.1.12: Cognition Test Scores Of The Anemic[1] and Non-Anemic[2] Girls Who Were Undernourished

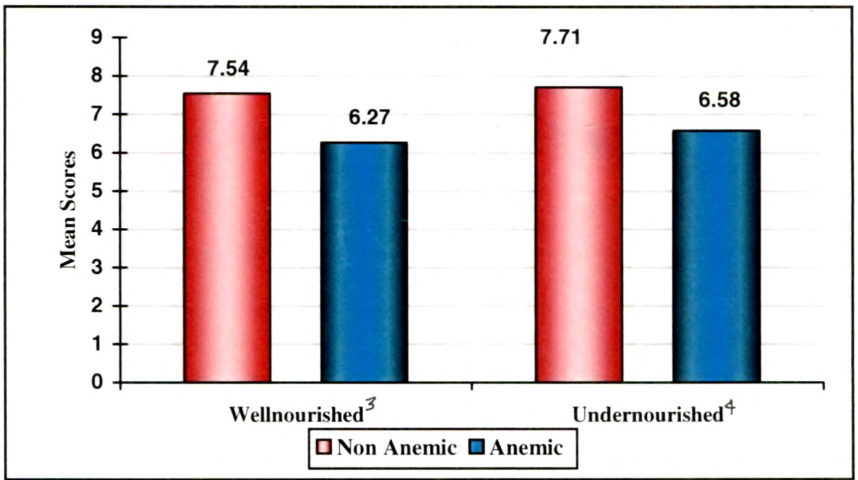
Indicator		Wellnourished[3]		Undernourished[4]	
		N	Mean ± SD	N	Mean ± SD
Digit span	Anemic	69	6.27 ± 1.78	106	6.58 ± 1.91
	Non anemic	35	7.54 ± 1.83	24	7.71 ± 2.17
	t-value		3.34***		2.53*
VMT	Anemic	69	0.48 ± 0.21	106	0.54 ± 0.21
	Non anemic	35	0.61 ± 0.20	24	0.62 ± 0.23
	t-value		2.99**		1.62^{NS}
Clerical Task	Anemic	69	0.63 ± 0.20	106	0.62 ± 0.19
	Non anemic	35	0.66 ± 0.22	24	0.63 ± 0.16
	t-value		0.54^{NS}		0.21^{NS}
Maze Test	Anemic	69	10.51 ± 4.84	106	10.86 ± 4.32
	Non anemic	35	11.74 ± 5.28	24	11.96 ± 4.39
	t-value		1.19^{NS}		1.12^{NS}

[1] Hb <12 g/dl, [2] Hb ≥12 g/dl, [3] BMI ≥5th percentile Must et al Std., [4] BMI <5th percentile Must et al Std., *p< 0.05, **p< 0.01, ***p< 0.001, NS non-significant

Does Undernutrition Have A Confounding Influence?

It was observed that anemic girls, whether in the well-nourished group or the undernourished group, showed a poorer performance. However, these differences were statistically non-significant (**Table 4.1.12**) except for the scores obtained in Digit Span test (**Figure 4.1.9**). Thus, irrespective of the overall nutrition status, anemia in itself is likely to adversely affect cognition.

Figure 4.1.9: Association of Nutritional Status With Digit Span Scores of the Anemic[1] and Non-Anemic[2] Girls



[1]Hb <12 g/dl, [2]Hb ≥12 g/dl, [3] BMI ≥5th percentile Must et al Std., [4] BMI <5th percentile Must et al Std.

Discussion

In brief, overall, in all the cognitive function tests, the mean scores were significantly better ($p<0.001$) in HIG girls compared to LIG girls. Further analysis in the LIG showed that the non-anemic girls scored higher than their anemic counterparts, the difference being significant in digit span and visual memory tests. It was also observed that anemic girls, whether in the well-nourished group or the undernourished group, showed a significantly poorer performance in the digit span test and tended to score less in the other tests. The findings of this study indicate that anemia is likely to compromise cognitive functions of girls in the pubertal phase of development; even the mild to moderate anemia that these girls had.

A study looked at the possible connection between iron deficiency and cognitive test scores in a national representative sample of 5,398 children 6- to 16-year-old in United States. Four standardized tests (math, reading, verbal/digit span, and performance/block design) were used. It was found that 49% of children with normal iron had below average math scores which were significantly better than the non-anemic iron deficient children (71%), and also the anemic iron deficient children (72%) (Halterman et al 2001).

In India, rural Varanasi, two studies conducted on school children (6-8 years) reported that verbal and performance IQ scores progressively decreased with fall in hemoglobin levels (Agarwal et al 1987, Agarwal et al 1989). The differences were significant for digit span test between non-anemics and severely anemic children. They also reported that anemics showed lower levels of attention and concentration in the arithmetic test. Similarly, another study assessing the mental and motor abilities of school children (6-11 years) in Coimbatore noted that the performance on cognitive test scores was better for the non-anemics than their anemic counterparts (Gowri and Sargunam 2005).

Literature findings support the present study; that is, various cognitive functions are compromised in anemic school children, including young adolescents.

Physical Work Capacity of the Girls

As described earlier, the girls of this study climbed a set of five stairs for three minutes as fast as they could and their pulse as well as recovery time to basal pulse rate was recorded. This Modified Harvard Step Test (MHST) performed by the girls was used to measure their physical work capacity. The data were compared with those of HIG girls.

Overall, the LIG girls climbed a mean of 176 steps, which was significantly lower than HIG value of 202 steps (**Table 4.1.13**). However, the mean time required to revert back to the basal pulse rate, i.e. the recovery time (RT), was similar in both the groups. This could be due to the presence of mild to moderate anemia in about 12% of the HIG girls and the fact that they are less used to physical exertion compared to the LIG girls. Comparing older and younger girls, younger girls in LIG girls climbed more number of steps and had lower RT than their older counterparts. However, among HIG, older girls climbed more steps and had lower RT than younger girls.

Table 4.1.13: Physical Work Capacity of The Young Primary School Girls

MHST	LIG Girls			HIG Girls			t-value (A vs B)
	Younger Girls (9-11yr) n=204	Older Girls (12-13yr) n=36	All Girls (A) N=240	Younger Girls (9-11yr) n=46	Older Girls (12-13yr) n=16	All Girls (A) N=62	
Number of Steps Climbed							
Mean ± SD	178 ± 37.15	167 ± 32.44	176 ± 36.64	200 ± 29.37	208 ± 35.29	202 ± 30.87	5.07***
Median	175	164	173	203	195	200.0	
Recovery Time (RT)							
Mean ± SD	3.16 ± 0.94	3.44 ± 0.93	3.20 ± 0.94	3.28 ± 1.11	3.00 ± 0.89	3.22 ±1.05	0.03^{NS}
Median	3.00	4.00	3.00	3.00	3.00	3.00	

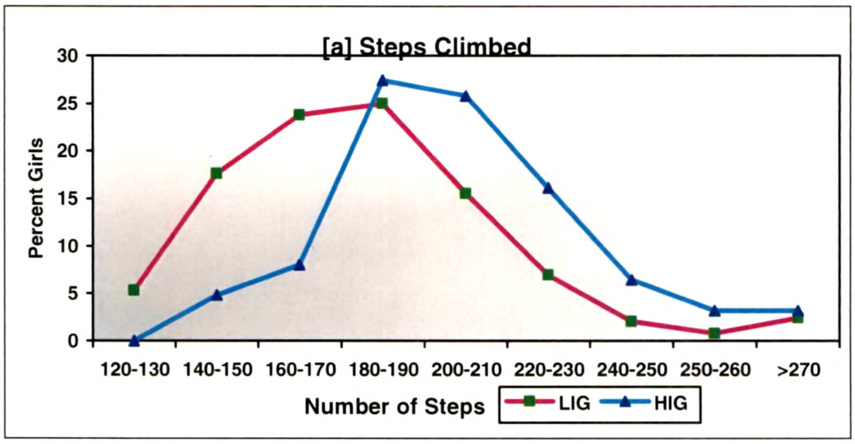
t test Younger girls vs. older girls: p>0.05, non-significant

The frequency distribution curves of the number of steps climbed corroborate the earlier results, that is, a higher percentage of girls in HIG climbed more number of steps than LIG (**Figure 4.1.10 [a]**). However, with regard to the recovery time taken, both the curves were similar (**Figure 4.1.10 [b]**). However, percentage of girls with RT more than three minutes was higher in LIG than in HIG (38% vs. 30%).

Does Anemia Significantly Influence Physical Work Capacity (PWC)?

Though a trend was seen that the mean number of steps climbed (182 steps) by the non-anemic girls in three minutes was higher than seen in the anemic girls (mean = 174 steps), this difference was not statistically significant. However the time taken to recover to the basal pulse rate was significantly higher ($p<0.001$) for anemic girls, i.e. anemic girls took longer than non-anemic girls to return to their basal pulse rate (RT) after finishing the step test (**Table 4.1.14**). In other words, RT appears to be a more sensitive indicator of the influence of anemia on PWC.

Figure 4.1.10: Frequency Distribution Curve of Steps Climbed and Recovery Time After MHST



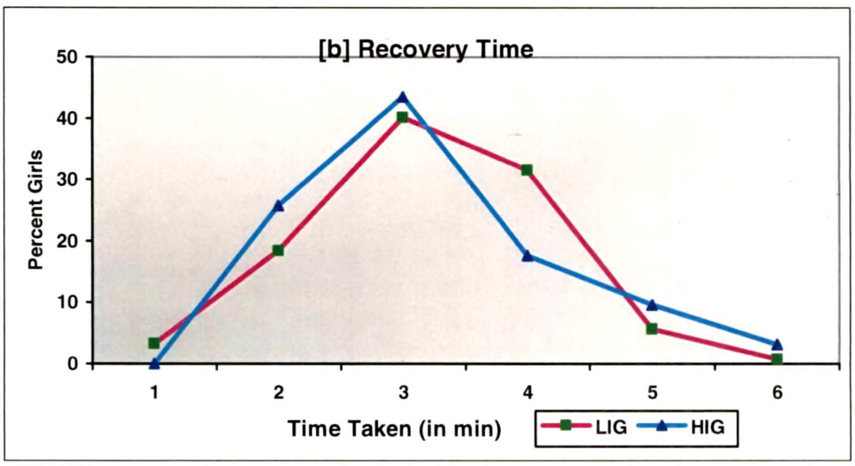


Table 4.1.14: Physical Work Capacity of The Anemic[1] and Non-Anemic[2] Girls

Indicator	Younger Girls (9-11 years)		Older Girls (12-13 years)		All girls (9-13 years)	
	N	Mean ± SD	N	Mean ± SD	N	Mean ± SD
Steps Climbed						
Anemic	150	176 ± 38.51	29	165 ± 34.25	179	174 ± 37.88
Non anemic	53	183 ± 33.93	6	173 ± 26.29	59	182 ± 33.18
t-value		1.27 NS		0.56 NS		1.51 NS
Recovery time+						
Anemic	150	3.36 ± 0.91	29	3.69 ± 0.71	179	3.41 ± 0.89
Non anemic	53	2.64 ± 0.78	6	2.16 ± 0.98	59	2.59 ± 0.81
t-value		5.09***		4.47***		6.26***

+in minutes, [1]Hb <12 g/dl, [2]Hb ≥12 g/dl, *p< 0.05, **p<0.01, ***p< 0.001

Does Undernutrition Have A Confounding Influence?

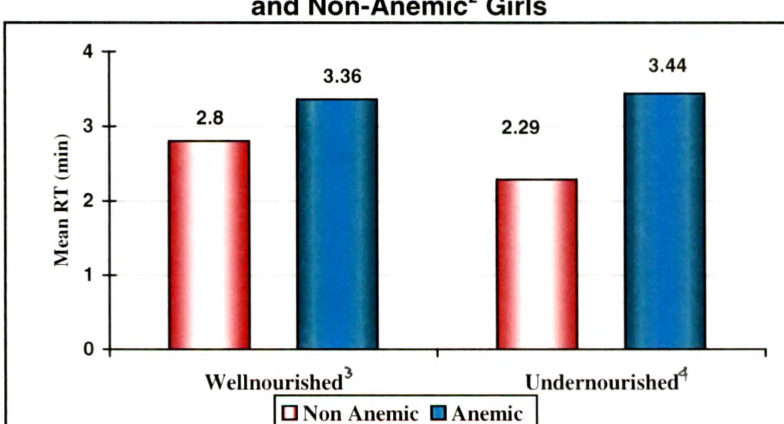
Within the wellnourished and undernourished groups, though the number of steps climbed was higher among non-anemics compared to anemics, there was no statistically significant difference (**Table 4.1.15**). On the other hand, RT was significantly better (lower) among non-anemics than their anemic counterparts in wellnourished and undernourished groups (**Figure 4.1.11**). This indicates that anemia adversely affects the PWC irrespective of nutritional status, especially the recovery time to basal pulse rate.

Table 4.1.15: PWC Of The Anemic[1] and Non-Anemic[2] Girls Who were Wellnourished[3] and Undernourished[4]

Indicator	Wellnourished		Undernourished	
	N	Mean ± SD	N	Mean ± SD
Steps Climbed				
Anemic	71	181 ± 35.62	106	175 ± 40.52
Non anemic	35	172 ± 33.93	24	184 ± 29.93
t-value		1.27 [NS]		1.00 [NS]
Recovery time[5]				
Anemic	71	3.36 ± 0.93	106	3.44 ± 0.86
Non anemic	35	2.80 ± 0.86	24	2.29 ± 0.62
t-value		3.01**		6.15***

[1]Hb <12 g/dl, [2]Hb ≥12 g/dl, [3]BMI ≥5th percentile Must et al Std., [4]BMI <5th percentile Must et al Std., [5]in minutes, *p< 0.05, **p< 0.01, ***p< 0.001, [NS]non-significant

Figure 4.1.11: Effect of Nutritional Status on Recovery Time of the Anemic[1] and Non-Anemic[2] Girls



[1] Hb < 12 g/dl, [2] Hb≥ 12 g/dl, [3] BMI ≥5th percentile Must et al Std., [4] BMI <5th percentile Must et al Std., t-test: anemic vs non-anemic: p< 0.01

Discussion

Summing up, the present study LIG girls climbed less number of steps than HIG girls. However, the mean time required to revert back to the basal pulse rate, the recovery time (RT), was similar in both the groups. The mean number of steps climbed was lower by anemic girls compared to the non-anemic girls, and the recovery time was significantly higher ($p<0.001$) for anemic girls. Further, the RT continued to be significantly higher in anemics vs. non-anemics irrespective of nutritional status (undernutrition or wellnourished). This indicates that anemia adversely affects PWC in young girls entering adolescence.

Literature in this age-group of children entering adolescence which relates anemia to functional consequences is scarce. However studies are available on younger children. In rural Varanasi, India, a study conducted on school children (6-8 years) for three years to assess their PWC using Harvard Step test (Agarwal et al 1987) found that there was a significant increase in steps taken with rise in hemoglobin ($p<0.01$). It was reported that with increasing severity of undernutrition, the number of steps climbed became fewer and the recovery time was prolonged. Another study assessing the mental and motor abilities of school children of 6-11 years in Coimbatore noted that the motor performance in various athletic events was significantly poorer among anemic children compared to the non-anemics (Gowri and Sargunam 2005).

Among adults also, anemia compromises work capacity. Scholz et al (1997) reported that anemia was associated with reduced productivity in female loom operators of jute mills of Jakarta (Indonesia) even for the less physically strenuous tasks. Anemic workers were significantly less active at home than non anemic workers; produced an average of 5.3% less in the factory and performed an average of 6.5 hours less on housework per week.

The effect of sub-clinical iron deficiency (as measured by total iron binding capacity, serum ferritin and serum iron) on physical fitness using Harvard Step Test was reported in India, Punjab, among 18-23 year old college girls (Baini and Mann 2000). A significantly ($p<0.05$) lower rapid fitness index (RFI: calculated from total exercise time and pulse rate 1 to 1 ½ min after the exercise) was observed among anemic subjects against non-anemics on paired comparison. This revealed that even sub-clinical iron deficiency reduces physical fitness.

In a Coimbatore study on twenty young adult women of same age (age not specified), it was found that non-anemic women performed much better than anemic women in various physical activities like walking, running, skipping, number of steps climbed and mopping/cleaning (area swept). After supplementation with iron, the anemic young women showed improvement in work capacity (Vijayalakshmi and Selvasundari 1983).

It appears therefore that not just preschool children and adults, but even older school children and those entering adolescence are vulnerable to the adverse functional consequences of IDA, that is, poor growth and physical work capacity, and compromised cognitive abilities. In the absence of interventions, iron deficiency will not only compromise the quality of life of these children; but the subsequent poor school performance and drop-outs will especially affect girls, as it is known that girls who do badly in school are likely to drop out earlier compared to boys. Their future reproductive health may also be jeopardized, as these girls continue to be anemic and may enter pregnancy with little iron stores, poor height and weight. It is time to focus on this neglected group of early adolescence for anemia control interventions.

Section II: Feasibility and Compliance of the IFA Intervention: A Process Evaluation

The IFA supplementation was carried out as described in the previous chapter, over one year. This section presents the results related to compliance and feasibility of supplementation with iron folic acid. In all the tables and figures presented in this section, only those girls were included for whom both **before** and **after** intervention data were available. Among the four LIG schools randomly selected, schoolgirls from three schools (experimental: ES) received either once weekly IFA tablets (IFA-1Wkly: E1) or twice weekly IFA (IFA-2Wkly: E2) or daily IFA (IFA-Daily: ED) over one year. The fourth school was the control (CS) and did not receive any supplementation (No-IFA: CS).

Compliance with Iron Folic Acid Supplementation

Overall the mean compliance was 71% to 75% of the total number of tablets distributed in the various groups (**Table 4.2.1**). The compliance was highest with twice weekly IFA supplementation groups, followed by daily group and then once a week supplementation. These differences however were not significant. A similar trend was seen among younger girls with regard to compliance. On comparing younger with older girls, compliance with IFA was better among older girls than their younger counterparts.

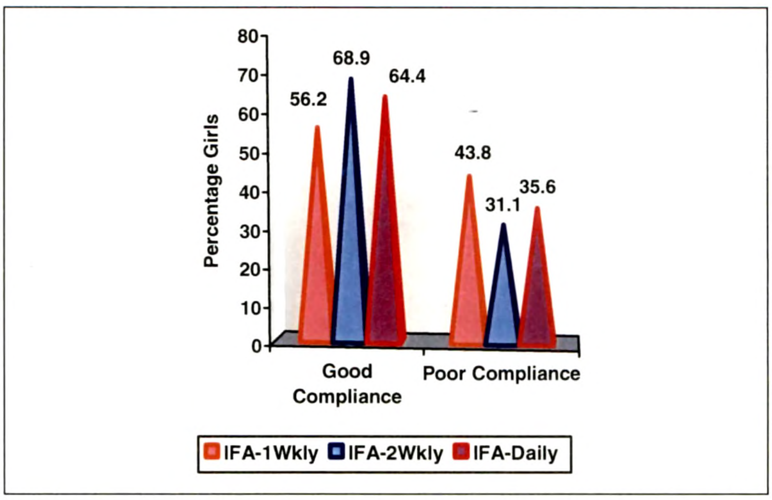
Table 4.2.1: Mean Compliance with Iron Folic Acid Tables Among the School Girls In Various Intervention Groups

Study Groups	Younger girls (9 – 11 yrs)		Older girls (12 – 13 yrs)		All Girls* (9-13 yrs)	
	N	Mean ± SD	N	Mean ± SD	N	Mean ± SD
IFA-1Wkly (E1)	58	71.30 ± 13.02	15	70.72 ± 14.36	73	71.06 ± 13.90
IFA-2Wkly (E2)	88	74.35 ± 10.36	15	76.40 ± 7.07	103	75.09 ± 12.30
IFA-Daily (ED)	49	72.42 ± 7.23	10	75.44 ± 4.81	59	72.93 ± 6.94

* The differences in the three groups are non-significant

Further, the girls were categorized into two groups: good compliance group (girls consuming ≥70% tablets) and poor compliance group (girls consuming <70% tablets) with IFA tablets. The percentage of girls with good compliance with IFA was higher in IFA-2Wkly and IFA-Daily groups than in IFA-1Wkly group (**Figure 4.2.1**).

Figure 4.2.1: Good and Poor Compliance with Iron Folic Acid Tablets In the Three Intervention Groups



Distribution and Recording of Compliance with Iron Folate Tablets

During the intervention period, the tablets were distributed on the assigned days in all the three schools: once weekly and twice weekly and daily school. On most days, the tablets were distributed, after the lunch break, to make sure that the girls do not take the tablets on empty stomach, in twice weekly and daily schools. However, in once weekly school the tablets were distributed just before the schools mid day meal, as a majority of the girls did not bring Tiffin or had very light snacks during lunch break; hence these girls also had tablets around meal time.

Two girls from each class were selected and they assisted in distribution and recording of the tablets. The investigator and the monitors made sure that each girl consumed the tablets immediately. The compliance was recorded in the compliance register, once each girl consumed it. As drinking water was made available in each class, the investigator, monitors and the class teachers were able to monitor/supervise the actual consumption by each girl. This was the case in all the schools.

The photographs show the IFA supplementation in progress in the classes: distribution, compliance and recording of compliance.

Further, the girls who remained absent on the supplementation day, were given the tablet the next day they attended the school and compliance was recorded, especially in twice weekly school. On the days when the girls observed fasts, they were given the tablets next day. In daily supplementation school, they given the tablets and were asked to consume it after the meal and compliance was recorded on the next day. In these few cases, direct supervision was not possible.

High Percentage of Absenteeism

The percentage of girls remaining absent was very high in all the Municipal schools. Attendance above 90% was seen only before and during the exams. The reasons for high absenteeism as stated by the teacher were lack of parents' interest in sending the girls to school, household responsibility on girls (if mother is sick, or is working). One of the teachers said,

- *"Mata pita ko farak nahi padta agar ladki school na jaye, aur apne chote bhai beheno ka ghar par dhyan rakhe."* (To parents it makes no difference if the girl remains at home and takes care of siblings.)

However, despite absenteeism, it was encouraging to note the average 70% compliance in all schools, perhaps because care was taken to cover the absent girls on the following days.

Iron Folic Acid Supplementation in the Classes

Distribution of IFA Tablets

Consumption of the Tablets Under Supervision

Recording of Compliance by Class Monitor

Sen and Kanani 2007

Benefits and Side Effects Experienced By the Girls

The girls were asked during the course of the intervention, in an open-ended way, regarding how they felt after consuming the tablets.

Benefits after Consuming Iron Folate Tablets

With regard to the benefits experienced and reported by the girls, a majority of the girls reported feeling energetic, having increased appetite, weight gain, reduced pallor and an overall feeling of wellness. Some of the girls also mentioned increased work capacity and increased concentration after consuming the iron tablets, especially in the twice weekly and daily groups.

About one-third of the girls mentioned having an improved appetite, leading to better food intake and weight gain. Some of them stated,

- *"Wajan vadhi jay che, lage che wadhare jami lau chu."* (I am gaining weight, I must be eating more.)
- *"Vadhare bhuk lage che. Pela be rotli khati thi, pan ave to tran khai lau chu ratre."* (Now I feel very hungry. Earlier I used to eat two chapatties, but now I eat three chapattis for dinner.)
- *"Akho diwas khawanu man thaye che."* (I feel like eating the whole day.)
- *"Wajan vadhi gayu che, pahela ochi khati thi ave vadhare khai lau chu."* (I have gained weigh, earlier I used to eat less, now I eat can eat more.)
- *"Bhookh bau sari lageche."* (Now I feel quite hungry.)
- *"Pela karta bhukh vadhare lage che."* (Now I feel more hungry than I did earlier)
- *"Wajan vadhi gayu ache."* (I have gained weight)

One girl stated that, *"Class ma badha thi lambi thai gai chu."* (Now I am the tallest amongst my classmates.)

About one-fourth of the girls mentioned feeling energetic. A few also mentioned that they don't get tired easily after doing some work. They mentioned,

- *"Ashakti nathi lagti. Pahela karta thak ocho lage che."* (I don't feel weak. Now I get tired less compared to earlier.)
- *"Mujhe to goli achi lagti hai, shakti mehsus hoti hai."* (I like the tablets, feel more energetic.)
- *"Ashakti nathi lagti."* (I don't feel tired.)
- *"Sarir ma shakti wadhi gayu ache."* (My body strength has increased.)
- *"Modha upar fikash nathi, sarir ma takat pan che."* (My face doesn't look dull and I also feel energetic.)

One girl from IFA-Daily group said, *"Mara bhai thi vadhare takat avi gaya che. Ene race ma haravi dau chu."* (I have more strength than my brother. He loses in a race with me.)

Some girls mentioned that they were able to concentrate better on their studies after receiving the tablets, *"Bhanva ma man lageche."* (I can concentrate on studies.). Others said,

- *"Kantalo nathi avto, vadhare bhanwa ma man lage che."* (I don't feel bored; I can concentrate more on my studies.)
- *"Bhanwa ma man lage che ane ave ungh pan nathi aavti goli galya pachi."* (After taking the tablet I can concentrate on my studies and don't feel sleepy.)
- *"Lesson sari reete thay che."* (I can do my lessons properly.)

A few other benefits mentioned by the girls were reduced illness, "improvement in blood",

- *"Swasthy saaru thai gayu ache, vadhare mandi nathi padti."* (My health has improved, I don't fall ill frequently.)
- *"Pahela goli lidha pachi mathu dukhtu hatu, ave nathi thatu. Sehat sari lage che."* (Earlier I used to get a headache after taking he tablets, now I don't get it. I feel better.)

- *"Lohi lal thai gayu che. Kale lohi tapas karva gai hati to, pahela karta lohi vadhare lal thai gayu che."* (My blood has become red. Yesterday I went to get my blood tested. The blood has become more red than it was earlier.)

As expressed by a few girls, even their mothers and friends noticed the beneficial effects of supplementation and some even asked for the tablets. In their words:

- *"Mummy mane kahe che ke tu pahela karta vadhare Khaye che."* (My mother says that you eat much more than before.)
- *"Mari maa to lade che ke kem etli bhookh lageche."* (My mother gets annoyed because I often feel hungry.)
- *"Pahela pet dukhtu hatu, pan ave saru lageche. Mari ma kahe che ke ave hu chust thai gai chu."* (Earlier my stomach used to pain, but now I feel better. My mother says I have become energetic.)
- *"Mari benpani kidhu, tu pehela karta gori lage che. Modha upar fikash nathi pan chamak che. Ave ene pan sakti ni goli joiyeche."* (My friend says you look beautiful. Your face does not look dull but looks brighter. Now she also wants strength giving (iron) tablets.)
- *"Meri benpani ke liye bhi goli le jau, uske school me goli nahi dete?"* (Can I take the tablet for my friend too; she doesn't get it from her school?)

Side Effects Experienced After Consuming Iron Folate Tablets

Overall less than one-third (about 20%) of the girls experienced any kind of side effect after taking the tablets and in most it was transient. The most common side effects experienced were stomach ache, vomiting/ nausea, headache, giddiness, loose motions and uneasiness. Some of the girls also mentioned fever, acidity and constipation. To quote:

- *"Pet dhukheche goli galya pachi."* (After consuming the tablet, my stomach aches.)
- *"Goli to na gali shakiye, pet dukheche ane pet saf pan nathi thatu."* (I cannot take the tablet, stomach aches and my stools are not clear.)

- *"Goli galya pachi mathu chakray che."* (My head feels dizzy after consuming he tablet.)
- *"Goli galya pachi ghabharoman thay che, ulti jevu lage che."* (I feel uneasy after taking the tablet, I feel nauseated.)
- *"Pet ma dhukhavo thay, saru nathi lagtu, goli galwanu man nathi thatu."* (Stomach aches, feel uneasy. Don't like taking the tablets.)

A majority of the girls who experienced side effects were from those receiving daily supplements. However, they continued to consume the tablets. They were explained that after continuing the tablets for some time, the side effects would gradually subside. Very few girls from IFA-2Wkly and IFA-1Wkly groups mentioned any side effects other than stomachache and vomiting. These complaints were more in IFA-1Wkly group, mainly because the girls had very light snacks for lunch and only had their meals after going back home. One girl from IFA-1Wkly group said, *"Pet dukheche, kokwar khali pet goli gali lau tyare."* (My stomachaches when I take the tablet on empty stomach).

Among the girls who were not consuming the tablets regularly, when asked the reason, mentioned that they didn't like the taste and smell of the tablet.

- *"Mane eno swad nathi bhavto, ulti jevu lage che."* (I don't like its taste, feel like vomiting.)
- *"Hu sathe chocolate rakhu chu, goli gadya pachi khauchu. Goli pehla to swad lageche pan pachi bahar nikdi jay che."* (I always keep a chocolate with me, after taking the tablet I eat the chocolate. When you take the tablet, first it is okay but then I feel it will come out.)

One girl in IFA-Daily group was not taking the tablets as she was ill and consuming other tablets. She said, *"Mane varamvar tav ave che, biji golio galu chu, etle aa goli nathi galti."* (I get fever often; I am taking a lot of other tablets so I don't take these tablets.)

Overall, the benefits of IFA tablets were much more compared to the side effects experienced. Further, the side effects were not very severe and did not lead to discontinuation of consumption of the tablets, except for a few girls.

Observations in School

The observations mentioned below are based on field notes of the investigator.

Involvement and Interest of Teachers

With regard to interest of the class teachers, they were highly motivated and enthusiastic about the iron supplementation, especially in twice weekly and daily school. The teachers helped in distribution of IFA and recording of compliance regularly and also supervised the process. Those who remained absent were given the tablets by the teachers and compliance was recorded. Even the girls themselves asked for the tablets, when they missed their dose. Initially, the girls had to be motivated, by the teachers and the investigator to consume the tablets. However, with time they started taking the tablet as a routine.

- *"Amara doctor e kidu che ki goli sari che ane jyare aape, gadi jawanu. Enathi shakti madse ane fikapan dur thase. Etle hu lal goldi gadu chu daroj."* (My doctor says the tablet is good, I should consume it. It gives energy and will remove paleness.)

The cooperation from the school receiving once a week was less compared to the other schools. The teachers were not motivated enough and only occasionally helped the girls. The investigator was present on all the days of supplementation and observed/ supervised the process herself in addition to the monitors assisting in distribution and recording of compliance. Some girls were highly motivated and regularly consumed the tablets, whereas a few threw the tablets outside.

In one of the three intervened schools, receiving twice weekly IFA tablets, drinking water was not available in the school premises; hence a few girls brought water bottles from home especially for the supplementation. The percentage compliance with IFA was highest in this school due to a high level of school and students cooperation.

Discussion

Summing up this section, on an average, compliance was 71% to 75% of the total tablets distributed. Compliance was better in IFA-2Wkly and IFA-Daily than IFA-1Wkly, mainly because of better students' and teachers' cooperation. Further, though the girls experienced some side effects with IFA tablets, the benefits were much more as expressed by the girls themselves. Most of those with side effects continued with supplementation due to monitoring and reassurance by the investigator and teacher.

What is the compliance reported in other regions? The prevalence of iron deficiency anemia is widespread, even though there are national programs to combat anemia. Many studies have looked at the issue but mostly for women. Iron supplementation is only effective over a relatively prolonged period and pills may be discontinued before the regimen has a positive impact hence monitoring and compliance is essential. Literature suggests that side effects are result of both physiological and psychological responses to iron supplementation but do not impede compliance in a major way (Galloway and McGurie 1994).

The pilot project of the Gujarat Government's Adolescent Anemia Control Program (UNICEF supported) conducted in Vadodara district supplemented secondary school girls in rural, tribal and urban areas with 100 mg Fe and 0.5 mg folic acid once weekly for one year (Kotecha et al 2002). A routine monitoring system was set up for the program at district level, school level, class level and at individual level. The overall compliance with IFA was about 89% for 17 months, based on the monthly compliance report data received by the District Education Office. Benefits after taking the tablets, such as increased work capacity and decreased pallor, was experienced by 51% of the girls. Initially 30% complained of side effects which reduced to 14.3% by the end of one year.

What causes poor adherence or compliance with iron folate tablets?

Gillespie (1998) suggests individual and programmatic factors for non-adherence to the medication.

- *Individuals do not perceive themselves to be 'ill' and lack of understanding of sings and consequences of anemia*: In this study the knowledge regarding anemia, its causes, consequences and treatment was very poor among all the girls. Further very few realized that they were anemic and that there was an urgent need to improve their hemoglobin status. Hence, before the initiation of the supplementation, the girls were sensitized regarding anemia and the importance of IFA.
- *Lack of motivation to take tablets over a long period of time*: Those students not motivated enough were regularly encouraged by the investigators, class teachers and fellow students. When motivated, they consumed that tablets and adhered to the supplementation regimen, mainly in the IFA-2Wkly and IFA-Daily groups.
- *Gastrointestinal side effects related to dose and unacceptable colour, taste*: Overall, very few girls experienced such side effects and expressed a dislike due to colour and taste. Further this did not lead to discontinuation of the tablets.
- *Poor distribution or supply of supplements*: Care was taken to ensure supply and regular distribution.
- *Lack of supportive community and education and counseling*: Co-operation of the school community is a critical factor for success. In IFA-2Wkly and IFA-Daily schools, the teachers were very supportive and took active interest in the supplementation.

Section III: Impact Of Iron-Folic Acid Supplementation

This section presents the results related to the impact of the intervention with iron folic acid on the schoolgirls. As stated earlier, all the experimental schoolgirls (ES) received either once weekly iron folic acid tablets (IFA-1Wkly: E1) or twice weekly IFA (IFA-2Wkly: E2) or daily IFA (IFA-Daily: ED) over a period of one year. The fourth school was the control and did not receive any supplementation (No-IFA: CS).

Impact on Anemia as Measured by Hemoglobin Levels

The impact on hemoglobin and prevalence of anemia is presented below.

Mean Increment in the Hemoglobin (Hb) Levels

As **Table 4.3.1** reveals, that the mean Hb increased to normal values of about 12 g/dl in ES groups after the intervention whereas there was a negligible increase in CS of 0.03 g/dl. This trend was seen within the younger as well as the older age group. There was an increment of 0.6 - 1 g/dl in Hb levels in all the ES groups.

Which intervention group was better? In the total sample, the increment in the mean Hb was highest in IFA-2Wkly (0.97 g/dl) and was comparable to IFA-Daily (0.93 g/dl). It was relatively less in the once weekly, though this too was significantly higher than control. Similar trends were observed with regard to Hb increments within the younger and older age groups. Also within the younger and older age groups, the treated group had significantly higher Hb increments than the control. Further, on comparing younger with older girls, it was seen that mean Hb increments in IFA-2Wkly and IFA-Daily were relatively higher in older girls.

Table 4.3.2 gives the inter group comparison and level of significance. Considering all girls, the difference in increments between ES groups and CS were highly significant. However, within the treatment groups the increments were not significantly different.

Therefore, statistically the three intervention groups were comparable. The trends were similar when only the younger girls were considered.

Table 4.3.1: Change in Mean Hemoglobin Levels of the Girls After The Intervention

Study Groups	Younger girls (9 – 11 yrs)				Older Girls (12 –13 yrs)				Total (9-13 yrs)			
	N	Initial Mean ± SD	Final Mean ± SD	Mean change ± SD	N	Initial Mean ± SD	Final Mean ± SD	Mean change ± SD	N	Initial Mean ± SD	Final Mean ± SD	Mean change ± SD
IFA-1Wkly	52	11.43 ± 1.09	12.07 ± 0.55	0.64 ± 0.92	13	11.66 ± 0.92	12.18 ± 0.35	0.52 ± 0.72	65	11.48 ± 1.06	12.09 ±.0.44	0.62 ± 0.88
IFA-2Wkly	77	11.12 ± 1.44	12.05 ± 0.43	0.95 ± 1.17	12	10.86 ± 1.75	11.97 ± 0.31	1.12 ± 1.59	89	11.09 ± 1.47	12.04 ± 0.41	0.97 ± 1.23
IFA-Daily	50	11.37 ± 1.70	12.18 ± 0.58	0.82 ± 1.37	9	10.61 ± 1.53	12.09 ± 0.44	1.51 ± 1.36	59	11.26 ± 1.69	12.18 ± 0.55	0.93 ± 1.38
No-IFA	34	11.53 ± 0.70	11.54 ± 0.67	0.03 ± 0.25	7	11.59 ± 0.54	11.54 ± 0.44	-0.01 ± 0.16	41	11.53 ± 0.67	11.55 ± 0.63	0.03 ± 0.24
(F-value)				5.9***				2.84*				8.0***

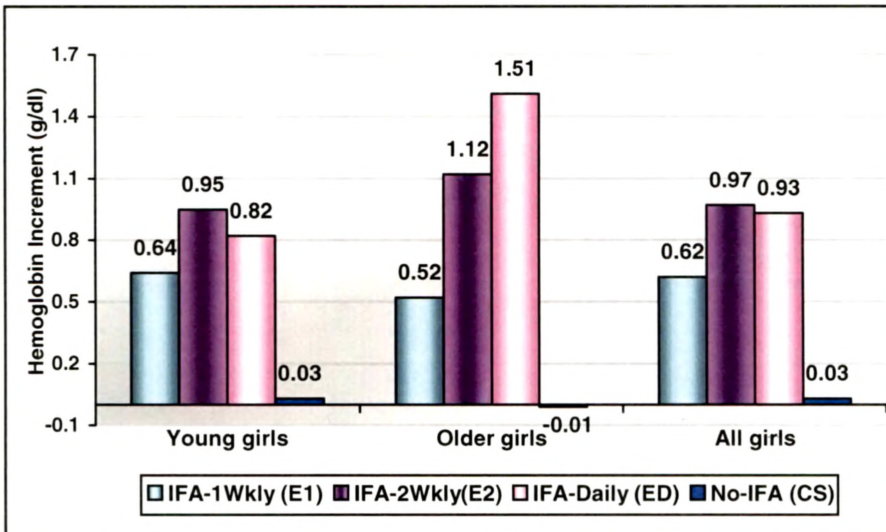
*p < 0.05, ***p<0.001

Table 4.3.2: Change in Mean Hemoglobin Levels in the School Girls After The Intervention: Level of Significance Between The Groups

Study Groups	Younger girls (9 – 11 yrs)		All Girls (9-13 yrs)	
	N	Mean change ± SD	N	Mean change ± SD
IFA-1Wkly (E1)	52	0.64 ± 0.92	65	0.62 ± 0.88
IFA-2Wkly (E2)	77	0.95 ± 1.17	89	0.97 ± 1.23
IFA-Daily (ED)	50	0.82 ± 1.37	59	0.93 ± 1.38
No-IFA (CS)	34	0.03 ± 0.25	41	0.03 ± 0.24
't' Value:				
E1 vs CS:		4.49***		5.07***
E2 vs CS:		6.52***		6.89***
ED vs CS:		3.94**		4.82***
E1 vs E2:		1.67 NS		2.04 *
E1 vs ED:		0.76 NS		1.45 NS
E2 vs ED:		0.54 NS		0.18 NS

NS non significant, *p < 0.05, **p < 0.01, ***p<0.001

Figure 4.3.1: Mean Increment in Hemoglobin Levels Among Younger And Older Girls After The Intervention



In all girls: p<0.001 (E1 vs CS, E2 vs CS, ED vs CS), *p < 0.05 (E2 vs E1), [NS]non significant (ED vs E1, E2 vs ED)

Figure 4.3.1 compares the mean change in the different groups after the intervention among younger and older girls. As the frequency of dosing increased from once weekly to twice weekly, the mean Hb increment also improved in total sample, in younger as well as older girls. The older girls benefited more than younger girls from IFA-2Wkly and from daily supplementation; with increments being marked in daily supplementation. In the total sample though, both IFA-2Wkly and IFA-Daily had similar benefits.

Did the Level Of Compliance Influence The Impact on Hemoglobin Levels? To better assess the efficacy of the intervention, the girls were further categorized according to their compliance with iron folic acid tablets. Those with '*good compliance*' (≥70% dose consumed) were compared to those with '*poor compliance*' (consumption less than 70% dose) (**Table 4.3.3**). As expected, the mean change in Hb levels was significantly better in girls with good compliance than those with poor compliance in all the intervention groups but the difference (0.8 to 1 g/dl Hb) was higher in the IFA-2Wkly and IFA-Daily groups compared to the IFA-1Wkly group (0.6 g/dl).

Table 4.3.3: Mean Hemoglobin Change in Girls with Good[1] Compliance and Poor[2] Compliance with Iron Folic Acid Tablets After the Intervention

Study Groups	Good Compliance[1]				Poor Compliance[2]				't' Value A vs B
	N	Initial Mean ± SD	Final Mean ± SD	Mean change ± SD (A)	N	Initial Mean ± SD	Final Mean ± SD	Mean change ± SD (B)	
IFA-1Wkly	32	11.29 ± 1.20	12.20 ± 0.42	0.90 ± 1.03	33	11.66 ± 0.88	11.98 ± 0.44	0.34 ± 0.59	2.64*
IFA-2Wkly	64	10.82 ± 1.42	12.04 ± 0.34	1.22 ± 1.23	25	11.76 ± 1.45	12.06 ± 0.57	0.31 ± 0.97	3.62***
IFA-Daily	37	10.59 ± 1.61	12.12 ± 0.46	1.53 ± 1.35	22	12.37 ± 1.14	12.26 ± 0.69	0.08 ± 0.66	5.43***
(F-value)				2.29[NS]				2.42[NS]	

[1]Compliance with ≥ 70% of IFA Tablets, [2]Compliance with < 70% of IFA Tablets, [NS]non significant, ***p<0.001

Table 4.3.4: Change in Mean Hemoglobin Levels of Initially Anemic Girls After the Intervention

Study Groups	Initially Anemic[1] Girls				Initially Non-Anemic[2] Girls				't' Value (A vs B)
	N	Initial Mean ± SD	Final Mean ± SD	Mean change ± SD (A)	N	Initial Mean ± SD	Final Mean ± SD	Mean change ± SD (B)	
IFA-1Wkly	46	10.93 ± 0.58	11.93 ± 0.33	0.98 ± 0.65	19	12.79 ± 0.76	12.48 ± 0.41	-0.28 ± 0.67	6.80***
IFA-2Wkly	61	10.38 ± 1.22	11.93 ± 0.42	1.55 ± 1.03	28	12.62 ± 0.48	12.29 ± 0.31	-0.30 ± 0.46	11.58***
IFA-Daily	34	10.07 ± 1.18	11.95 ± 0.43	1.89 ± 1.07	25	12.87 ± 0.55	12.55 ± 0.35	-0.30 ± 0.47	10.45***
No-IFA	30	11.30 ± 0.63	11.33 ± 0.59	0.50 ± 0.22	11	12.18 ± 0.14	12.12 ± 0.24	-0.04 ± 0.27	5.71***
(F-value)				30.16***				0.84[NS]	

[1]Hb < 12 g/dl, [2]Hb ≥ 12 g/dl, [NS]non significant, *p < 0.05, **p < 0.01, ***p<0.001

Mean Increment In Hemoglobin Levels Of Initially Anemic Girls

From the total sample, the girls were categorized into initially anemic and non-anemic girls and the mean Hb increments were compared. The mean Hb increments among initially anemic girls in all the supplemented groups were significantly higher (p<0.001) than those among initially non-anemic girls (**Table 4.3.4**). Among the non-anemic girls there was no significant difference between the ES groups and CS. In anemic girls, the increment in the mean Hb of the ES groups was 1 to 1.5 g/dl as compared to the mean Hb increment in CS of 0.5 g/dl.

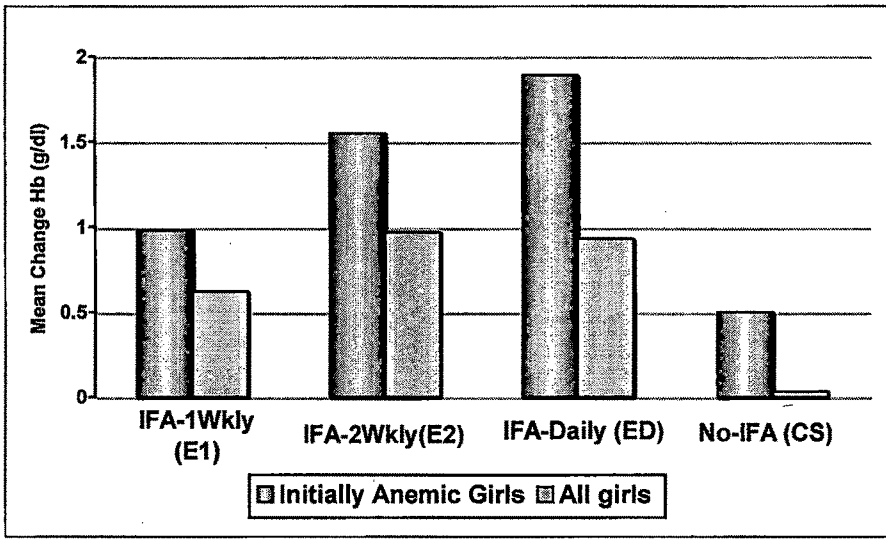
Which intervention group was better? Among initially anemic girls, IFA-daily group showed highest increments (1.9 g/dl) followed by IFA-2Wkly (1.6 g/dl). Further, though the gain was relatively less, even those anemic girls who were supplemented only once a week (IFA-1Wkly) gained about 1 g/dl of Hb. In No-IFA group, initially anemic girls showed small increment in Hb levels; while the non-anemics showed a small deterioration in Hb levels. **Table 4.3.5** further shows the inter-group comparison and extent of change. Among the initially anemic girls in the intervened groups, the difference in Hb increment was comparable and non-significant between IFA-Daily and IFA-2Wkly groups showing that twice weekly has a similar impact as daily in presence of anemia. Though IFA-1Wkly was significantly better than the No-IFA group, the gain was not as high as IFA-2Wkly and IFA-Daily. IFA-2Wkly and IFA-Daily anemic girls had significantly better Hb gains than in IFA-1Wkly.

Table 4.3.5: Change in Mean Hemoglobin Levels in Initially Anemic Girls After the Intervention: Level of Significance Between The Groups

Study Groups	**Initially Anemic[1] Girls**		**Initially Non-Anemic[2] Girls**	
	N	Mean change ± SD	N	Mean change ± SD
IFA-1Wkly (E1)	46	0.98 ± 0.65	19	-0.28 ± 0.67
IFA-2Wkly (E2)	61	1.55 ± 1.03	28	-0.30 ± 0.46
IFA-Daily (ED)	34	1.89 ± 1.07	25	-0.30 ± 0.47
No-IFA (CS)	30	0.50 ± 0.22	11	-0.04 ± 0.27
't' Value:				
E1 vs CS:		8.84***		1.31 NS
E2 vs CS:		10.79***		2.04*
ED vs CS:		9.69***		2.56*
E1 vs E2:		3.46***		0.11 NS
E1 vs ED:		4.33***		0.11 NS
E2 vs ED:		1.49 NS		0.00 NS

[1]Hb < 12 g/dl, [2]Hb ≥ 12 g/dl, NS non significant, *p < 0.05, **p < 0.01, ***p<0.001

Figure 4.3.2: Mean Change In Hemoglobin Levels among Initially Anemic and All Girls After The Intervention



Initially anemic vs All girls:'t' value: No-IFA: 8.43***, IFA-1Wkly: 2.46*, IFA-2Wkly: 3.11***, IFA-Daily: 3.68***

Figure 4.3.2 shows the mean Hb increments among the initially anemic girls compared with total sample of all girls (anemics as well as non-anemics). The figure corroborates the previous findings that the initially anemic girls show higher gains, irrespective of the treatment group. Considering all girls together, the increments in Hb in IFA-Daily and IFA-2Wkly were similar, and higher than IFA-1Wkly. However, in the initially anemic girls the increments in Hb clearly increased with increase in the frequency of the doses, highest being in the IFA-Daily group.

The trend is similar when minimum 1 g/dl Hb gain was considered, with a higher proportion gaining $\geq$1 g/dl Hb in IFA-2Wkly and IFA-Daily compared to IFA-1Wkly, as seen below.

Proportion Of Girls Gaining At least 1 g/dl In Different Groups

Table 4.3.6 shows that in the total sample, more than one-third of the girls gained $\geq$1 g/dl of Hb after the intervention. About 40% of the girls in IFA-Daily and IFA-2Wkly gained $\geq$1 g/dl of Hb, which was higher than 35% in IFA-1Wkly. No-IFA group has not been shown in the table as none of the girls in this group gained $\geq$1 g/dl of Hb.

Table 4.3.6: Proportion of Girls Showing Various Levels Of Hemoglobin Increments In Experimental And Control Groups After Intervention

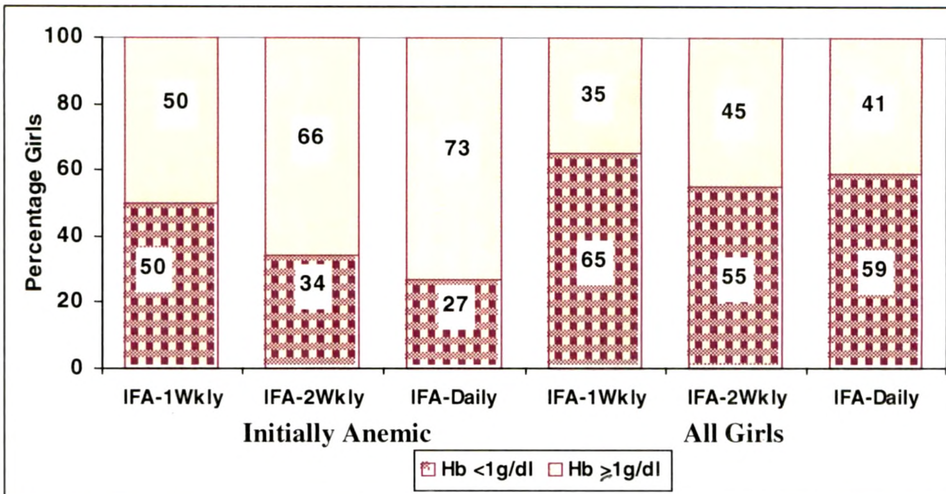
Hemoglobin Increment	All Girls (A)		Initially Anemics[1] (B)		Chi Sq test (A vs B)
	N	n (%)	N	n (%)	
IFA-1Wkly	65		46		2.37 [NS]
≥ 1 g/dl		23 (35)		23 (50)	
< 1 g/dl		42 (65)		23 (50)	
IFA-2Wkly	89		61		6.19*
≥ 1 g/dl		40 (45)		40 (66)	
< 1 g/dl		49 (55)		21 (34)	
IFA-Daily	59		33		8.71**
≥ 1 g/dl		24 (41)		24 (73)	
< 1 g/dl		35 (59)		9 (27)	

[1]Hb < 12 g/dl, [NS]non significant, *p < 0.05, **p < 0.01, ***p<0.001, Percentages are given in parentheses.

A significantly higher percentage of initially anemic girls in IFA-Daily (p<0.01) and IFA-2Wkly (p<0.05) gained ≥1 g/dl of Hb as compared to all girls, in their respective groups (**Figure 4.3.3**). Three-fourth of the initially anemic girls in the IFA-Daily group gained ≥1 g/dl of Hb. Further, more than 50% initially anemic girls in IFA-2Wkly and IFA-1Wkly also gained ≥1 g/dl of Hb.

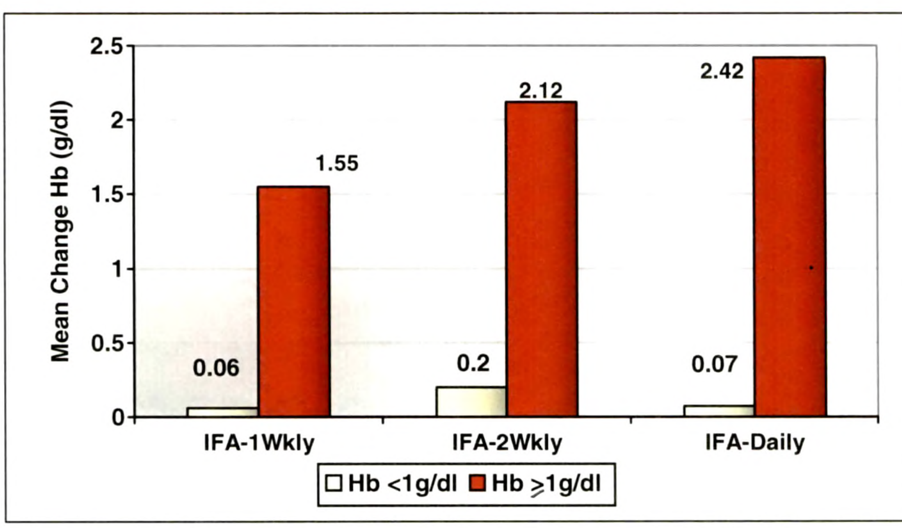
Did the Level Of Compliance Influence The Impact on Hemoglobin Levels? To rule out the confounding effect of compliance with IFA tablets, girls with good compliance were selected and the impact was seen. **Figure 4.3.4** illustrates that the impact of IFA supplementation on the girls with good compliance was higher in IFA-Daily and IFA-2Wkly as they gained more than 2 g/dl Hb compared to IFA-1Wkly (1.5 g/dl change).

Figure 4.3.3: Percentage Girls Showing More Than 1 g/dl Hemoglobin Increment: Initially Anemic[1] And All Girls



[1]Hb < 12 g/dl

Figure 4.3.4: Mean Change In Hemoglobin Levels Among Those Who Had Good Compliance With IFA Tablets



Percentage Reduction In The Prevalence Of Anemia

Table 4.3.7 compares the prevalence of anemia before and after the intervention program. After one year of intervention the prevalence of anemia significantly decreased in the ES groups, while no change was seen in CS. The percentage reduction in anemia was highest in IFA-Daily (66.6%) and IFA-2Wkly (63.9%), followed by IFA-1Wkly (41.3%). Even with a weekly dose of IFA per week (IFA-

1Wkly) the reduction in anemia was highly significant. The prevalence of anemia in the No-IFA group remained the same.

Table 4.3.7: Change in Prevalence of Anemia[1] in the Experimental and Control Groups After The Intervention

Study Groups	N	Pre – Intervention Prevalence of Anemia[1] (A)		Post – Intervention Prevalence of Anemia[1] (B)		% Reduction in Anemia	Chi Sq test (A vs B)
		n	%	n	%		
IFA-1Wkly	65	46	70.8	27	41.5	41.3	6.83***
IFA-2Wkly	89	61	68.5	22	24.7	63.9	14.01***
IFA-Daily	59	33	57.9	11	18.6	66.6	5.13*
No-IFA	41	30	73.2	30	73.2	0	0^{NS}

[1]Hb < 12 g/dl, [NS]non significant, *p < 0.05, **p < 0.01, ***p<0.001

Figure 4.3.5 compares the prevalence of anemia before and after the intervention among younger and older girls. In CS, the prevalence remained similar (pre and post) in both younger and older girls. In ES groups, the prevalence of anemia significantly reduced in both age groups but the decrease was more marked (by 40% to 50%) in IFA-2Wkly and IFA-Daily among both younger and older girls. Thus in both younger and older girls, anemia was around 40% in IFA-1Wkly in younger and older girls while it was around 20% in IFA-2Wkly and IFA-Daily groups. Relatively, older girls (whose anemia prevalence was higher at baseline) showed a higher reduction of anemia compared to younger girls.

Similarly the reduction in prevalence of anemia in girls with good compliance was significantly higher than those with poor compliance **(Table 4.3.8 and Figure 4.3.6)** and the reduction was comparable in the three intervened groups (68%–72%). Further, even with poor compliance some reduction in prevalence was seen which was relatively better in IFA-Daily and IFA-2Wkly. Therefore compliance of more than 70% is likely to significantly improve the iron-folate status of the girls, even in IFA-1Wkly. However, even in less compliant girls, there was reduction in anemia provided the dose was at least twice weekly or daily. Given the fact that compliance will vary in program situation, giving IFA twice a week as a minimum appears desirable.

Figure 4.3.5: Change In Prevalence Of Anemia Among Younger And Older Girls After The Intervention

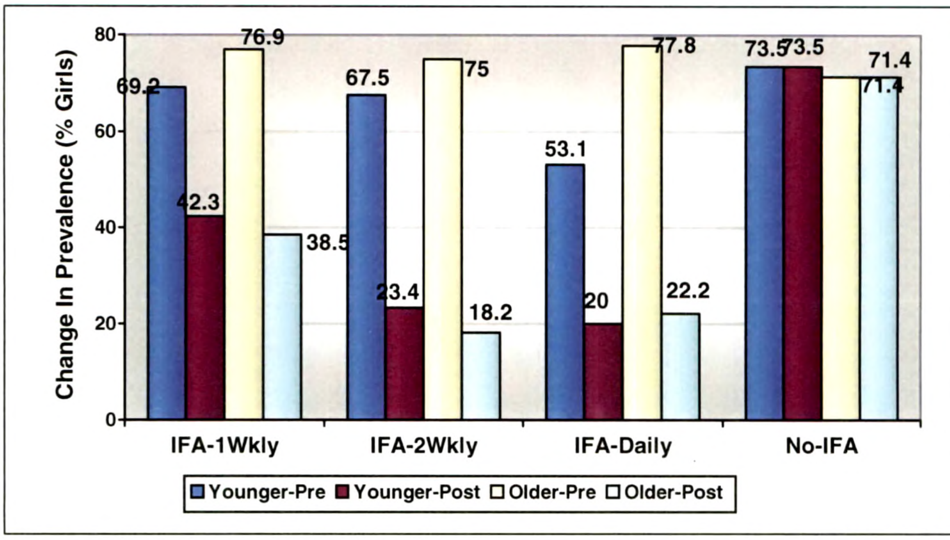
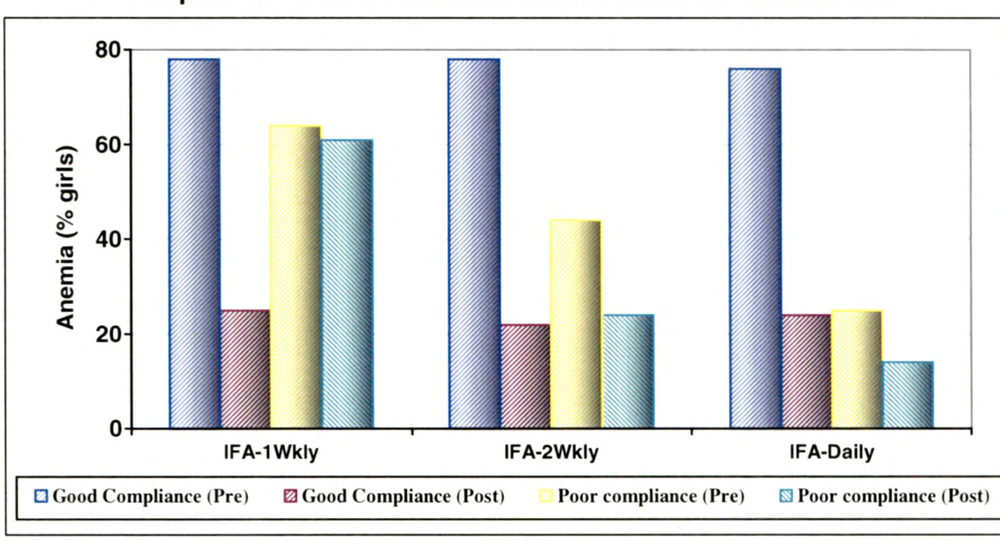


Figure 4.3.6: Prevalence of Anemia with Good Compliance[1] and Poor Compliance[2] of Iron Folic Acid Tablets After the Intervention



[1]Compliance of ≥70% of IFA Tablets, [2]Compliance of <70% of IFA Tablets, [3]Hb <12 g/dl, [NS]non significant, ***p<0.001

Table 4.3.8: Prevalence of Anemia in Girls with Good Compliance[1] and Poor Compliance[2] of Iron Folic Acid Tablets After the Intervention

Study Groups	Good Compliance				Poor Compliance			
	N	Pre % Anemic[3] n (X1)	Post % Anemic[3] n (Y1)	% Reduction in Anemia	N	Pre % Anemic[3] n (X2)	Post % Anemic[3] n (Y2)	% Reduction in Anemia
IFA-1Wkly	32	25(78)	7(25)	72***	33	21(64)	20(61)	5^{NS}
IFA-2Wkly	64	50(78)	16(22)	68***	25	11(44)	6(24)	45^{NS}
IFA-Daily	37	28(76)	9(24)	68***	22	5(25)	2(9)	60^{NS}
Chi-Sq test: X1 vs Y1 and X2 vs Y2								

[1]Compliance of ≥70% of IFA Tablets, [2]Compliance of <70% of IFA Tablets, [3]Hb <12 g/dl, [NS]non significant, ***p<0.001

Shift In Severity Of Anemia After The Intervention

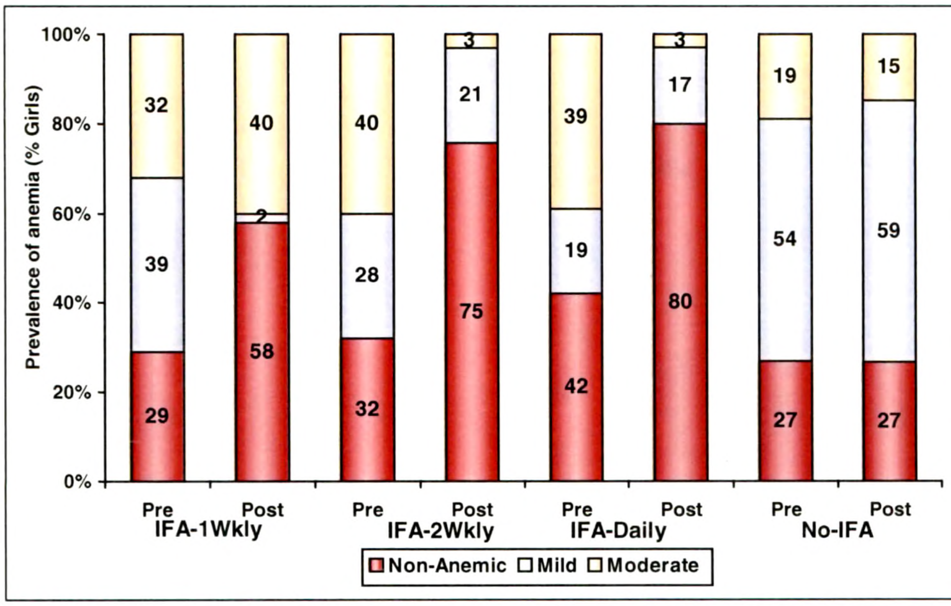
The girls were categorized to see the shift in the severity of anemia (**Table 4.3.9**). There was a significant shift from moderate anemia to mild anemia and further to non-anemic status in the intervened groups. A non-significant shift was seen in the No-IFA group from moderate to mild anemia. The figure (**Figure 4.3.7**) clearly shows the shift towards non-anemic status from mild-moderate anemia in the four groups, in particular the higher proportion of non-anemics in IFA-Daily and IFA-2Wkly (70-80%) post intervention. Therefore, compared to once weekly iron folate supplementation, supplements given more often were more beneficial to girls in moving them towards normal Hb levels.

Table 4.3.9: Shift in Severity of Anemia in Girls After the Intervention

Study Groups	Severity of Anemia							Chi Sq Test A vs B
	N	Before Intervention (A)			Post Intervention (B)			
		Non-Anemic[1]	Mild[2]	Moderate[3]	Non-Anemic	Mild	Moderate	
		n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	
IFA-1Wkly	65	19 (29)	25 (39)	21 (32)	38 (58)	26 (40)	1 (2)	24.53***
IFA-2Wkly	89	28 (32)	25 (28)	36 (40)	67 (75)	19 (21)	3 (3)	44.75***
IFA-Daily	59	25 (42)	11 (19)	23 (39)	47 (80)	10 (17)	2 (3)	24.41***
No-IFA	41	11 (27)	22 (54)	8 (19)	11 (27)	24 (59)	6 (15)	0.37^{NS}

[1]Hb ≥12 g/dl, [2]Hb = 11.99 to 11.00 g/dl, [3]Hb = 10.99 to 7.00 g/dl, [NS]non significant, ***p<0.001

Figure 4.3.7: Shift in Severity of Anemia in Girls after the Intervention



Non-anemic: Hb ≥12 g/dl, Mild anemia: Hb = 11.99 to 11.00 g/dl, Moderate anemia: Hb = 10.99 to 7.00 g/dl

Discussion

To state briefly, in this study, iron folic acid supplementation significantly improved the Hb levels in all the three intervention regimens. The IFA-2Wkly and IFA-Daily groups consistently showed better impact than IFA-1Wkly. Older girls (12-13 years) benefited more compared to younger girls (9-11 years). Overall, the prevalence of anemia significantly reduced in all the intervened groups, however, within these groups, more number of girls shifted to non-anemic status in the daily group and twice weekly group than in once weekly group.

Two studies on Bangladeshi anemic adolescent girls (14-19 yrs) reported significant and comparable improvement in the hematologic status (Hb and serum ferritin) in both IFA group and multiple micronutrients group after 12 weeks. In the first study the girls were supplemented twice a week IFA tablets (IFA group or MMN group) (Ahmed et al 2005). In the second study to group 1, weekly IFA (120 mg elemental Fe + 3.5 mg folic acid) doses were given (n=289). Group 2 received the same IFA tablet along with vitamin A (2.42 mg retinol), group 3 received only vitamin A, and group 4 was the control (Ahmed, Khan and Jackson 2001). Post intervention, there was a significant increase in TIBC and transferring saturation in IFA and IFA + vitamin A groups than in placebo and only vitamin A groups. Moreover, there was a significant reduction in anemia: 92% in IFA + vitamin A, followed by 85% in IFA group.

Similarly in Malaysia, adolescent girls supplemented with different dose levels of iron-folate supplements (either 60 or 120 mg iron + 3.5 mg folic acid once a week) for 22 weeks showed a significant improvement in the Hb levels in both groups (Tee et al 1999). The proportion of non-anemic girls increased after intervention.

In Indonesia, various studies have been done to study the efficacy of IFA interventions in different age groups. Anemic non-pregnant women factory workers (n=42) were supplemented with either daily or once a week IFA tablets (60 mg Fe + 250 µg folic acid) for 9 weeks. Weekly supplementation with a relatively low dose of medicinal iron was as effective as daily supplementation in improving the iron status (Gross and Schultink 1994). A double blind placebo control trial among 14 – 18 years old girls (N=273) supplemented IFA daily or twice weekly for 3 months (group1: Daily: 60mg Fe + 250 µg folic acid + 750 µg retinal + 60 mg vitamin C, group 2: Weekly iron + 500 µg folic acid + 6000 µg retinal + vitamin C, group 3: 120 mg Fe + folic acid + Retinol + vitamin C, and group 4: placebo). Hb, ferritin, and retinol response was significantly better in daily and weekly regimens compared to placebo. Further, the prevalence of anemia significantly decreased in weekly group, supplemented with 60 mg iron (Schultnik et al 1997).

Studies among preschool children in Indonesia also reported similar impact on Hb levels with IFA supplementation. One study on anemic 2-5-year-olds, supplementing 30 mg Fe for 8 weeks, reported that for pre-school children with low iron levels, twice-weekly iron supplementation has an effect on iron status similar to that of daily supplementation. Hb, serum ferritin, and protoporphyrin levels increased significantly in both groups (Schultnik et al 1995). Another study on the same age group showed Hb levels were significantly better in once weekly group (30 mg Fe for 9 weeks) than placebo (Palupi et al 1997).

Primary schoolchildren (n=397) in southern Thailand received Albendazole and then received ferrous sulfate (300 mg/tablet) either daily or weekly, or a placebo for 16 week (Sungthong et al 2002). The increase in Hb was not significantly different between the daily and once weekly groups. However, the increase in serum ferritin was greater ($p<0.01$) in the daily than the weekly group. All anemic became non-anemic after 16 weeks in both daily and weekly groups, whereas no reduction in prevalence occurred in the placebo group.

In Karachi, after two months of supplementation with ferrous sulfate (200 mg) among anemic school children (5-10 y), there was a significant rise in Hb, hemotocrit, serum iron and serum ferritin levels in both daily and once-weekly supplementation school groups (Siddiqui, Rahman and Jaleel 2004). There was a decrease in TIBC in both groups. Therefore, the authors concluded that iron available by once weekly supplementation could also fully saturate transferring in iron deficient individuals. Weekly supplementation not only replete functional iron stores but storage iron as well.

In India, Sharma, Prasad and Rao (2000) administered once `weekly' and `daily' IFA tablets to anemic (Hb<12 g/dl) adolescent girls of rural parts of Bharatpur (Rajasthan) (n=82) for 6 months. The treatment groups were: group 1: once weekly IFA (100 mg elemental iron + 500 μg folate); group 2: once weekly IFA + 25 mg vitamin C; group 3: daily IFA. Daily IFA supplementation was more effective than once weekly supplementation groups; however, response with once weekly was considerable.

In a similar study in urban areas of Delhi in the same age group (n=164) by the same authors, group 1 and 2 received similar supplements as in earlier study; however, group 3 (the control group) did not receive any supplementation. With weekly IFA supplementation the change in the mean Hb level were higher than controls. Pooling the urban and rural data, the authors found that the response obtained with IFA given daily was superior to that obtained with IFA supplemented weekly after three months. After 6 months, overall the reduction in prevalence of anemia was about 50% in all the groups, including in once weekly groups.

A study reported by Indian Institute of Health and Family Welfare (IIHFW) (2002-2003) examined the efficacy of once weekly IFA supplementation among rural school going adolescent girls in Andhra Pradesh and reported beneficial effects on Hb levels in the once weekly supplementation group. A shift was seen from mild-moderate anemia to non-anemic status; increase in non-anemic status being 17% to 60%. In our study also, the percentage reduction in anemia occurred in all the supplementation groups after one year, however, the reduction in anemia was more than 60% in daily and twice weekly groups and less (41%) in once-weekly group.

Studies reviewed by Hallberg (1998) on daily as well as intermittent IFA supplementation reported that six times more iron was absorbed when IFA was given daily than when given weekly and concluded that there was no mucosal block during oral iron therapy in humans. However, he further stated that, if relatively high iron doses were given for a long time to subjects with low grade anemia, then all the doses of iron, all dosage schedules, and all iron preparations will give a similar Hb response. Thus, in the long run, intermittent iron-folate therapy will perhaps have a satisfactory improvement on reducing anemia at lower cost and greater compliance. From our study and literature reviewed also, it appears that long-term supplementation program, whether once or twice weekly, is likely to be as effective as daily IFA.

Further, in the present study highest gain in Hb was seen amongst those initially having lowest Hb levels. Initially anemic girls gained more Hb compared to their non-anemic counterparts. This gain was highest among the IFA-Daily and IFA-2Wkly group. With the increase in the frequency of doses the proportion of girls gaining at least 1 g/dl Hb increased.

Literature reviewed show similar results. In China, the Hb response of the anaemic children (3-6-year-old) was higher in every regimen than that of the non-anaemic girls (Hb>11 g/ dl) who received 6 mg elemental iron/kg of body weight as ferrous sulphate daily or twice a week, or weekly under direct supervision for three months (Liu et al 1995). The increments in Hb observed with the three regimens in both groups were similar. All three regimens resulted in significant increases in serum ferritin. Non-anemic as well as anemic children receiving iron only once a week had lower values than those receiving more frequent doses. Among the anemic weekly-supplemented children, none had serum ferritin levels above 44 μg/L. In contrast, the 20 (64%) who received daily supplementation had levels above 50 μg/L, as did 9 (33%) of those receiving supplements twice weekly. The authors concluded that the amount of iron absorbed from a weekly and twice weekly dose was well tolerated and effective enough to prevent and correct mild to moderate anemia in 3 months.

Tee et al (1999) also reported that the Hb increase in anemics was two times greater than borderline-anemics regardless of iron dose. He supplemented Malaysian adolescent girls with different dose levels of iron-folate supplements (either 60 or 120 mg iron + 3.5 mg folic acid once a week) for 22 weeks.

Ahmed, Khan and Jackson (2001) reported similar impact among Bangladeshi teenager girls. The increase in Hb levels was greater in the subgroup with lower initial Hb levels than those with higher initial Hb levels. Adolescent girls (n=85) in Indonesia received weekly IFA (60 mg Fe) or weekly IFA + Vit A + Vit C for 5 weeks (Katelhut et al 1996). Among anemics improvement was reported in Hb levels. It is well known that in anemics absorbed iron is first utilized to normalize Hb concentration in plasma; thereafter iron stores are replenished by increasing serum ferritin. Here the period of supplementation was not enough to normalize the iron levels in anemic girls. While in non-anemics the improvement was reported in serum ferritin. This was likely as non-anemic girls had adequate iron status and supplementation increased iron storage in these girls.

What about the effect of compliance?

In the present study, upon removing the confounding effect of compliance, and comparing only girls with good compliance (≥70% compliance with IFA tablets), again the daily and twice weekly groups had greater impact than once weekly. The impact of IFA supplementation in terms of Hb gain ≥1 g/dl was better in daily and twice weekly groups compared to the once weekly group. Similarly the reduction in prevalence of anemia in girls with good compliance was comparable between twice weekly and daily groups. All girls with good compliance in the three intervened groups shifted towards non-anemic status from mild-moderate anemia in post intervention.

Almost all studies and reports reviewed and presented in this section earlier showing significant impact of IFA supplementation on Hb levels and serum ferritin levels have reported high level of compliance with IFA irrespective of the frequency of the doses i.e. daily or intermittent (Ahmed, Khan and Jackson 2001, Tee et al 1999) and emphasized the importance of supervision with once weekly or twice weekly regimens.

Importance of compliance has been pointed out by a review of supplementation trials by Beaton and McCabe (1998). In the meta-analysis of results of 22 completed trials of iron supplementation among adolescents they concluded that weekly supplementation should be considered only in situations where there is strong assurance of supervision and high compliance. Overall daily supplementation may be more likely to have greater impact on final Hb and prevalence of anaemia than in weekly supplementation if compliance is poor. Daily tablet intake during a prolonged period of time may be unappealing over the long run. Tablet intake on an intermittent basis may be a promising alternative to improve the efficacy of supplementation programs, with steps taken to ensure compliance. In fact compliance is better and cost is less with intermittent IFA supplementation.

Considering the fact that a majority of girls are anemic and that there will be mixed compliance rates (good to poor) even in supervised situations like schools, twice weekly IFA appears to be a better option than once weekly IFA in young adolescent girls.

Impact on Growth With Regard To Gain in Height-for-Age, Weight-for-Age and Body Mass Index

In line with the study objectives of assessing the impact of iron folic acid supplementation on growth of the girls, this section presents data related to height-for-age, weight-for-age and BMI of the girls in the various groups.

Mean Increment in Height, Weight and Body Mass Index (BMI)

Height

As **Table 4.3.10** shows, overall, the mean height after the intervention ranged from 140 cm to 142 cm with the mean increment in height in ES groups (>6 cm) being almost double than that in CS group (3.6 cm) after the intervention. The mean increment in height was similar among the three intervened groups i.e. IFA-1Wkly[1], IFA-2Wkly[2] and IFA-Daily[3], considering the total sample, the younger and older girls. In IFA-1Wkly and IFA-2Wkly, younger girls gained more height compared to their older counterparts, whereas the gain in IFA-Daily was similar among younger and older age groups.

Weight

With regards to weight, overall the mean weight after the intervention ranged from 31Kgs to 33 Kgs, with the mean increment in weight being about 5 to 5.6 Kgs in ES groups compared to 3.6 Kgs gain in CS (**Table 4.3.10**). In the total sample, girls receiving IFA-2Wkly and IFA-Daily had relatively better weight gain (about 0.5 Kg more) than girls receiving IFA-1Wkly. A similar trend was observed among younger and older girls where girls in IFA-1Wkly gained less compared to the other two intervened groups. Among older girls, the gain in weight seems to increase with increase in the frequency of doses, though these differences were not significant; also the sample size was small in this group.

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[1] IFA-1Wkly: IFA given once a week, [2] IFA-2Wkly: IFA given twice a week, [3] IFA-Daily: IFA given daily

Table 4.3.10: Change in Mean Height for Age, Weight for Age And Body Mass Index Among The School Girls After the Intervention

Study Groups	Younger Girls (9 – 11 yrs)				Older Girls (12 –13 yrs)				Total (9-13 yrs)			
	N	Initial Mean ± SD	Final Mean ± SD	Mean change ± SD	N	Initial Mean ± SD	Final Mean ± SD	Mean change ± SD	N	Initial Mean ± SD	Final Mean ± SD	Mean change ± SD
Height for Age												
IFA-1Wkly	58	133.1 ± 7.99	139.5 ± 8.06	6.38 ± 1.55	15	140.2 ± 11.2	146.0 ± 10.7	5.82 ± 1.69	73	134.5 ± 9.11	140.8 ± 9.00	6.27 ± 1.59
IFA-2Wkly	88	132.1 ± 7.57	138.6 ± 7.38	6.61 ± 1.96	15	143.1 ± 5.65	148.7 ± 5.27	5.65 ± 1.73	103	133.6 ± 8.27	140.1 ± 7.93	6.46 ± 1.95
IFA-Daily	49	134.6 ± 7.47	140.6 ± 7.23	6.09 ± 1.32	10	146.6 ± 6.94	152.7 ± 7.14	6.10 ± 1.23	59	136.6 ± 8.62	142.7 ± 8.49	6.09 ± 1.29
No-IFA	35	134.1 ± 7.63	137.9 ± 7.31	3.78 ± 1.26	8	145.4 ± 5.49	148.7 ± 6.42	3.34 ± 1.35	43	136.3 ± 8.46	139.9 ± 8.25	3.69 ± 1.27
(F-value)				26.6***				5.7**				30.7***
Weight for Age												
IFA-1Wkly	58	26.1 ± 5.24	30.0 ± 5.56	4.93 ± 1.99	15	29.14 ± 6.37	34.3 ± 5.76	5.15 ± 2.70	73	26.71 ± 5.58	31.7 ± 5.72	4.97 ± 2.14
IFA-2Wkly	88	24.7 ± 4.42	30.3 ± 5.39	5.57 ± 1.83	15	29.84 ± 3.7	35.5 ± 4.44	5.66 ± 1.66	103	25.45 ± 4.68	31.0 ± 5.56	5.58 ± 1.80
IFA-Daily	49	26.4 ± 4.56	31.9 ± 5.16	5.51 ± 1.75	10	32.48 ± 4.07	38.5 ± 4.51	6.03 ± 1.24	59	27.44 ± 5.00	33.04 ± 5.51	5.59 ± 1.68
No-IFA	35	25.8 ± 4.51	29.5 ± 5.14	3.66 ± 1.87	8	35.28 ± 5.46	38.5 ± 5.30	3.29 ± 1.78	43	27.61 ± 5.94	31.2 ± 6.22	3.59 ± 1.84
(F-value)				9.76***				3.26*				13.0***
Body Mass Index (BMI)												
IFA-1Wkly	58	14.61 ± 1.98	15.83 ± 1.81	1.23 ± 1.04	15	14.70 ± 1.73	16.03 ± 1.62	1.34 ± 1.24	73	14.63 ± 1.92	15.87 ± 1.76	1.25 ± 1.08
IFA-2Wkly	88	14.05 ± 1.42	15.66 ± 1.72	1.61 ± 0.82	15	14.56 ± 1.09	16.01 ± 1.29	1.46 ± 0.57	103	14.16 ± 1.38	15.71 ± 1.66	1.58 ± 0.79
IFA-Daily	49	14.46 ± 1.70	16.09 ± 1.91	1.63 ± 0.94	10	15.08 ± 1.47	16.50 ± 1.30	1.43 ± 0.52	59	14.57 ± 1.67	16.16 ± 1.81	1.59 ± 0.88
No-IFA	35	14.27 ± 1.37	15.41 ± 1.51	1.14 ± 0.86	8	16.61 ± 1.63	17.37 ± 1.22	0.76 ± 0.92	43	14.71 ± 1.68	15.77 ± 1.64	1.06 ± 0.87
(F-value)				3.9**				1.22NS				4.88**

NS non significant, *p < 0.05, **p < 0.01, ***p<0.001

Body Mass Index (BMI)

BMI is the recommended indicator for nutritional status in adolescents. The impact on growth in terms of BMI gain in the girls was measured after the intervention and all the groups were compared. Overall, in the total sample, the mean BMI increased from 14 Kg/m^2 before the intervention to 15-16 Kg/m^2 after the intervention (**Table 4.3.10**) with the mean increment in BMI being significantly higher in ES groups compared to those in CS group. Further, this trend was seen in younger and older girls also. Within the intervened groups, the girls in IFA-2Wkly and IFA-Daily had similar BMI gains after the intervention, which were higher than IFA-1Wkly. **Figure 4.3.8** shows at a glance this trend. Among younger and older girls also (**Table 4.3.10**), IFA-2Wkly and IFA-Daily had better and comparable increments compared to IFA-1Wkly and No-IFA group.

Figure 4.3.8: Mean Increment in BMI (kg/m^2) Among The School Girls After The Intervention

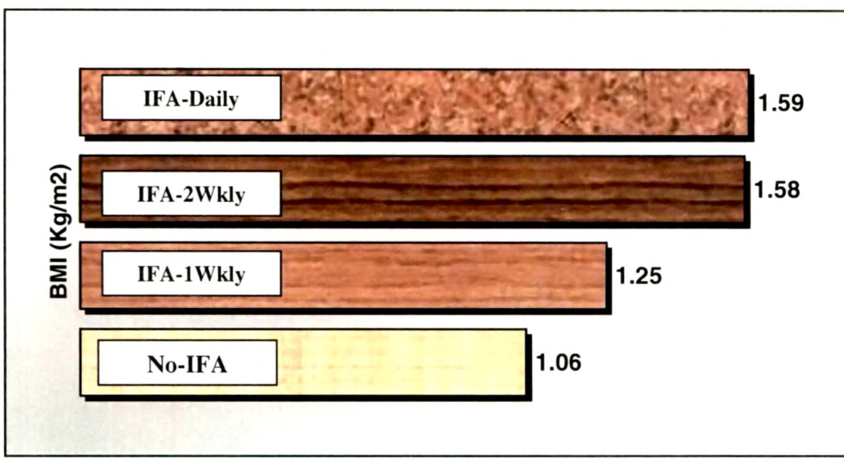


Table 4.3.11: Change in Mean Height, Weight and BMI after The Intervention: Level of Significance Between The Groups

Study Groups	N	Height	Weight	BMI
		Mean Change ± SD	Mean Change ± SD	Mean Change ± SD
IFA-1Wkly (E1)	73	6.27 ± 1.59	4.97 ± 2.14	1.25 ± 1.08
IFA-2Wkly (E2)	103	6.46 ± 1.95	5.58 ± 1.80	1.58 ± 0.79
IFA-Daily (ED)	59	6.09 ± 1.29	5.59 ± 1.68	1.59 ± 0.88
No-IFA (CS)	43	3.69 ± 1.27	3.59 ± 1.84	1.06 ± 0.87
't' Value:				
E1 vs CS:		9.52***	3.63***	1.03 NS
E2 vs CS:		10.07***	5.94***	3.35***
ED vs CS:		9.27***	5.56***	2.99**
E1 vs E2:		0.71 NS	1.98*	2.21*
E1 vs ED:		0.71 NS	1.93 NS	1.98*
E2 vs ED:		1.44 NS	0.04 NS	0.07 NS

NS Non Significant, *p<0.05, **p<0.01, ***p<0.001

How significant was the impact when one group was compared with another?

Intervened vs. controls: Height and weight gains among the girls supplemented with IFA (all ES groups) were significantly higher (p<0.001) compared to the non-supplemented counterparts (CS group) **(Table 4.3.11).** However, with regard to BMI, only IFA-2Wkly (p<0.001) and IFA-Daily (p<0.01) had significantly higher increments compared to No-IFA, the control group. IFA-1Wkly was not significantly different from control group.

Within the intervened groups: All the three groups (IFA-1Wkly, IFA-2Wkly and IFA-Daily) were comparable in terms of gain in height and the difference was not statistically significant. However, weight gain in IFA-2Wkly was significantly higher than in IFA-1Wkly. Moreover, BMI increments in IFA-2Wkly and IFA-Daily were significantly higher (p<0.05) than in IFA-1Wkly group. In IFA-2Wkly and IFA-Daily, the mean increment in height, weight and BMI was comparable and statistically similar. Therefore, though height gain was similar with the three IFA regimens, in terms of BMI gains, the benefits were higher among girls receiving more than once weekly doses of IFA tablets i.e. daily and twice weekly groups.

Table 4.3.12: Mean Change in BMI (% Std[1]) After the Intervention

Study Groups	Younger girls (9 – 11 yrs)				Older Girls (12 –13 yrs)				Total (9-13 yrs)			
	N	Initial Mean ± SD	Final Mean ± SD	Mean change ± SD	N	Initial Mean ± SD	Final Mean ± SD	Mean change ± SD	N	Initial Mean ± SD	Final Mean ± SD	Mean change ± SD
IFA-1Wkly	58	85.91 ±11.77	89.21 ± 9.80	3.32 ± 6.62	15	78.99 ± 9.81	83.79 ± 8.96	4.63 ± 6.77	73	84.49 ± 11.68	88.10 ± 9.82	3.59 ± 6.63
IFA-2Wkly	88	82.54 ± 8.54	88.19 ± 9.84	5.74 ± 4.69	15	78.28 ± 6.14	83.75 ± 6.09	4.93 ± 3.75	103	81.92 ± 8.35	87.54 ± 9.57	5.62 ± 4.54
IFA-Daily	49	85.58 ± 10.00	90.86 ± 10.7	5.28 ± 5.24	10	79.98 ± 5.91	84.84 ± 5.95	4.86 ± 3.00	59	84.63 ± 9.62	89.84 ± 10.33	5.21 ± 4.92
No-IFA	35	83.99 ± 8.16	86.86 ± 8.72	2.86 ± 5.19	8	89.57 ± 9.86	90.66 ± 7.41	1.09 ± 5.30	43	85.03 ± 8. 65	87.57 ± 8.54	2.53 ± 5.19
(F-value)				3.81*				1.23[NS]				4.51**

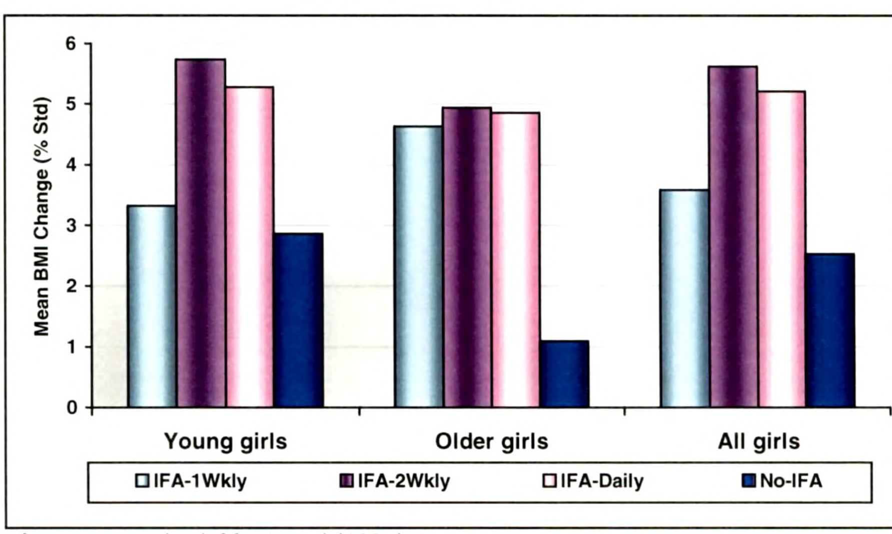
[1]BMI reference standard: Must et al (1991), [NS]non significant, *p < 0.05, **p < 0.01, ***p<0.001

Impact on Body Mass Index When Expressed as Percent of Reference Standards

Body Mass Index of the girls was compared with Must et al standards (1991). When BMI was expressed as percentage of these standards and the impact was compared between different groups, the results showed similar trends. Overall the improvement in BMI (% Std.) was higher in ES groups compared to CS group after the intervention (**Table 4.3.12**). *Within the two age groups:* Growth in terms of BMI (% Std.) was higher in younger girls compared to older girls in IFA-2Wkly and IFA-Daily. This could be due to higher weight gain among the older girls in proportion to their height.

Within the intervened groups: IFA-2Wkly and IFA-Daily had similar gains which were higher compared to IFA-1Wkly girls. Among younger girls the trend was similar. However, in older girls, gain was similar in all the three intervention groups. **Figure 4.3.9** demonstrates the trend in BMI increments (% Std.) among younger and older girls.

Figure 4.3.9: Mean Change in BMI (% Std[1]) Among Younger and Older Girls After The Intervention



[1]BMI reference standard: Must et al (1991)

How significant was the impact when one group was compared with another?

The level of significance between the groups is presented in **Table 4.3.13.**

Intervened vs. controls: The IFA-2Wkly and IFA-Daily groups were significantly better than No-IFA control group. However, though BMI gain was higher in IFA-1Wkly compared to No-IFA group, the difference was not statistically significant.

Within the intervened groups: Though IFA-2Wkly and IFA-Daily groups had higher BMI gains (% Std.), only IFA-2Wkly was significantly better compared to IFA-1Wkly.

Table 4.3.13: Mean Change in BMI (% Must et al) In The School Girls After The Intervention: Level of Significance Between The Groups

Study Groups	N	Mean Change ± SD	't' Value
IFA-1Wkly (E1)	73	3.59 ± 6.63	E1 vs CS: 0.95 [NS]
IFA-2Wkly (E2)	103	5.62 ± 4.54	E2 vs CS: 3.36***
IFA-Daily (ED)	59	5.21 ± 4.92	ED vs CS: 2.60**
No-IFA (CS)	43	2.53 ± 5.19	E1 vs E2: 2.25*
			E1 vs ED: 1.60 [NS]
			E2 vs ED: 0.52 [NS]

[1]BMI reference standard: Must et al (1991), [NS]non significant, *p < 0.05, **p < 0.01, ***p<0.001

BMI of Present Study Girls Compared To The CDC Growth Standards Given By National Health and Nutrition Examination Survey, United states (2005)

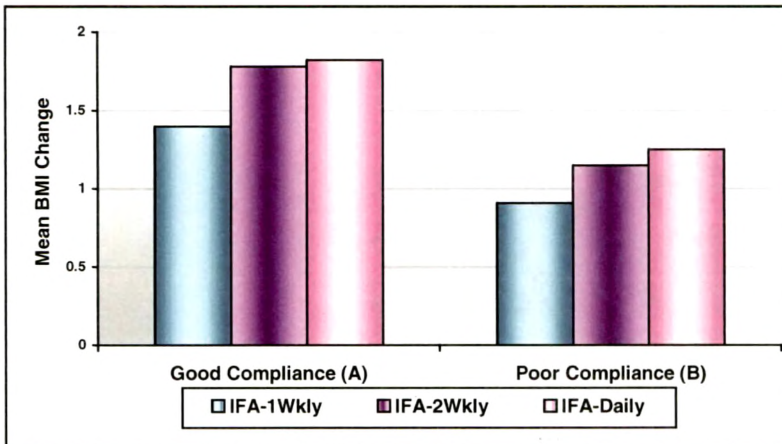
The mean BMI (% Std.) of the present study girls were also calculated using the CDC growth standards (2000) and the groups were compared (**Table 4.3.14**). It was seen that the trends as regards impact were similar, i.e. the IFA-2Wkly and IFA-Daily groups were significantly better than No-IFA control group and IFA-1Wkly group.

Table 4.3.14: Mean Change in BMI (% CDC) In the School Girls after the Intervention

Study Groups	N	Mean Change ± SD	't' Value
IFA-1Wkly (E1)	73	3.84 ± 6.21	E1 vs CS: 0.93 [NS]
IFA-2Wkly (E2)	103	5.79 ± 4.41	E2 vs CS: 3.34***
IFA-Daily (ED)	59	5.81 ± 4.93	ED vs CS: 2.95**
No-IFA (CS)	43	2.85 ± 4.96	E1 vs E2: 2.29*
			E1 vs ED: 2.02*
			E2 vs ED: 0.03 [NS]

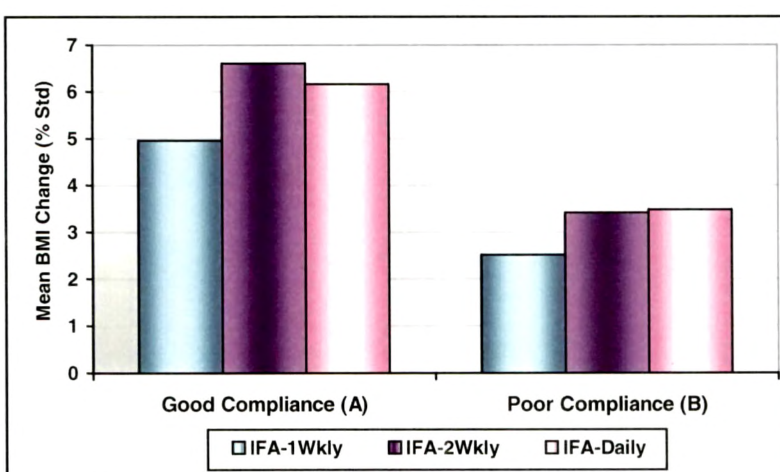
[1]BMI reference standard: CDC (2000), [NS]non significant, *p < 0.05, **p < 0.01, ***p<0.001

Figure 4.3.10: Mean Change in BMI among Girls with Good[1] And Poor[2] Compliance With Iron Folic Acid Tablets After the Intervention



[1]Compliance of ≥ 70% of IFA Tablets, [2]Compliance of < 70% of IFA Tablets
't' test (A vs. B): E1 $p<0.05$, E2 $p<0.01$, ED $p<0.001$
Within good compliance group 't' test: E1 vs E2: $p<0.05$, E1 vs ED: $p<0.05$, E2 vs ED: $p>0.05$
Within poor compliance group 't' test: All groups: $p>0.05$

Figure 4.3.11: Mean Change in BMI (% Must et al Std.) With Good[1] And Poor[2] Compliance



BMI reference standard: Must et al (1991), [1]Compliance of ≥ 70% of IFA Tablets, [2]Compliance of < 70% of IFA Tablets; 't' test (A vs. B): E1 $p>0.05$, E2 $p<0.001$, ED $p<0.05$

Did the Level of Compliance Influence the Impact on Growth in terms of BMI?

The girls were categorized according to their compliance with iron folic acid tablets. BMI of those with good compliance (≥70% dose consumed) were compared to those with poor compliance (consumption <70% dose). BMI increments were significantly higher in all the three intervened groups for girls showing good compliance with IFA (**Figure 4.3.10**). Although when all girls were considered, IFA-1Wkly did not show significant improvement in BMI, on removing the confounding effect of compliance, this group also showed significant gains in BMI. Therefore, with high level of compliance, even a single dose of IFA can significantly improve growth in young adolescent girls.

How significant was the impact when one group was compared with another? Within the good compliance group, mean BMI gain was significantly higher in IFA-2Wkly and IFA-Daily compared to IFA-1Wkly. The two groups, IFA-2Wkly and IFA-Daily were similar and comparable.

Did the Level Of Compliance Influence The Impact On BMI Expressed as Percentage of Reference Standards?

The mean increment in BMI (% Must et al Std.) was significantly better in good compliance group girls in IFA-Daily ($p<0.05$) and IFA-2Wkly ($p<0.001$) (**Figure 4.3.11**). However, the mean change in BMI within good compliance group, though higher in IFA-Daily and IFA-2Wkly groups than IFA-1Wkly, this difference was not significant.

Mean Increment in Growth Of Initially Anemic and Non-anemic Girls

The girls were categorized based on their initial Hb levels into initially anemic (Hb <12 g/dl) and non-anemic, and the mean increments in their anthropometric indices were compared (**Table 4.3.15**).

Anemic vs. non-anemic within each intervened group: The mean height gain of anemics vs. non-anemics was similar and non-significant in the IFA-1Wkly and IFA-2Wkly groups, while the increment in height in IFA-Daily was significantly higher among anemic girls than in non-anemics. As regards BMI, the BMI increments were significantly higher among the anemic girls in all the three treatment groups compared to their non-anemic counterparts. In No-IFA control, the mean increment in height and BMI among anemics and non-anemics was similar and non- significant.

Within anemic girls: In IFA-2Wkly and IFA-Daily groups the BMI gains were higher compared to IFA-1Wkly.

Table 4.3.15: Mean Change in Anthropometric Indices in Initially Anemic Girls After The Intervention

Study Groups	Initially Anemic[1] Girls				Initially Non-Anemic[2] Girls				't' Value A vs B
	N	Initial Mean ± SD	Final Mean ± SD	Mean change ± SD (A)	N	Initial Mean ± SD	Final Mean ± SD	Mean change ± SD (B)	
Height									
IFA-1Wkly	48	134.7 ± 9.26	140.8 ± 9.41	6. 33 ± 1.68	19	134.2 ± 8.91	140.4 ± 8.83	6.23 ± 1.52	0.21[NS]
IFA-2Wkly	64	133.2 ± 8.49	139.6 ± 8.24	6.45 ± 1.56	32	134.5 ± 7.81	140.9 ± 7.70	6.52 ± 2.57	0.18[NS]
IFA-Daily	33	136.7 ± 9.23	142.4 ± 8.85	6.50 ± 1.22	23	136.6 ± 7.84	142.6 ± 7.87	5.55 ± 1.19	2.92**
No-IFA	29	135.5 ± 8.23	138.6 ± 7.75	3.59 ± 1.09	11	138.4 ± 9.14	142.7 ± 9.05	4.25 ± 1.40	1.58[NS]
(F-value)				31.8***				4.27**	
BMI									
IFA-1Wkly	48	14.34 ± 1.53	15.85 ± 1.63	1.47 ± 0.89	19	15.44 ± 2.62	16.35 ± 2.05	0.92 ± 1.27	2.00*
IFA-2Wkly	64	14.15 ± 1.41	16.03 ± 1.62	1.80 ± 0.76	32	14.06 ± 1.76	15.36 ± 1.54	1.31 ± 0.74	3.01**
IFA-Daily	33	14.34 ± 1.23	16.03 ± 1.42	1.81 ± 0.95	23	14.89 ± 2.14	16.26 ± 2.35	1.29 ± 0.67	2.23*
No-IFA	29	14.39 ± 1.33	15.49 ± 1.47	1.18 ± 0.79	11	15.62 ± 2.62	16.35 ± 1.89	0.73 ± 1.07	1.48[NS]
(F-value)				4.74**				1.64[NS]	

[1]Hb <12 g/dl, [2]Hb ≥12 g/dl, [NS]non significant, *p< 0.05, **p< 0.01, ***p<0.001

How significant was the impact when one group was compared with another? The anemic as well as non-anemic girls receiving IFA had significantly better (p<0.001) height gains than those who did not receive any intervention **(Table 4.3.16)**. Even a single dose of IFA per week had beneficial effect on anemic and non-anemic girls. Within the intervention groups, height gain was not significantly different between IFA-Daily, IFA-2Wkly and IFA-1Wkly indicating comparable impact.

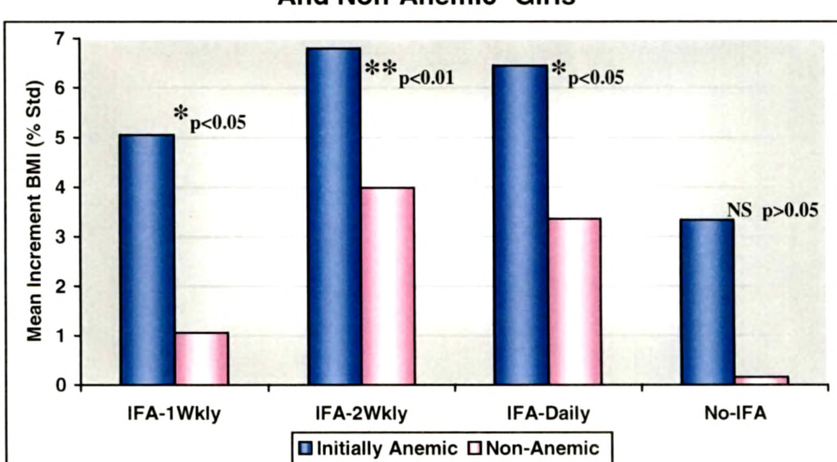
With regard to BMI increment only among anemic girls, IFA-Daily and IFA-2Wkly were significantly better than No-IFA. The difference in BMI increments in IFA-1Wkly and No-IFA were statistically non-significant. Initially anemic girls benefited more compared to non-anemic girls. Daily IFA dosage, followed closely by twice weekly group, showed maximum impact on BMI of anemic girls.

Table 4.3.16: Mean Change in Anthropometric Indices: Height and BMI in Initially Anemic Girls: Level of Significance between the Groups

Study Groups	Height				BMI			
	Initially Anemic[1] girls		Initially Non-Anemic[2] Girls		Initially Anemic girls		Initially Non-Anemic Girls	
	N	Mean change ± SD	N	Mean change ± SD	N	Mean change ± SD	N	Mean change ± SD
IFA-1Wkly (E1)	48	6. 33 ± 1.68	19	6.23 ± 1.52	48	1.47 ± 0.89	19	0.92 ± 1.27
IFA-2Wkly (E2)	64	6.45 ± 1.56	32	6.52 ± 2.57	64	1.80 ± 0.76	32	1.31 ± 0.74
IFA-Daily (ED)	33	6.50 ± 1.22	23	5.55 ± 1.19	33	1.81 ± 0.95	23	1.29 ± 0.67
No-IFA (CS)	29	3.59 ± 1.09	11	4.25 ± 1.40	29	1.18 ± 0.79	11	0.73 ± 1.07
't' Value:								
E1 vs CS:		9.05***		3.48***		1.55 NS		0.44 NS
E2 vs CS:		10.58***		3.55***		3.68***		2.01*
ED vs CS:		10.16***		2.56 **		2.92**		1.56 NS
E1 vs E2:		0.40 NS		0.50 NS		2.17*		1.19 NS
E1 vs ED:		0.55 NS		1.56 NS		1.67 NS		1.12 NS
E2 vs ED:		0.18 NS		1.85 NS		0.05 NS		0.10 NS

[1]Hb<12 g/dl, [2]Hb ≥12 g/dl, NS non significant, *p< 0.05, **p< 0.01, ***p<0.001

Figure 4.3.12: Mean Change in BMI (% Must et al) in Initially Anemic[1] And Non-Anemic[2] Girls

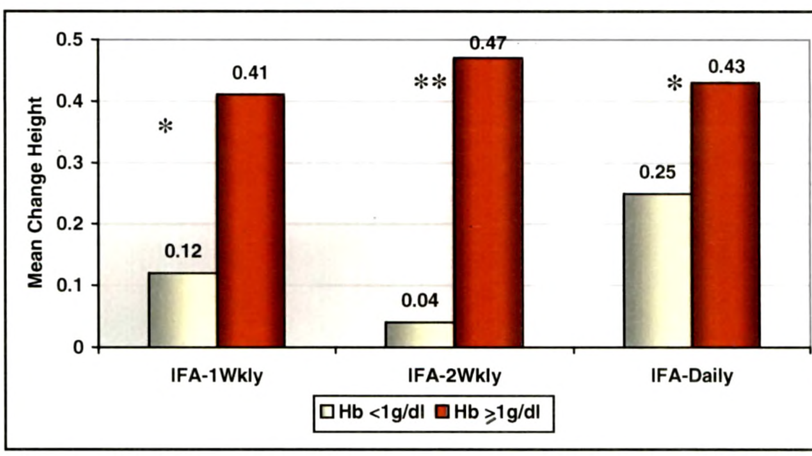


[1]Hb <12 g/dl, [2]Hb ≥12 g/dl

Impact of IFA Supplementation on BMI (as % Must et al) In Initially Anemic and Non-Anemic Girls

Anemic and non-anemic girls were also compared with regard to BMI gain as percent of the Must et al standards. In the intervened groups, BMI increments (% Std.) were significantly better among anemic girls compared to non-anemics (**Figure 4.3.12**). Further, within the initially anemic girls, the increments were higher in IFA-2Wkly and IFA-Daily groups.

Figure 4.3.13: Mean Change in Height (% CDC) in the School Girls After the Intervention: Hb Increment ≥1 g/dl vs. <1 g/dl



*p<0.05, **p<0.01, ***p<0.001

Figure 4.3.14: Mean Change in BMI (% Must et al) in the School Girls After the Intervention: Hb Increment ≥ 1 g/dl vs. <1 g/dl

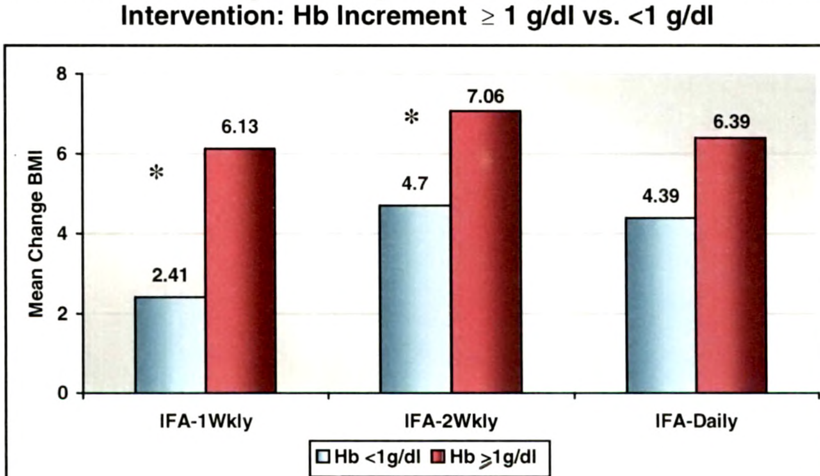
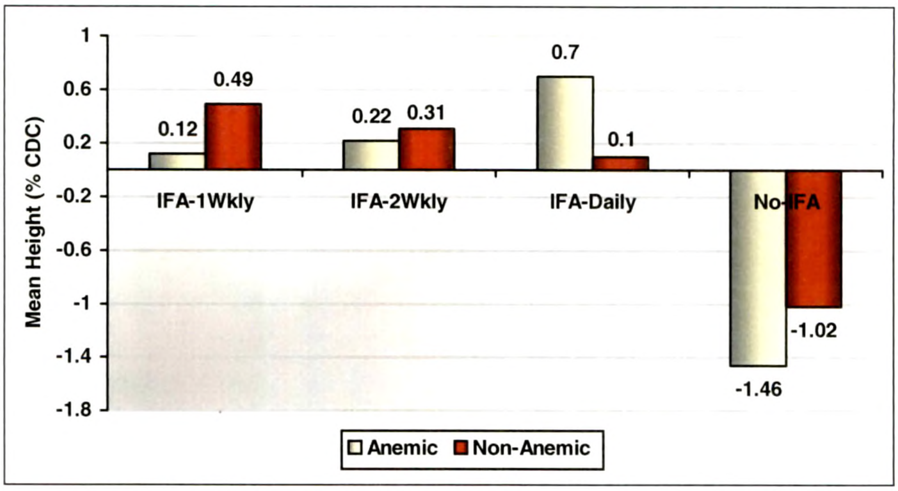
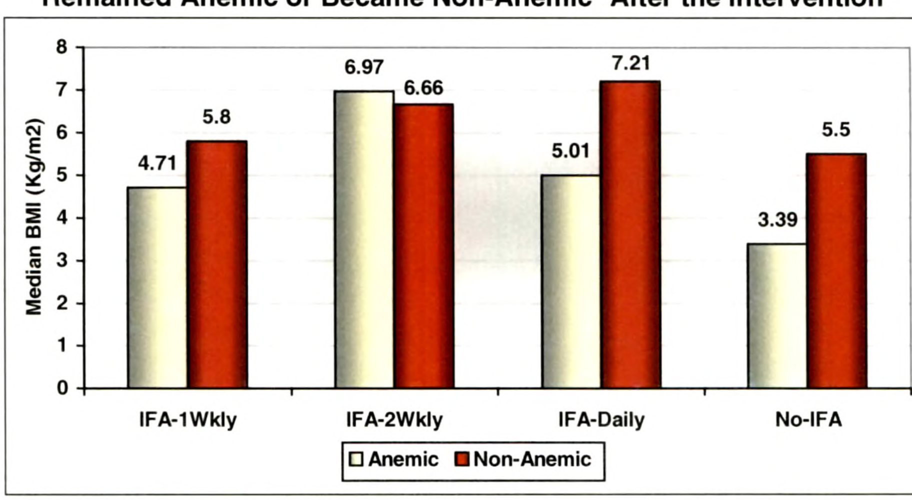


Figure 4.3.15: Mean Change in Height (% CDC) in Initially Anemic[1] Girls Who Remained Anemic or Became Non-Anemic[2] After the Intervention



[1]Hb <12 g/dl, [2]Hb ≥12 g/dl

Figure 4.3.16: Mean Change in BMI (% Must et al) in Initially Anemic[1] Girls Who Remained Anemic or Became Non-Anemic[2] After the Intervention



[1]Hb <12 g/dl, [2]Hb ≥12 g/dl

Did The Extent Of Hemoglobin Gain Influence The Gain In Height and BMI?

The height gain (% CDC) was markedly higher in the groups gaining ≥1 g/dl in all the three treatment regimens than those who gained less than 1 g/dl Hb and this difference was statistically significant (**Figure 4.3.13**). In No-IFA group, none of the girls gained more than 1 g/dl of Hb, therefore, this group has not been included in the figure.

The BMI change (% Std.) was significantly better, in girls whose Hb gain was ≥1 g/dl, than those whose Hb gain was <1 g/dl, in IFA-1Wkly and IFA-2Wkly groups (**Figure 4.3.14**). This difference was not seen in IFA-Daily group, perhaps due to smaller sample size – however, extent of change was similar as in twice-weekly group.

Is It That Girls Who Turn Non-Anemic After Intervention Eventually Benefit More In Terms Of Height And BMI Compared To Those Who Remain Anemic?

To answer this question **Figure 4.3.15 & 16** compares mean change in height and BMI (% Std.) among initially anemic girls who either remained anemic or became non-anemic end of the intervention. In all the three intervention regimens there was no consistent difference ($p>0.05$) indicating that even if girls remain anemic at the end of the supplementation program they will still benefit significantly in terms of Hb and growth, perhaps because they have low Hb levels to begin with.

Shifts In Prevalence Of Undernutrition Expressed as Below Normal BMI After The Intervention

The shift in prevalence of undernutrition (BMI <5th percentile of Must et al standard) before and after the intervention were compared between the four groups (**Table 4.3.17**). There was a significant reduction in the percentage of girls below normal BMI (above 50%) among the intervened groups, highest reduction being in IFA-Daily followed by IFA-2Wkly and IFA-1Wkly. Further, only girls who had good compliance with IFA were selected and the reduction in the percentage of girls undernourished was compared (**Table 4.3.17**). A similar trend was observed even among good compliance girls, i.e. all three regimens led to significant reduction in undernutrition.

Table 4.3.17: Percentage Girls Undernourished[1] After The Interventions

Study Groups	N	Pre – Intervention Prevalence (A)		Post – Intervention Prevalence (B)		% Reduction in Prevalence	Chi Sq test (A vs B)
		n	%	n	%		
Percentage Girls Undernourished Taking All Girls							
IFA-1Wkly	73	44	60.3	22	30.1	50.1	13.4***
IFA-2Wkly	103	64	62.1	27	26.2	57.8	26.9***
IFA-Daily	59	33	55.9	13	22.0	60.6	14.3***
No-IFA	43	23	53.5	17	39.5	26.1	1.68^{NS}
Percentage Girls Undernourished Among Good Compliance[2] Girls							
IFA-1Wkly	32	21	65.6	5	15.6	76.2	14.57***
IFA-2Wkly	71	40	56.3	13	18.3	67.5	20.35***
IFA-Daily	38	21	55.3	7	18.4	66.7	9.56***

[1]BMI <5^{th} percentile of Must et al standard (1991), [2]≥70% Compliance with IFA Tablets, [NS]non significant, *p<0.05, **p<0.01, ***p<0.001

Discussion

Summing up, growth in terms of BMI, height and weight gain was significantly higher in all the three treatment groups compared to controls. Within the treatment groups, BMI increments in twice weekly and daily groups were consistently higher than in IFA-1Wkly group. However, as regards linear growth (height gain) once weekly was as effective as the more frequent dosing regimens perhaps because of the long duration of intervention (one year). On removing the confounding effect of compliance, within the three intervention groups, IFA-Daily and IFA-2Wkly continued to have significantly higher BMI gains than IFA-1Wkly. Further, when expressed as percent standard, BMI gains of good compliance group was significantly better than poor compliance group only in IFA-2Wkly and IFA-Daily groups. Therefore, even with a high level of compliance, once weekly IFA did not significantly improve BMI among young adolescent girls. In contrast, once weekly IFA showed significant impact in girls with good compliance.

In many research studies, intermittent iron supplementation has been suggested as a replacement for daily iron supplements for reducing anemia in developing countries. This aspect has been inadequately researched for young adolescents undergoing pubertal growth spurt, in particular, impact of IFA on adolescent growth. Literature and reports available in this regard are presented below.

A study among Tanzanian adolescent girls comparing weekly iron supplementation and a vitamin B-12 control group reported a significantly greater weight gain in the weekly iron supplemented group than in the vitamin B-12 control group after 4 months of supplementation (Beasley et al 2000). Studies in Indonesia found an improvement in growth after iron supplementation (Angeles et al 1993). Improved appetite and decreased morbidity were the explanations given in those studies for enhanced growth after iron supplementation.

Studies in Mexico, Bangladesh and Thailand, however, reported no benefit of iron supplementation on growth (Rosado et al 1997; Migasena et al 1972). Long-term supplementation for one year amongst undernourished Bangladeshi children (6 – 71 months) did not enhance their growth. One proposed explanation given was that deficiency of multiple micronutrients such as zinc and vitamin A could have limited the growth response to iron (Rahman et al 1999).

In the present study, comparing anemic and non-anemic girls, the BMI increments in all the treatment groups were significantly higher in anemic girls compared to non-anemics. Within initially anemic girls, the gain in height was almost double in ES groups compared to that in No-IFA group. Also, BMI increment among anemic girls, in daily and twice weekly, were better than IFA-1Wkly and No-IFA, control. Daily IFA dosage showed maximum impact on growth of anemic girls. Therefore, though, even a weekly dose of IFA per week had beneficial effect on BMI among anemic girls, these girls benefited more with twice weekly and daily supplementation. However, linear growth (height) was enhanced in all treatment groups irrespective of anemic status.

A study done by Chwang et al (1988) on rural Indonesian school children (8 to 14 years) indicated that treatment with 10 mg ferrous sulfate/Kg/day for 12 weeks improved anemic subjects (Hb<11 g/ dl, transferring saturation <15%) hemoglobin levels, growth velocity and decreased level of morbidity. However, among normal subjects (Hb>12 g/dl, transferring saturation >20%) there was no difference in the increments between iron treated and placebo group. A randomized double blind placebo control iron supplementation trial on Kenyan anemic primary school children (6 – 11 years) (n=87) receiving 150 mg sustainable release ferrous sulphate daily for 14 weeks, showed an improvement in growth and appetite as compared with children receiving the placebo. It was concluded that it is plausible and likely that provision of iron tablets to anemic children results in improved appetite, which in turn results in improved growth (Lawless et al 1994).

Bhatia and Seshadri (1993) studied the growth status of four Balwadi school children (3-5 yrs): anemic (Hb <10 mg/dl) and normal (Hb ≥11 mg/dl). Randomly selected two Balwadis received 40 mg elemental iron per day for 6 months and the other two received sugar placebos for the same time. The mean weight gain in iron treated anemic girls was higher than anemic placebo group. However, the weight gains in anemic as well as normal treated groups were similar to that in normal placebo group.

However, a study on Indonesian primary schoolchildren (Soemantri et al 1997) reported no significant differences in increases of weight-for-age, weight-for-height or height-for-age after 3 months of weekly and daily iron supplementation among anemic schoolchildren.

In the present study those who gained higher Hb levels showed better response to growth. BMI as well as height gain was better in girls with Hb gain ≥1 g/dl, than with Hb gain <1 g/dl. The favorable impact on height and BMI gain appears to be related to Hb gains.

More frequent dosing with iron folate leading to higher Hb levels appears to be necessary for achieving higher weight gains as suggested in a study on anemic preschool children who were either supplemented with iron and vitamin C or vitamin

C only (control group) for two months (Aukett et al 1986). The study reported that the rate of weight gain in the children whose hemoglobin concentration rose by atleast 2 g/dl was greater than in those whose hemoglobin did not ($p \approx 0.05$).

Amongst the present study girls, a reduction in prevalence of undernutrition was observed after the intervention. More than half of the girls undernourished before the intervention achieved normal BMI status after supplementation in the intervened groups, highest being in IFA-Daily followed by IFA-2Wkly and IFA-1Wkly.

Bhatia and Seshadri (1993) reported similar findings in their study among 3 to 5 year olds, where a significantly larger proportion of anemic and normal children in the iron treated group moved to better nutritional categories compared to the controls. In a double blind placebo control trial, 6 – 24 months old Vietnamese children received either daily (5 days/week: 8 mg Fe + 5 mg Zn + 333 µg retinal and 20 mg Vit C) or once a week (20 mg Fe + 17 mg Zn + 1700 µg retinal and 20 mg Vit C) or a placebo tablet for 3 months (Thu et al 1999). Although there was no significant difference in growth in supplemented groups and the placebo groups, the height-for-age of subjects stunted at baseline increased in both supplemented groups, whereas the values for the placebo remained the same.

IFA in Program Settings

Given the programmatic difficulties and lack of proven effectiveness of food supplementation programs for improving growth, it has been suggested that iron-folate supplements be considered for their growth benefits. Recent literature on daily vs. weekly supplements seems to suggest that for prophylactic purposes and to build up iron stores, adolescent girls maybe given once weekly IFA (100 mg elemental iron, 0.5 mg folic acid) as part of National Anemia Control efforts. While improvement in hemoglobin and reduction in anemia is likely to be significant with once weekly dose, this dose may be inadequate for growth (BMI) improvement. Earlier studies in our department showed indicate that *daily* IFA supplements were necessary to significantly enhance BMI in already anemic adolescents, and that *once weekly* IFA was not effective.

One study looked at growth benefits of once weekly IFA given for 6 months and reported negligible benefits on BMI (Kanani et al 1998). However, in the pilot phase of the governments once weekly IFA in the Vadodara district, longer duration intervention with once weekly IFA indicated definite impact on the hemoglobin levels and a trend towards impact on BMI as well (Kotecha et al 2002). In this study, linear growth (height gain) appears to be enhanced even with once weekly IFA provided it's a long duration supplementation (over a year) or is on regular basis as in a program setting.

Given programmatic setting with mixed compliance and variable quality of implementation, twice weekly IFA is recommended rather than once weekly IFA as it has a better impact and even with less compliance will at least enable once weekly IFA to reach girls. Besides it is less expensive and more feasible than daily IFA.

Impact on Food and Nutrient Intake as measured by Dietary Recall Method (DRM)

The intake of various food groups such as cereals, pulses, green leafy vegetables, fruits and milk - milk products was calculated pre and post intervention to study the impact on dietary intake. Further, the macronutrient, mineral and vitamin intakes before and after the intervention in the intervened groups were studied and are presented below from the four study groups [Once a week: IFA-1Wkly (E1), Twice a week: IFA-2Wkly (E2), Daily: IFA-Daily (ED) and Control: No-IFA (CS)].

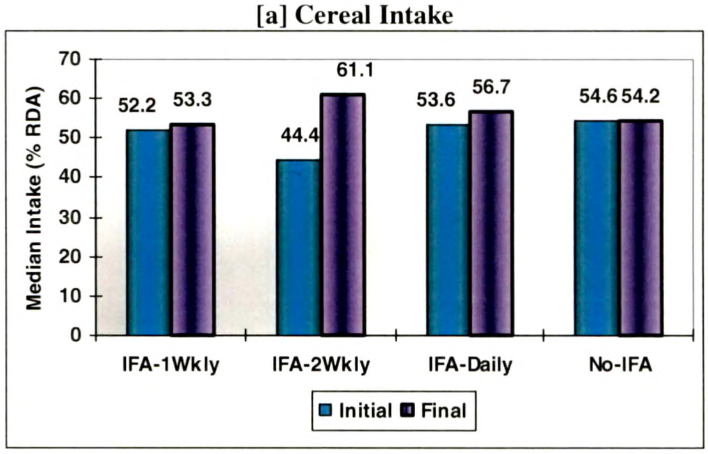
Impact on Food Intake

Overall, the cereal intake (% RDA) was higher among the intervened groups compared to the controls after the intervention period. The median cereal intake (% RDA) improved in all the ES groups, highest being in IFA-2Wkly (**Figure 4.3.17 [a]**). A negligible decline in cereal intake was seen in No-IFA control group. After intervention, pulses intake (% RDA) decreased in IFA-2Wkly as well as No-IFA. The median pulse intake in IFA-Daily and IFA-1Wkly was better than the control group (**Figure 4.3.17 [b]**).

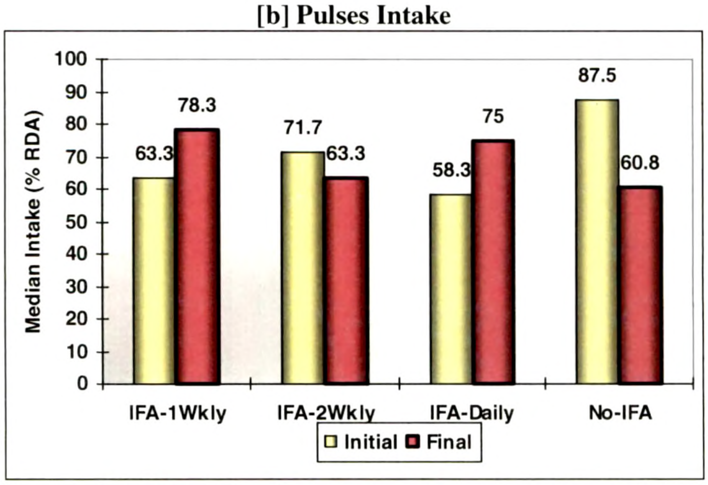
Milk consumption also remained as low as 10 to 12% RDA post intervention (**Figure 4.3.17 [c]**). Milk and milk products were mainly consumed in the form of tea and/or curd. It was relatively more in IFA-2Wkly and IFA-Daily groups. The mean intake of green leafy vegetables (GLVs) remained very low, just about 10 to 15% of RDA, after the intervention in all the groups. All the groups showed a decline in fruit intake except IFA-Daily, the reduction being highest in No-IFA group. The commonly consumed fruits were banana, apple and grapes. Consumption of tomato was very common among these girls.

Figure 4.3.17: Median Food Intake (% RDA[1]) Before and After The Intervention

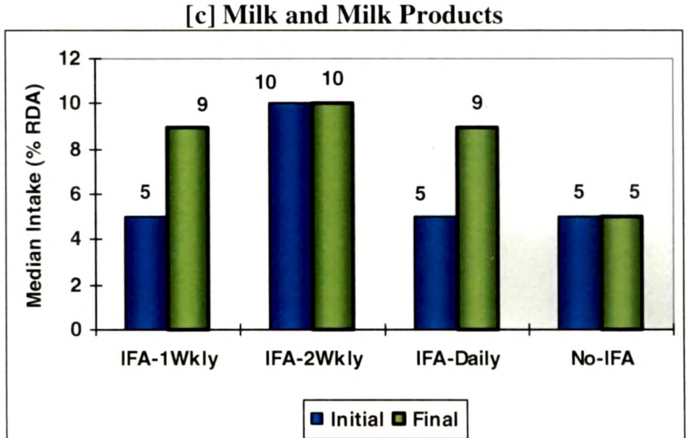
[a] Cereal Intake



[b] Pulses Intake



[c] Milk and Milk Products



[1]Recommended Dietary Allowances, NIN (1998)

Shifts in Percentage Girls Meeting Various Levels of RDA For Various Food Groups

The percentage of the girls consuming various levels of RDA of various food groups before and after the intervention in the four study groups were compared. With regard to cereal intake, there was a significant ($p<0.05$) increase in the percentage of girls consuming more than 50% of the RDA after the intervention in the IFA-Daily group (**Figure 4.3.18 [A]**). Similar shift was also observed in IFA-1Wkly and IFA-2Wkly groups; however these changes were not significant. In No-IFA, control group, there was a decline in the percentage of girls consuming more than 75% of RDA.

A positive and significant ($p<0.05$) shift in girls consuming pulses more than 50% RDA was seen in IFA-Daily and IFA-1Wkly groups (**Figure 4.3.18 [B]**). IFA-2Wkly showed a negligible shift towards higher intakes as percentage of RDA whereas No-IFA group showed a non-significant decline in girls consuming >75% RDA.

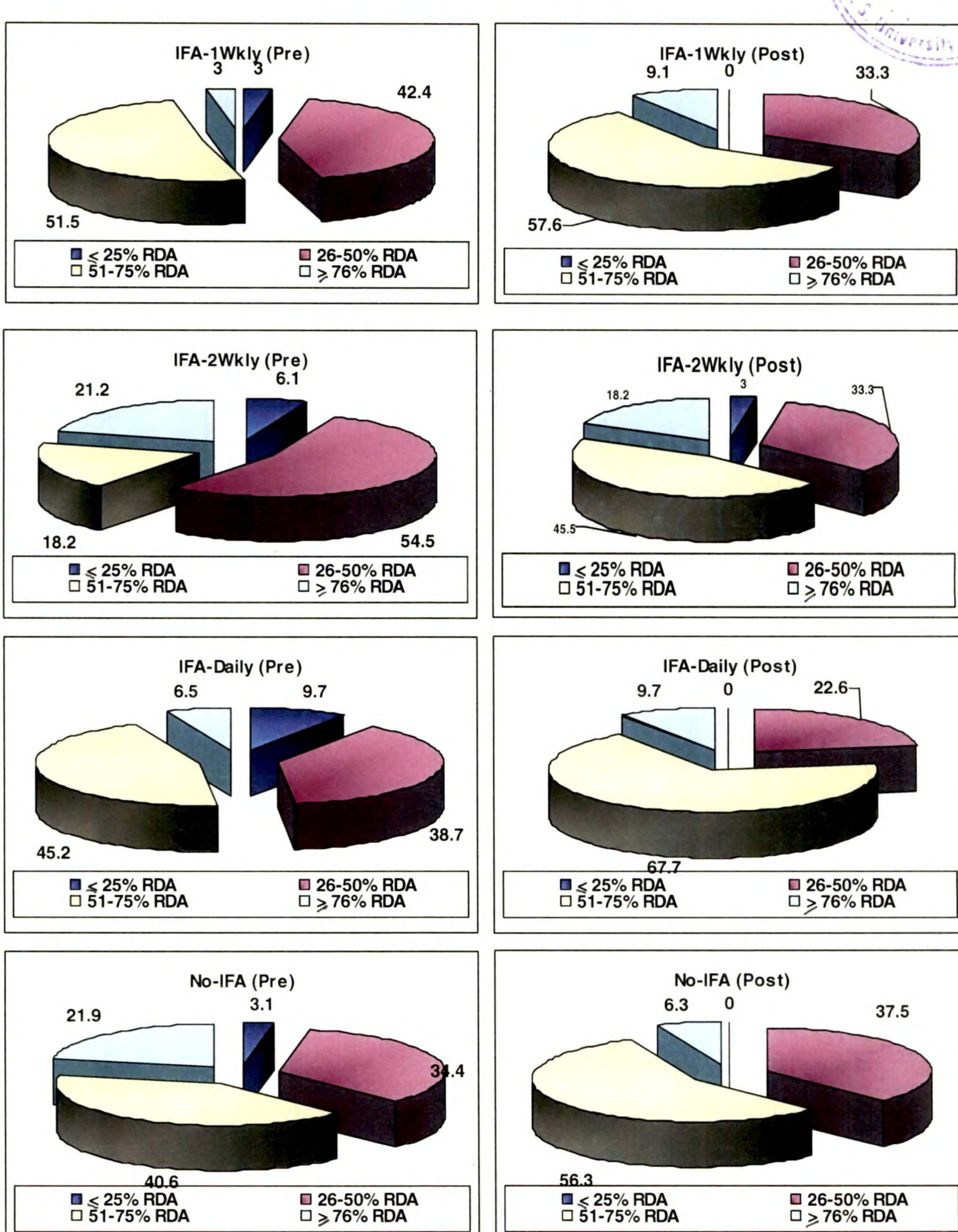
Though a shift was observed with regard to GLV intake in all the three intervened groups (from <26% RDA to higher intakes), these changes were not significant (**Figure 4.3.18 [C]**). This shift towards higher GLV intake (% RDA) was maximum in IFA-Daily group followed by IFA-2Wkly and IFA-1Wkly groups. A negligible decline to lower RDA intakes was observed in control group after the intervention.

Negligible shifts towards higher RDA intakes were observed with regard to fruit intake in all the study groups. However, intake of milk and milk products remained less than 50% of the RDA in all the study groups.

Overall, there was no consistent change in intake of various food groups in the various treatment regimens. However, IFA supplemented girls qualitatively reported feeling better, more hungry and more energetic during the intervention.

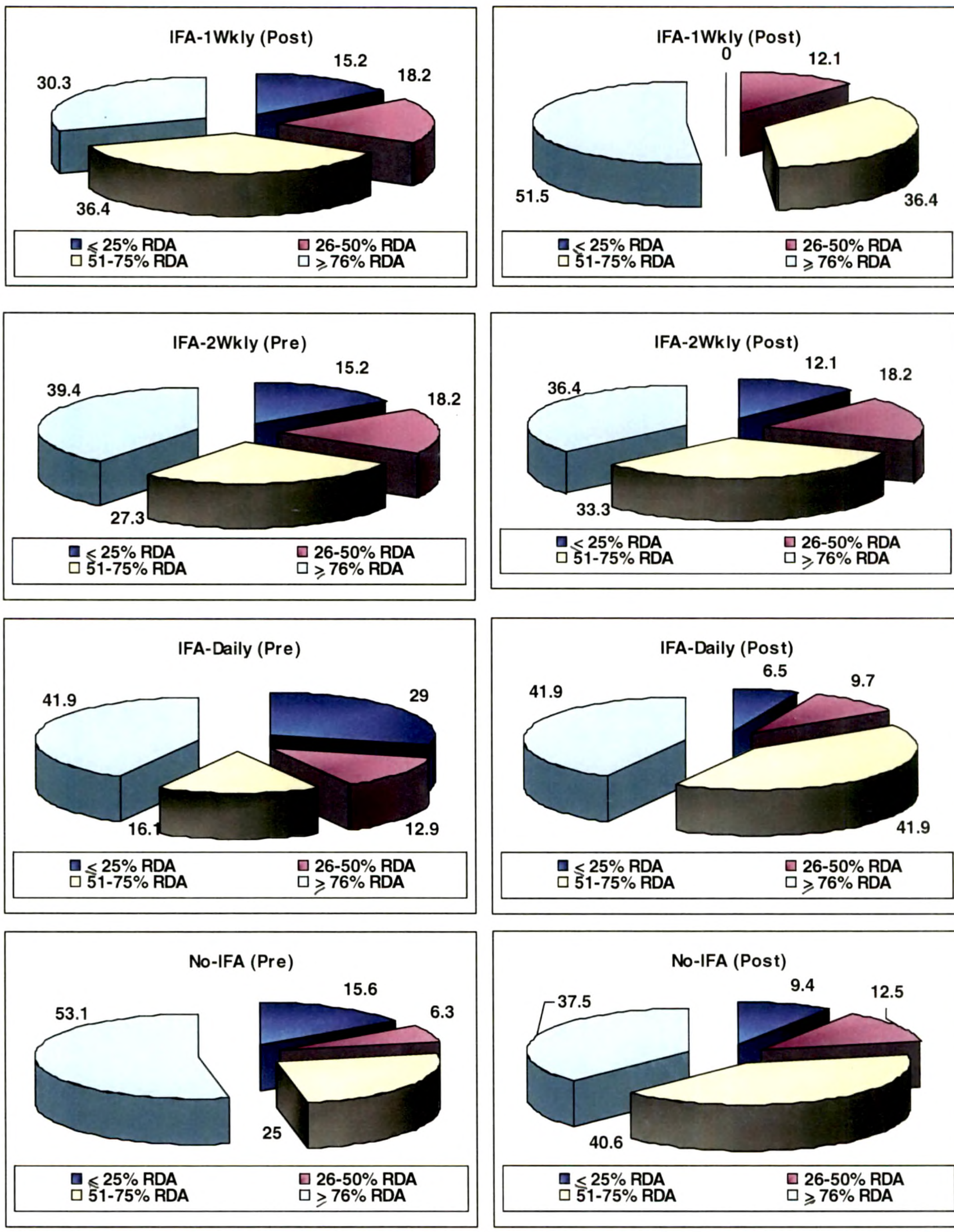
Figure 4.3.18: Shift in Intake of Various Food Groups as Percentage of RDA[1]

A. Cereal Intake (% RDA)



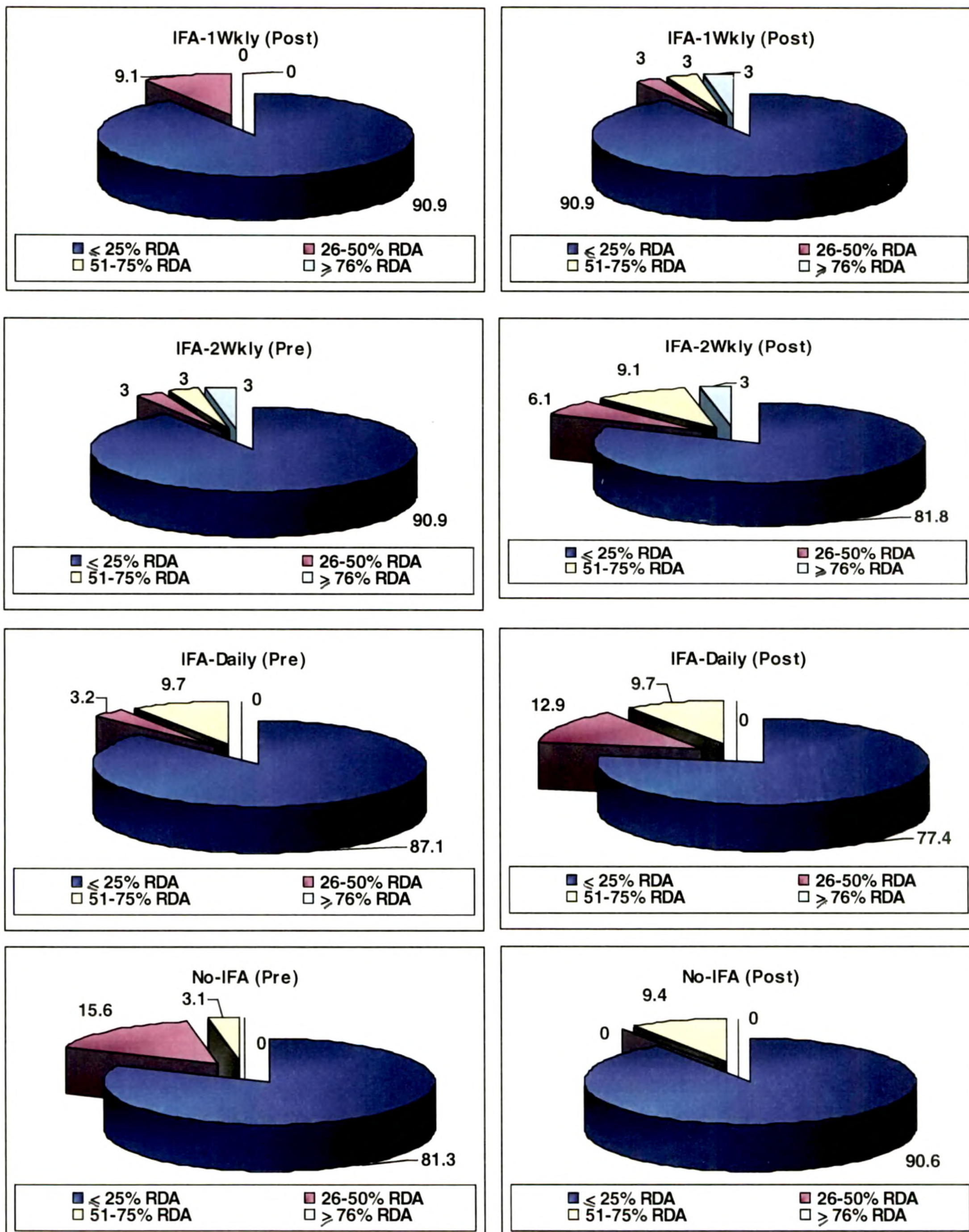
[1] RDA: NIN (1998)

B. Pulses Intake (% RDA[1])



[1] RDA NIN (1998)

C. Green Leafy Vegetable Intake (% RDA[1])



[1] RDA: NIN (1998)

Qualitative Feedback on Benefits Experienced

Table 4.3.18 presents the benefits experienced by the girls with regard to appetite after consuming the iron-folate tablets. These were spontaneous responses given by the girls towards the later half of the intervention. A majority of the girls experienced improvement in appetite and expressed that they ate much more now compared to what they ate before the supplementation was started, especially the IFA-twice weekly and IFA-Daily groups. They felt they were gaining weight, were feeling healthier and more energetic. According to some of the girls, their mothers also felt that they were consuming more food than they did earlier.

Table 4.3.18: Benefits Experienced By the Girls: In Their Own Words

Voices of the Girls
• *"Bhookh bau sari lageche."* (Now I feel quite hungry.) (IFA-1Wkly)
• *"Mari maa to lade che ke kem etli bhookh lageche."* (My mother gets annoyed because I often feel hungry.) (IFA-1Wkly)
• *"Wajan wadhi gayu che. Lage che vadhare jamu chu."* (I have gained weight. I must be eating more.) (IFA-2Wkly)
• *"Pela karta bhukh vadhare lage che."* (Now I feel more hungry than I did earlier) (IFA-2Wkly)
• *"Mari benpani kidhu, tu pehela karta gori lage che. Modha upar fikash nathi pan chamak che. Ave ene pan sakti ni goli joiyeche."* (My friend says you look more fair and beautiful. Your face does not look dull and pale but looks brighter. Now she also wants to take strength giving (iron) tablets.) (IFA-2Wkly)
• *"Modha upar fikash nathi, sarir ma takat pan che."* (Face doesn't look pale and I also feel energetic.) (IFA-2Wkly)
• *"Wadhare bhuk lage che. Pela be rotli khati thi, pan ave to tran khai lau chu ratre."* (Now I feel very hungry. Earlier I used to eat two chapatties, but now I eat three chapatti for dinner.) (IFA-Daily)
• *"Akho diwas khawanu man thaye che."* (I feel like eating the whole day.) (IFA-Daily)
• *"Mummy mane kahe che ke tu pahela karta vadhare Khaye che."* (My mother says that you eat much more than before.) (IFA-Daily)

The actual voices are given in italics. Parenthesis gives the translation in English, and the treatment group.

Impact on Nutrient Intakes

The mean intakes of macronutrients (energy, protein, fat, fiber and carbohydrate), vitamins and minerals (iron, vitamin C and β carotene) before and after the intervention are given in **Annexure 13 and 14.** The mean changes in the nutrient intakes in the different groups were non-significant after the supplementation program except for protein and carbohydrate intakes, which were higher in intervened groups than controls. Further, iron and β carotene intakes were also higher in twice weekly and daily intervened girls.

Table 4.3.19: Mean Change In The Macro Nutrient Intakes as % RDA[1] of the Girls Before and After Intervention

Study Groups	N	Initial Mean ± SD Median	Final Mean ± SD Median	Mean change ± SD % RDA
Energy				
IFA-1Wkly (E1)	33	51.20 ± 15.02 51.76	53.91 ± 11.88 52.33	2.71 ± 9.3
IFA-2Wkly (E2)	33	50.41 ± 16.67 49.26	55.06 ± 13.47 54.47	4.65 ± 8.7
IFA-Daily (ED)	31	53.87 ± 17.01 53.07	55.99 ± 10.12 55.22	2.12 ± 10.0
No-IFA (CS)	32	53.81 ± 18.86 50.67	51.93 ± 12.23 51.75	-1.88 ± 11.6
Protein				
IFA-1Wkly (E1)	33	53.89 ± 20.5 53.23	52.65 ± 13.73 51.62	-1.24 ± 15.0
IFA-2Wkly (E2)	33	51.72 ± 19.7 49.41	53.59 ± 13.60 54.75	1.88 ± 14.0
IFA-Daily (ED)	31	51.26 ± 22.3 50.91	53.78 ± 13.79 49.85	-0.79 ± 17.1
No-IFA (CS)	32	54.90 ± 20.9 51.47	47.75 ± 13.26 44.41	-7.15 ± 15.4
Fat				
IFA-1Wkly (E1)	33	108.1 ± 57.1 101.25	114.56 ± 45.6 105.5	6.45 ± 50.7
IFA-2Wkly (E2)	33	107.7 ± 47.6 97.11	104.24 ± 51.7 97.9	-3.53 ± 53.9
IFA-Daily (ED)	31	117.7 ± 70.9 102.5	109.1 ± 43.8 110.4	-8.61 ± 58.5
No-IFA (CS)	32	113.3 ± 83.0 98.02	120.31 ± 68.9 100.6	7.00 ± 84.5

[1]Recommended Dietary Allowances, ICMR (1991)

Macronutrients

The mean intake of calories, protein and fat as percent of the RDA before and after the intervention are given in **Table 4.3.19**. Overall the mean caloric intake remained about half of the recommended allowances even after the intervention in ES groups as well as CS. A marginal increase of 2 - 4% in the mean energy intake (% RDA) was seen in ES groups whereas a decrease of about 2% was seen in CS group. Further, within the intervened groups the increments were highest in IFA-Daily group, followed by IFA-2Wkly and then, IFA-1Wkly. Similarly with regard to protein, the intake remained around 50% of the RDA even after intervention, and there were no consistent changes in the four groups. Fat intake was above RDA in all the groups.

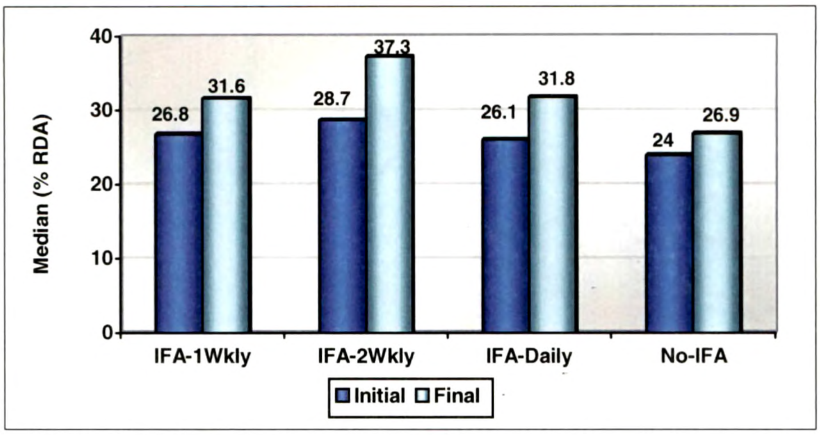
Micronutrients

The mean mineral and vitamin intakes of the girls before and after the intervention are presented in **Table 4.3.20** Overall the mean intake of dietary iron (% RDA) was higher in ES group compared to CS group. The mean increment in dietary iron (% RDA) was highest in IFA-Daily and was lowest in No-IFA group. Mean increments in vitamin C intakes (% RDA) in the ES groups as well as CS group do not show any specific trend. Mean increments in β-carotene (% RDA) were higher ES groups than in control group. All these differences in minerals and vitamin intakes (% RDA) between ES and CS groups were not significant. One reason could be the high variation seen in the intakes in the girls studied.

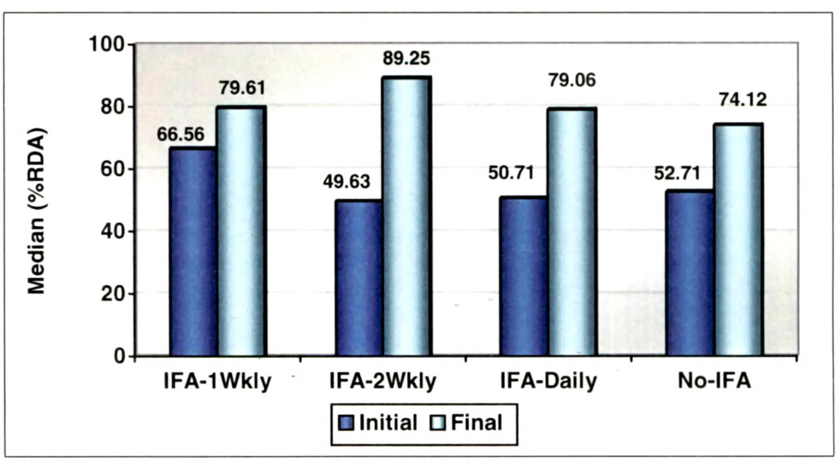
Figure 4.3.19 compares the median (% RDA) dietary iron, vitamin C and β-carotene intakes before and after the intervention. Unlike mean intakes, the median values showed a more consistent impact in the intervened girls compared to the control girls after the intervention. There was a higher increase in median intakes of dietary iron, vitmain C as well as β-carotene in ES girls than in CS girls.

Figure 4.3.19: Median Iron, Vitamin C and β Carotene Intake as % RDA[1] of the Girls Before and After Intervention

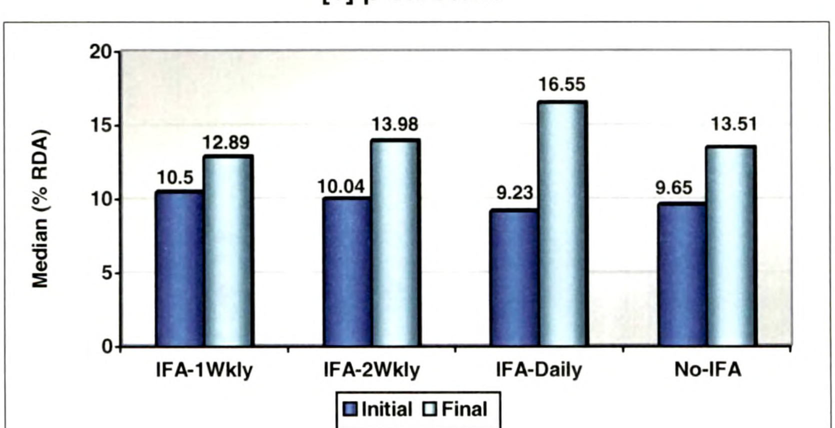
[a] Iron



[b]Vitamin C



[c] β Carotene



[1]Recommended Dietary Allowances, ICMR (1991)

Table 4.3.20: Mean Change in Mineral and Vitamin Intake as % RDA[1] of the Girls

Study Groups	N	Initial Mean ± SD Median	Final Mean ± SD Median	Mean change ± SD
Iron				
IFA-1Wkly (E1)	33	28.55 ± 11.46 26.82	31.07 ± 10.13 31.68	2.52 ± 10.98
IFA-2Wkly (E2)	33	33.49 ± 23.54 28.75	35.35 ± 12.08 37.37	1.86 ± 22.86
IFA-Daily (ED)	31	29.02± 15.18 26.11	34.26± 11.71 31.81	5.23± 17.22
No-IFA (CS)	32	27.29± 10.50 24.05	28.42± 7.38 26.91	1.13± 10.67
Vitamin C				
IFA-1Wkly (E1)	33	80.69± 62.56 66.56	93.76± 92.94 79.61	13.14 ± 33.89
IFA-2Wkly (E2)	33	60.55± 47.29 49.63	125.75± 96.83 89.25	28.14 ± 64.35
IFA-Daily (ED)	31	70.18± 55.10 52.71	99.74± 70.54 79.06	28.73 ± 64.65
No-IFA (CS)	32	61.30± 55.68 52.71	86.15± 81.05 74.12	23.99 ± 79.94
β Carotene				
IFA-1Wkly (E1)	33	12.34± 7.14 10.5	17.77± 14.10 12.89	5.33 ± 22.6
IFA-2Wkly (E2)	33	12.32± 8.52 10.04	20.29± 13.91 13.98	5.41 ± 16.84
IFA-Daily (ED)	31	10.83± 6.20 9.23	24.99± 23.51 16.55	9.03 ± 22.56
No-IFA (CS)	32	17.28± 20.16 9.65	17.62± 12.95 13.51	4.99 ± 15.23

[1]Recommended Dietary Allowances, ICMR (1991)

Shifts in Percentage Girls Meeting Various Levels of RDA Post Intervention

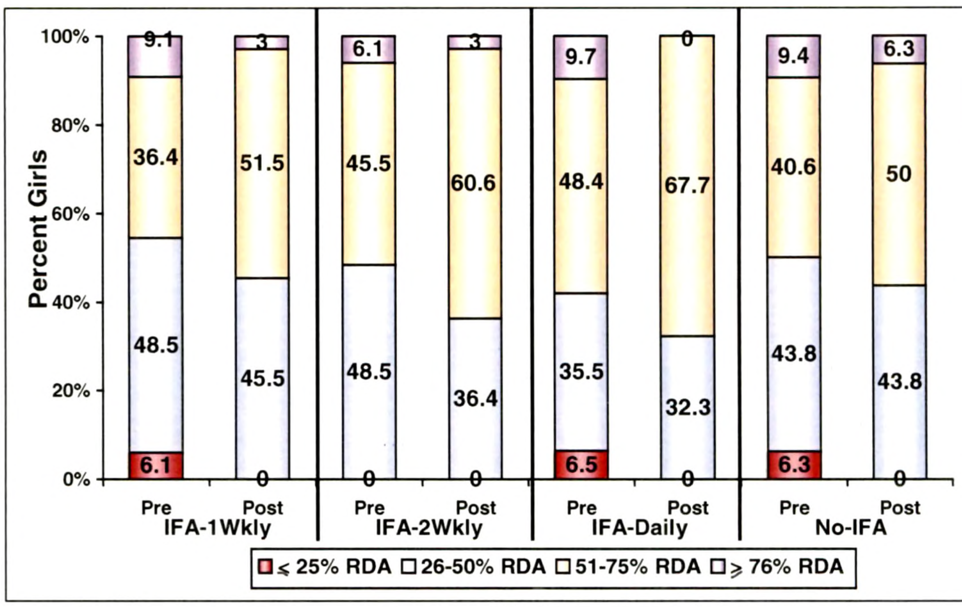
Figures 4.3.20/21/22/23 give the percentage of the young girls consuming various levels (as % RDA) of calories, dietary iron, vitamin C and β-carotene. **Figure 4.3.20** illustrates the percentage of girls consuming calories at various levels of RDA. After the intervention period, there was a shift from low calorie intakes (26 to 50% RDA) to good intakes (51 to 75% RDA) in all the groups. This shift to higher calorie intake was highest in IFA-Daily group and least in No-IFA control group.

Similarly, with regard to dietary iron intake, in both, ES groups as well as CS group there was an upward shift from severely low intakes (≤25%RDA) to moderately low intakes (26-50% RDA), and these shifts were more evident in girls supplemented in IFA-Daily and IFA-2Wkly groups (**Figures 4.3.21**).

Further, post intervention there was an increase in the percentage girls consuming vitamin C more than 75% RDA in all the groups, highest being in IFA-Daily and IFA-2Wkly groups (**Figures 4.3.22**). However, not much change was observed in β-carotene intakes. A marginal shift was observed from low intakes (≤25% RDA) to higher intakes in the IFA intervened groups (**Figures 4.3.23**).

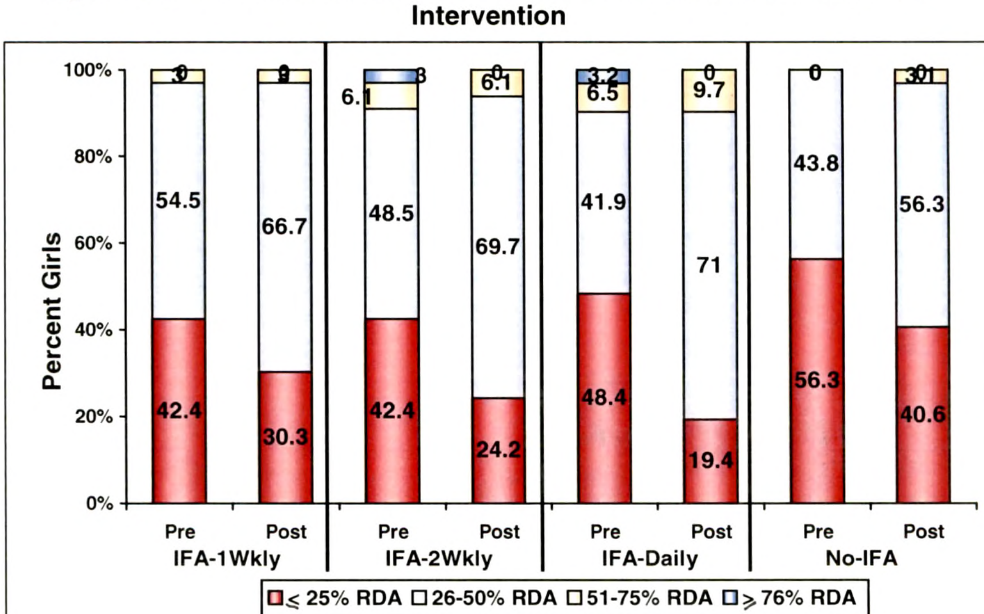
Thus, the existing diets seem to have improved – qualitatively and quantitatively - compared to the diets consumed before the intervention, especially in intervened girls.

Figure 4.3.20: Shift in Calorie Intake At Various Levels of RDA[1] After The Intervention



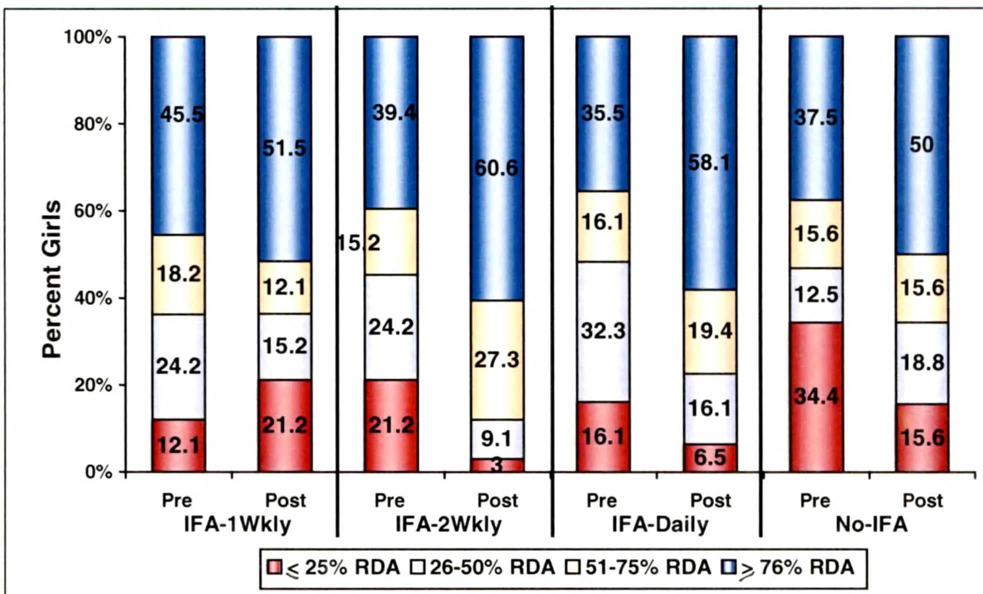
[1]RDA: Recommended Dietary Allowances, ICMR (1991)

Figure 4.3.21: Shift in Iron Intake At Various Levels of RDA[1] After The Intervention



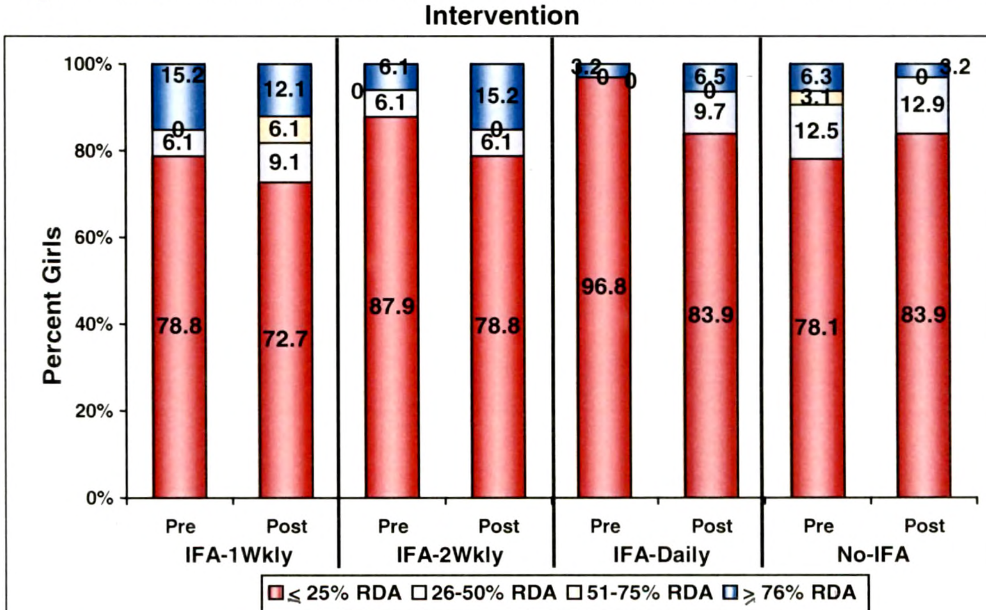
[1]RDA: Recommended Dietary Allowances, ICMR (1991)

Figure 4.3.22: Shift in Vitamin C Intake At Various Levels of RDA[1] After The Intervention



[1]RDA: Recommended Dietary Allowances, ICMR (1991)

Figure 4.3.23: Shift in β Carotene Intake At Various Levels of RDA[1] After The Intervention



[1]RDA: Recommended Dietary Allowances, ICMR (1991)

Discussion

Summing up, the food intake as percent of RDA (cereals, pulses, green leafy vegetables) were higher among the intervened groups after the intervention compared to the control. There was a significant increase in the percentage of girls consuming cereals and pulses more than 50% of the RDA after the intervention in the IFA-Daily group. A shift towards higher food intake was observed in the intervened groups compared to a decline towards lower RDA intakes seen in the No-IFA, control group. Overall, however, the changes were not consistent among the four study groups, perhaps because of high variability in their dietary intakes.

Further with regard to nutrient intakes, i.e. macronutrients, vitamins and mineral intakes (% RDA), values were higher in girls supplemented with iron folate tablets than controls. The beneficial affect of iron folate supplementation was also evident from the shift in the percentage girls from lower RDAs (<50% RDA) for energy and dietary iron to higher RDA levels (>50% RDA) among girls supplemented with IFA tablets compared to controls. The trends would have been more evident had the sample size been larger.

The girls expressed qualitative benefits such as improvement in appetite, food intake and increased weight, especially among girls receiving IFA-2Wkly and IFA-Daily tablets. They expressed that the beneficial impact in the girls were also perceived by their mothers and some friends. Many girls expressed that their mothers thought that they ate much more now (after taking the tablets) than they ate before the supplementation was started.

Improvement in cereal intakes due to improved appetite may have lead to better calorie intakes. The diets of the girls predominantly remain cereal based and the quantities were not sufficient enough to meet the increased energy requirements. Also, the consumption of sugar was mainly in tea only. The energy yielding foods, oils and sugars, were low in the diets. Milk was also used in small quantities, mostly in tea only. Tea, a polyphenol containing beverage and known to reduce non-heme iron bioavailability, was a very popular drink and was consumed before or after each meal. Further, a majority were vegetarian consuming non-heme dietary iron.

A randomized, double blind, placebo-controlled iron supplementation trial conducted in Kenya examined the effect of iron supplements given daily for three months on appetite and growth in 87 primary school children (6-11 years) receiving sustained-release ferrous sulfate (150 mg) or placebo tablets. Appetite was measured using a culturally appropriate food which the children had consumed ad libitum as a snack during mid morning. Iron supplements resulted in improved growth and appetite as compared with children receiving placebo capsules (Lawless et al 1994).

A study done by Kanani and Poojara (2000) on adolescent unmarried girls of Vadodara revealed that daily iron folic acid supplementation (60 mg elemental iron and 0.5 mg folic acid) significantly improved hemoglobin levels, weight and appetite. In contrast, with once weekly IFA given to adolescent girls, Kanani et al (1998) did not find any consistent differences between those receiving the weekly IFA doses (100 mg elemental iron and 0.5 mg folic acid) and placebo, with regard to appetite scores and dietary intake.

Additional information and nutrition education may help to improve the dietary intakes of the girls. A study in Vadodara, India (Kanani and Agarwal, 1997) clearly showed that nutrition communication alone could significantly improve levels of awareness, intake of specific foods and nutritional status (Height, Weight and BMI) in school going adolescent girls. Therefore there is a need to educate the girls about anemia, especially dietary changes at home level. The improvement in appetite due to IFA supplements may help girls eat better provided there is effective nutrition education to increase their awareness about the importance of adequate and healthy diets.

Impact on Cognitive Functions as Measured by Various Cognitive Tests

The impact of the various iron folate interventions on the cognitive function of the primary schoolgirls was analyzed and is presented below. The girls were subjected to four cognitive function tests (pre-tested and modified) before and after iron folate interventions. The tests used to measure cognitive abilities were **Digit Span** (DS), **Visual Memory Test** (VMT), **Maze Test** (MZ) **and Clerical Task** (CT). Detailed description has been given in the methodology chapter.

Mean Increment in the Cognitive Test Scores

Digit Span Test measures the short-term memory; sequencing and concentration. After the intervention, the overall mean DS score ranged from 7.7 to 10 points in the ES groups (mean increments being 1.05 to 2.56 points), compared to 7.2 points in CS (mean increment 0.5 points). ***Visual Memory Test*** assesses the ability to remember non-verbal material and memorizing capacity. The maximum score given in this test is one. Overall the mean VMT scores in ES groups ranged from 0.7 to 0.9 (mean increments being 0.19 to 0.21 points) after the intervention. Lowest points were obtained by CS girls i.e. 0.65 (mean increment 0.08 points).

Maze Test measures visual-motor coordination; fine motor coordination, following directions and speed. Eighteen is the maximum score given on completion of the seven mazes without any error. The mean MT score obtained post intervention ranged from 13 to 16 points in ES group (mean increment 3.25 to 4.35 points) whereas it was 12.8 points in CS girls (mean increment 1.47 points). ***Clerical Task*** tests attention, concentration and discrimination abilities of the children. The maximum score given in this test is one. The mean CT scores, 0.83 to 0.89 points, were higher among ES group girls (mean increment 0.15 to 0.34 points) than in CS girls, 0.77 points (mean increment 0.14 points).

The changes in the mean cognitive function (CF) test scores are presented in **Table 4.3.21**.

Table 4.3.21: Mean Change in Cognitive Test Scores in the School Girls After the Intervention: Level of Significance Between The Groups

Study Groups	N	Digit Span Test	Visual Memory Test	Maze Test	Clerical Task
		Mean change ± SD	Mean change ± SD	Mean change ± SD	Mean change ± SD
IFA-1Wkly (E1)	43	1.05 ± 1.47	0.191 ± 0.13	3.25 ± 3.39	0.149 ± 0.12
IFA-2Wkly (E2)	42	1.41 ± 1.28	0.198 ± 0.13	4.35 ± 3.16	0.340 ± 0.21
IFA-Daily (ED)	42	2.56 ± 2.05	0.207 ± 0.15	4.07 ± 3.24	0.215 ± 0.14
No-IFA (CS)	34	0.50 ± 1.23	0.079 ± 0.14	1.47 ± 3.12	0.141 ± 0.16
't' Value:					
E1 vs CS:		1.76 NS	3.55***	2.38*	0.23 NS
E2 vs CS:		13.35***	3.75***	3.92***	4.47***
ED vs CS:		5.35***	3.79***	3.50***	2.01 *
E1 vs E2:		11.11***	0.24 NS	1.54 NS	4.95***
E1 vs ED:		3.85***	0.52 NS	1.14 NS	2.26*
E2 vs ED:		4.90***	0.29 NS	0.40 NS	3.14**

NS Non Significant, *p<0.05, **p<0.01, ***p<0.001

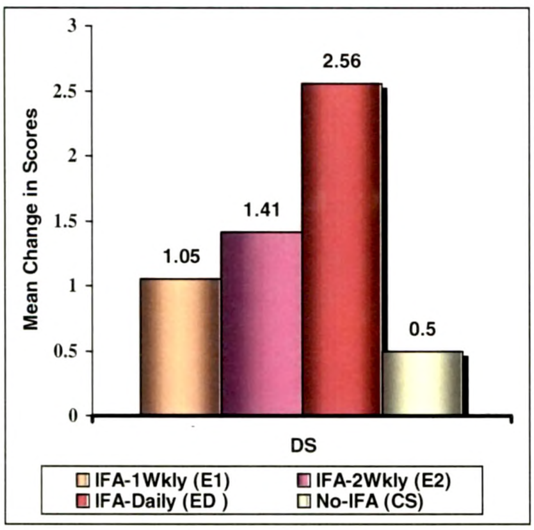
How significant was the impact when one group was compared with another? *Intervened vs. controls*: Overall, the increments in IFA-Daily and IFA-2Wkly were significantly higher than No-IFA, in all the four cognitive tests; whereas IFA-1Wkly was significantly better than No-IFA group, only in two of the four tests (**Table 4.3.21**). *Within the intervened groups*, in DS and CT, IFA-Daily and IFA-2Wkly ($p<0.05$) had significantly better scores than IFA-1Wkly. In VMT and MT, there was no significant difference between the three IFA intervention regimens.

Overall, IFA-Daily and IFA-2Wkly showed marked improvement in most tests, while IFA-1Wkly consistently showed poor impact.

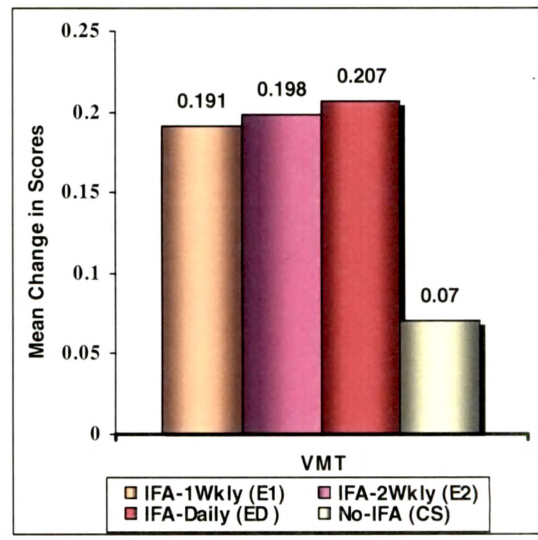
Figure 4.3.24 clearly shows the significant impact in all the ES groups vs. CS group and the relatively better impact of IFA-Daily and IFA-2Wkly compared to IFA-1Wkly.

Figure 4.3.24: Mean Change in Cognitive Function Test Scores Of The Girls After The Intervention

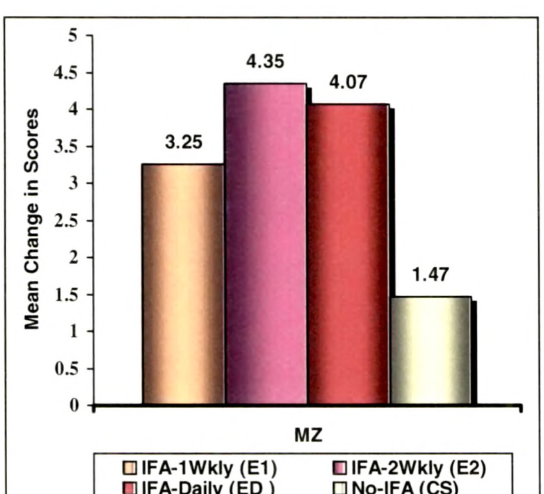
[a] Digit Span



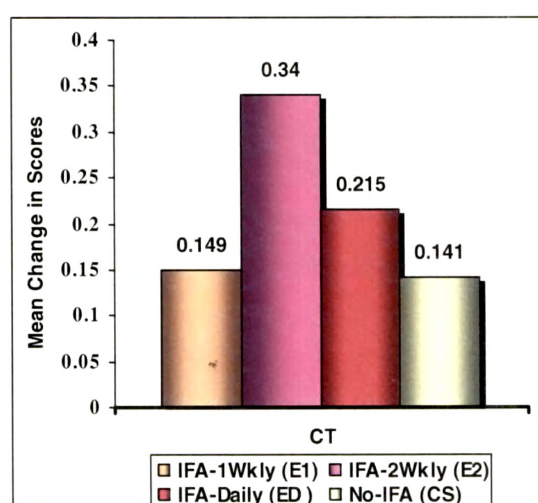
[b] Visual Memory Test



[c] Maze Test



[d] Clerical Task



Among younger as well older girls, the mean increment was higher in all ES group than in CS. Overall older girls scored higher in all the CF tests than younger girls. As **Table 4.3.22** shows both younger and older girls followed a similar trend as above i.e. IFA-2Wkly and IFA-Daily showed relatively better impact than IFA-1Wkly in all the tests.

Table 4.3.22: Mean Change in Cognitive Test Scores in Younger and Older School Girls after the Intervention

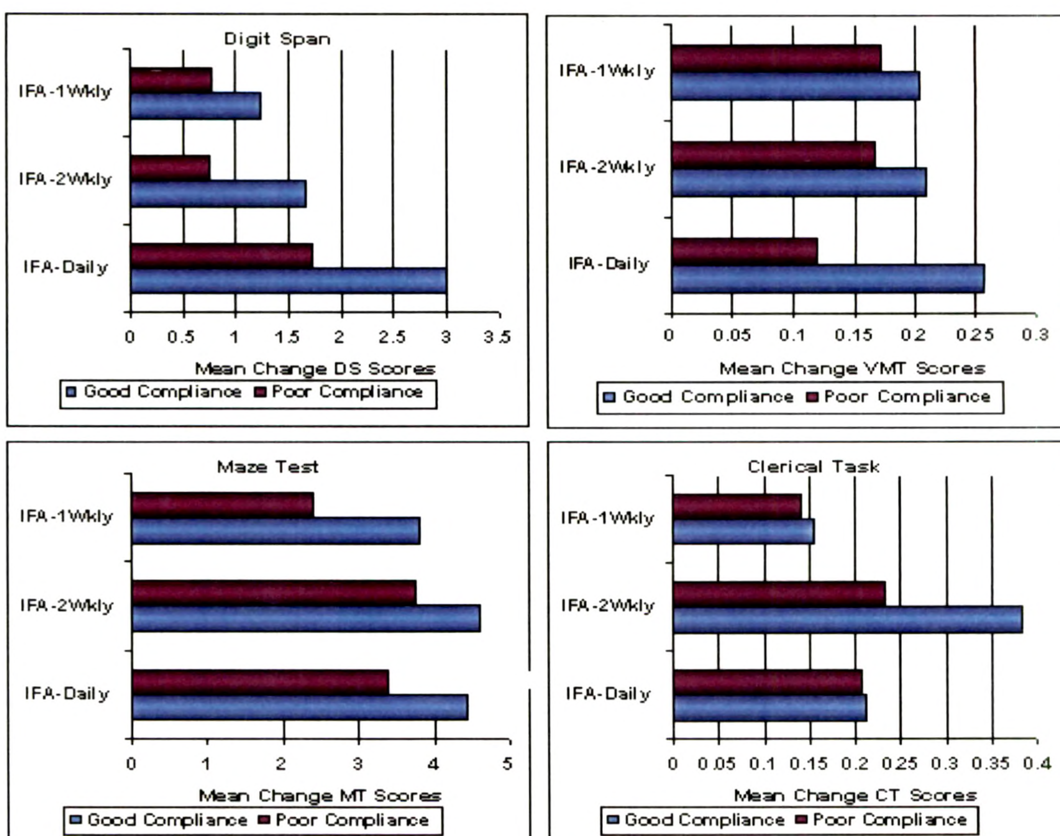
Study Groups	Younger girls (9 – 11 yrs)				Older Girls (12 –13 yrs)				Total (9-13 yrs)			
	N	Initial Mean ± SD	Final Mean ± SD	Mean change ± SD	N	Initial Mean ± SD	Final Mean ± SD	Mean change ± SD	N	Initial Mean ± SD	Final Mean ± SD	Mean change ± SD
Digit Span												
IFA-1Wkly	34	6.85 ± 2.16	7.82 ± 1.51	0.97 ± 1.60	9	6.11 ± 2.26	7.44 ± 1.94	1.33 ± 0.87	43	6.69 ± 2.17	7.74 ± 1.59	1.05 ± 1.47
IFA-2Wkly	37	6.35 ± 1.39	7.70 ± 1.54	1.35 ± 1.25	5	6.20 ± 1.30	8.00 ± 1.22	1.80 ± 1.64	42	6.33 ± 1.37	7.74 ± 1.49	1.41 ± 1.28
IFA-Daily	37	7.70 ±2.11	9.94 ± 1.84	2.24 ± 1.72	5	6.20 ± 2.95	11.00 ± 2.55	4.80 ± 3.03	42	7.52 ± 2.23	10.07 ± 1.93	2.56 ± 2.05
No-IFA	30	7.06 ± 1.96	7.43 ± 1.67	0.37 ± 1.18	4	4.50 ± 1.73	6.00 ± 1.15	1.50 ± 1.29	34	6.76 ±2.09	7.26 ± 1.67	0.50 ± 1.23
(F-value)				9.7***				4.68*				12.1***
Visual Memory Test												
IFA-1Wkly	34	0.502 ± 0.25	0.690 ± 0.21	0.188 ± 0.14	9	0.452 ± 0.26	0.667 ± 0.31	0.200 ± 0.08	4 3	0.491 ± 0.25	0.685 ± 0.23	0.191 ± 0.13
IFA-2Wkly	37	0.555 ± 0.21	0.739 ± 0.23	0.186 ± 0.13	5	0.347 ± 0.28	0.620 ± 0.17	0.280 ± 0.13	42	0.530 ± 0.22	0.724 ± 0.22	0.198 ± 0.13
IFA-Daily	37	0.647 ± 0.17	0.849 ± 0.12	0.197 ± 0.15	5	0.546 ± 0.21	0.827 ± 0.14	0.280 ± 0.13	4 2	0.635 ± 0.18	0.846 ± 0.11	0.207 ± 0.15
No-IFA	30	0.593 ± 0.12	0.673 ± 0.17	0.080 ± 0.14	4	0.433 ± 0.21	0.500 ± 0.30	0.07 ± 0.17	3 4	0.574 ± 0.14	0.653 ± 0.19	0.079 ± 0.14
(F-value)				4.67**				2.73 NS				6.44***
Maze Test												
IFA-1Wkly	34	10.08 ± 3.91	13.26 ± 4.09	3.17 ± 3.07	9	10.11 ± 3.85	13.66 ± 4.12	3.55 ± 4.61	43	10.09 ± 3.85	13.34 ± 4.05	3.25 ± 3.39
IFA-2Wkly	37	9.54 ± 5.78	13.70 ± 4.67	4.18 ± 3.09	5	8.20 ± 4.97	13.80 ± 1.64	5.60 ± 3.84	42	9.38 ± 5.65	13.71 ± 4.41	4.35 ± 3.16
IFA-Daily	37	12.56 ± 3.95	16.54 ± 1.80	3.97 ± 2.69	5	12.00 ± 7.24	16.80 ± 1.30	4.80 ± 6.45	42	12.50 ± 4.34	16.57 ± 1.74	4.07 ± 3.24
No-IFA	30	11.93 ± 4.94	13.03 ± 4.46	1.10 ± 2.94	4	7.25 ± 4.27	11.50 ± 1.29	4.25 ± 3.50	34	11.38 ± 5.05	12.85 ± 4.23	1.47 ± 3.12
(F-value)				7.28***				0.21 NS				5.86***
Clerical Task												
IFA-1Wkly	34	0.685 ± 0.13	0.823 ± 0.16	0.147 ± 0.12	9	0.722 ± 0.11	0.875 ± 0.13	0.156 ± 0.15	43	0.692 ± 0.13	0.834 ± 0.16	0.149 ± 0.12
IFA-2Wkly	37	0.537 ± 0.25	0.869 ± 0.18	0.343 ± 0.21	5	0.515 ± 0.30	0.839 ± 0.12	0.320 ± 0.27	42	0.534 ± 0.25	0.865 ± 0.17	0.340 ± 0.21
IFA-Daily	37	0.682 ± 0.14	0.898 ± 0.09	0.208 ± 0.12	5	0.646 ± 0.35	0.874 ± 0.14	0.220 ± 0.22	42	0.678 ± 0.17	0.895 ± 0.17	0.215 ± 0.14
No-IFA	30	0.632 ± 0.21	0.780 ± 0.12	0.150 ± 0.17	4	0.643 ± 0.20	0.722 ± 0.16	0.075 ± 0.17	34	0.634 ± 0.21	0.773 ± 0.13	0.141 ± 0.16
(F-value)				11.4***				1.26 NS				12.6***

NS non significant, *p < 0.05, **p < 0.01, ***p<0.001

Did the Level Of Compliance Influence The Impact Of Iron Supplementation On Cognitive Test Scores?

Figure 4.3.25 illustrates the comparative picture of the mean increment in the four cognitive tests in groups with good and poor compliance with IFA. As expected, girls with good compliance showed better improvement in all four tests compared to those with poor compliance; almost twice as much benefit in some cases. The IFA-Daily groups with good compliance showed the best impact. Further IFA-2Wkly with good compliance was comparable to IFA-Daily in three of the four tests.

Figure 4.3.25: Mean Change in Cognition Test Scores among Girls with Good Compliance and Poor Compliance with Iron Folic Acid Tablets



1: Compliance of ≥ 70% of IFA Tablets, 2: Compliance of < 70% of IFA Tablets, NS non significant, ***$p<0.001$, No-IFA: no IFA tablet, IFA-1Wkly: Once a week IFA tablet, IFA-2Wkly: Twice a week IFA tablet, IFA-Daily: Daily IFA tablet

Comparing significance of the impact only among the girls with good compliance

Within the good compliance group, the girls receiving IFA tablets daily had significantly better impact than the other two intervened groups. However, IFA-2Wkly was comparable (or better) compared to IFA-Daily, in three of the four tests (**Table 4.3.23**).

Table 4.3.23: Mean Change in Cognition test With Good Compliance: Level of Significance

Study Groups	N	Digit Span Test	Visual Memory Test	Maze Test	Clerical Task
		Mean change ± SD	Mean change ± SD	Mean change ± SD	Mean change ± SD
IFA-1Wkly (E1)	26	1.23 ± 1.24	0.204 ± 0.13	3.80 ± 3.74	0.154 ± 0.11
IFA-2Wkly (E2)	30	1.66 ± 1.26	0.210 ± 0.14	4.60 ± 2.87	0.383 ± 0.22
IFA-Daily (ED)	27	3.00 ± 2.16	0.256 ± 0.13	4.44 ± 3.47	0.211 ± 0.160
't' Value					
E1 vs E2:		1.26 NS	0.08 NS	2.18*	4.89***
E1 vs ED:		3.61***	1.31 NS	2.06*	1.47 NS
E2 vs ED:		2.77**	1.24 NS	1.45 NS	3.34**

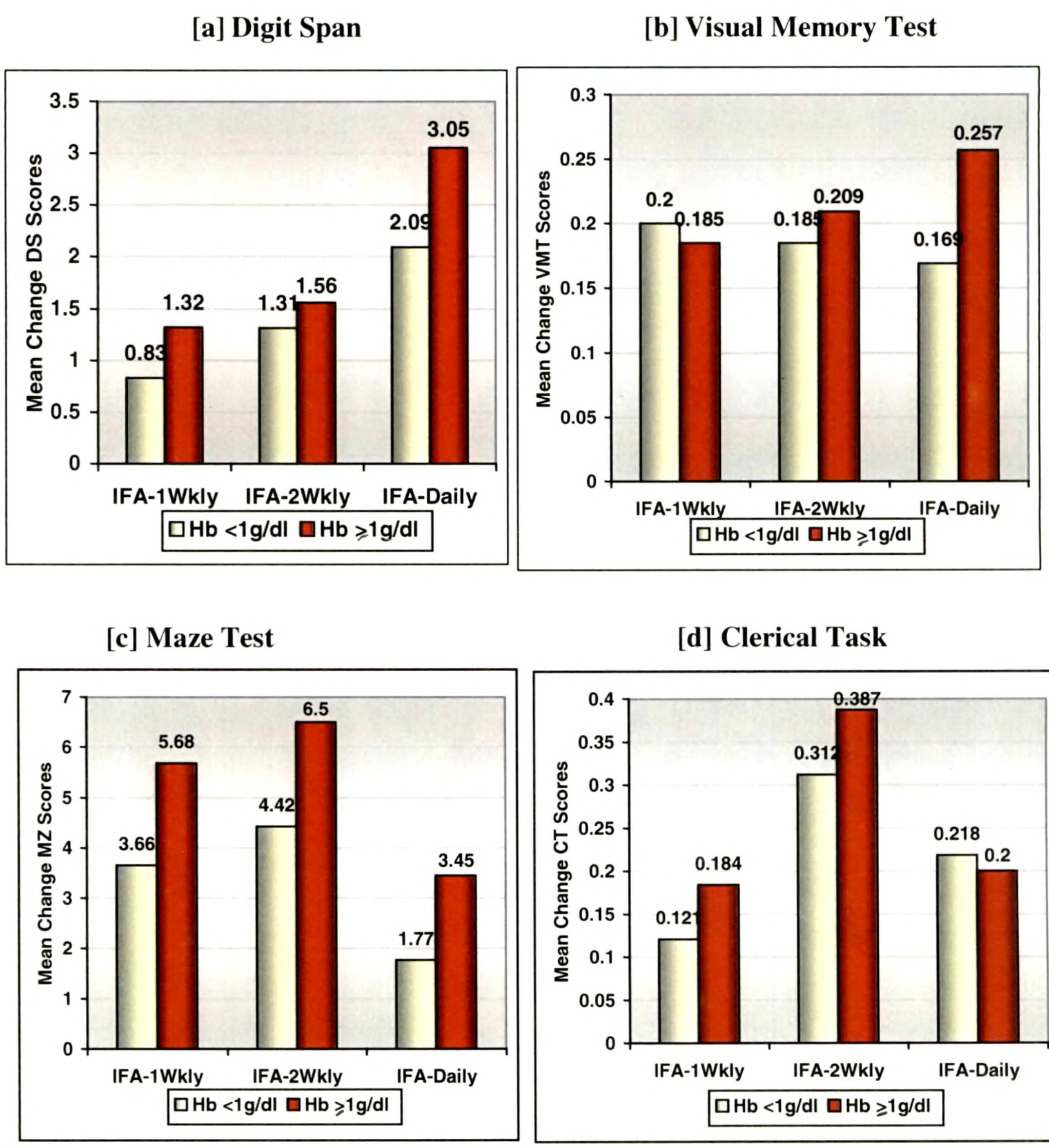
NS Non Significant, $*p<0.05$, $**p<0.01$, $***p<0.001$

Did The Extent Of Hemoglobin Gain Influence The Gain in Cognitive Function Test Scores?

The **Figure 4.3.26** illustrates and compares the increase in the mean cognitive function tests scores among those who gained ≥1 g/dl Hb vs. those who gained < 1g/dl Hb after the intervention. In all the CF tests, the scores were higher among those who gained more than 1 g/dl of Hb than those who gained less, however these differences were not significant.

Within those who gained higher extent of Hb, IFA-2Wkly and IFA-Daily had better improvement in scores than IFA-1Wkly. IFA-2Wkly had significantly better scores than IFA-Daily in two of the four tests (**Table 4.3.24**).

Figure 4.3.26: Mean Change In Cognition Test Scores In The School Girls Who Gained ≥1 g/dl vs. <1g/dl Hemoglobin After the Intervention



Gained ≥1 g/dl Hb vs. <1g/dl Hb: t value, all groups: non-significant

Table 4.3.24: Mean Change In Cognition Test Scores In Girls Who Gained ≥1 g/dl vs. <1g/dl Hemoglobin After the Intervention

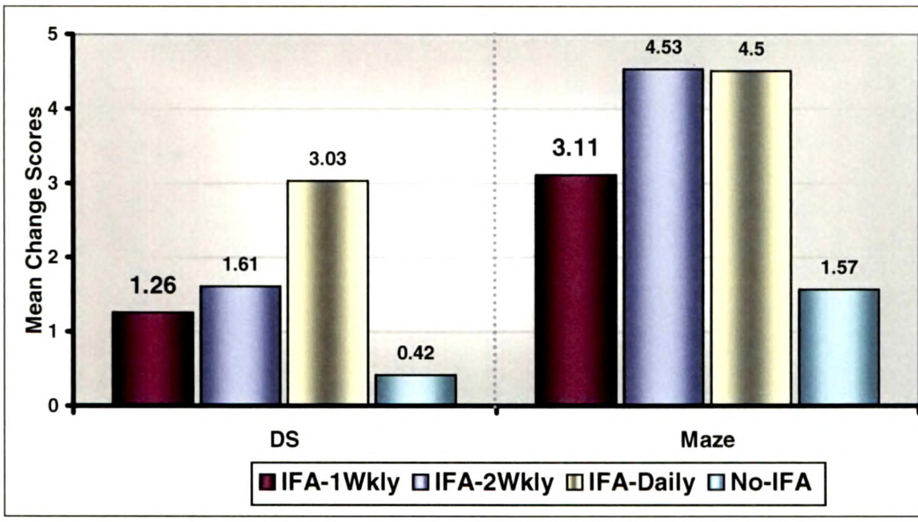
Study Groups	N	Digit Span Test	Visual Memory Test	Maze Test	Clerical Task
		Mean change ± SD	Mean change ± SD	Mean change ± SD	Mean change ± SD
Gained ≥1 g/dl					
IFA-1Wkly (E1)	19	1.32 ± 1.33	0.185 ± 0.15	5.68 ± 3.51	0.171 ± 0.14
IFA-2Wkly (E2)	16	1.56 ± 1.50	0.209 ± 0.16	6.50 ± 2.87	0.370 ± 0.18
IFA-Daily (ED)	20	3.05 ± 2.43	0.257 ± 0.15	3.45 ± 3.77	0.204 ± 0.16
't' Value					
E1 vs E2:		0.48 NS	0.45 NS	0.74 NS	3.38***
E1 vs ED:		2.70*	1.49 NS	1.86 NS	0.66 NS
E2 vs ED:		2.20*	0.91 NS	2.68 *	2.69*
Gained <1g/dl					
IFA-1Wkly (E1)	24	0.83 ± 1.57	0.200 ± 0.12	3.66 ± 3.98	0.119 ± 0.11
IFA-2Wkly (E2)	26	1.31 ± 1.15	0.185 ± 0.12	4.42 ± 4.57	0.304 ± 0.21
IFA-Daily (ED)	22	2.09 ± 1.54	0.169 ± 0.15	1.77 ± 2.38	0.228 ± 0.13
't' Value					
E1 vs E2:		1.22 NS	0.45 NS	0.62 NS	3.81**
E1 vs ED:		2.71*	0.77 NS	1.93 NS	3.01 **
E2 vs ED:		1.92 NS	0.41 NS	2.52 *	1.50 NS

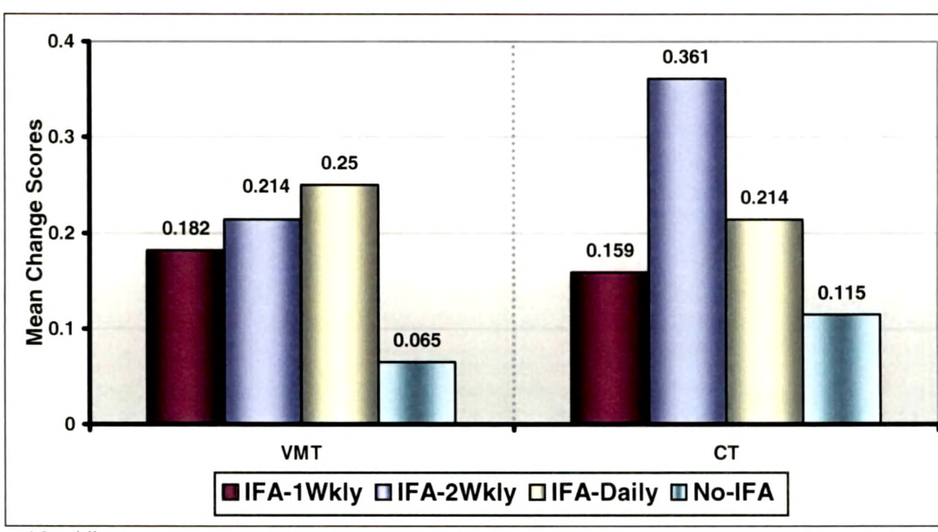
NS Non Significant, *p<0.05, **p<0.01, ***p<0.001

Impact On The Cognitive Test Scores Of The Initially Anemic Girls After The Intervention

Only initially anemic girls were compared among the four groups (**Figure 4.3.27**). When anemic girls were compared, the trend was similar as in the total sample i.e. IFA-Daily and IFA-2Wkly groups showed higher increments compared to once weekly group and controls.

Figure 4.3.27: Mean Change in Cognitive Function Test Scores In Initially Anemic[1] Girls





[1]Hb <12 g/dl

Comparison of Cognitive Function Test Scores of Low-Income Group Girls with High-Income Group Girls

The cognitive function test scores of the girls from the four Municipal Primary schools were compared with the cognitive function test scores of the girls from a High-Income Group (HIG) school. In the HIG, the median test scores of the girls who were non-anemic and had BMI within 18 to 22 kg/m^2 were selected, to serve as an operational standard to compare with the cognitive function test scores of the LIG girls.

Figure 4.3.28 to **Figure 4.3.31** compares the mean scores of the four tests obtained pre and post intervention in the four groups against the HIG scores. In all the four tests, the IFA-Daily group, post intervention came close to matching the HIG scores; followed by IFA-2Wkly. the impact was more marked in three of the four tests (VMT, CT and maze compared to Digit Span).

Figure 4.3.28: Mean Digit Span Test Scores Before and After The Intervention: Comparison Between HIG and LIG Girls

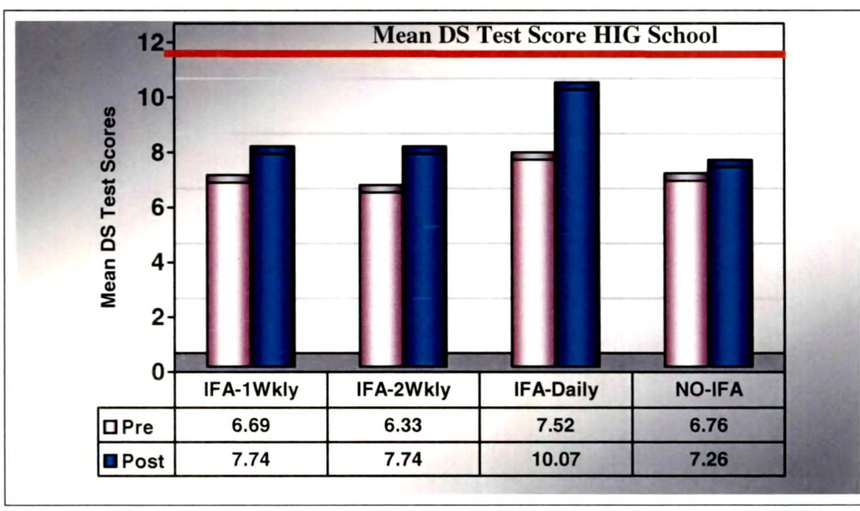


Figure 4.3.29: Mean Visual Memory Test Scores Before and After The Intervention: Comparison Between HIG and LIG Girls

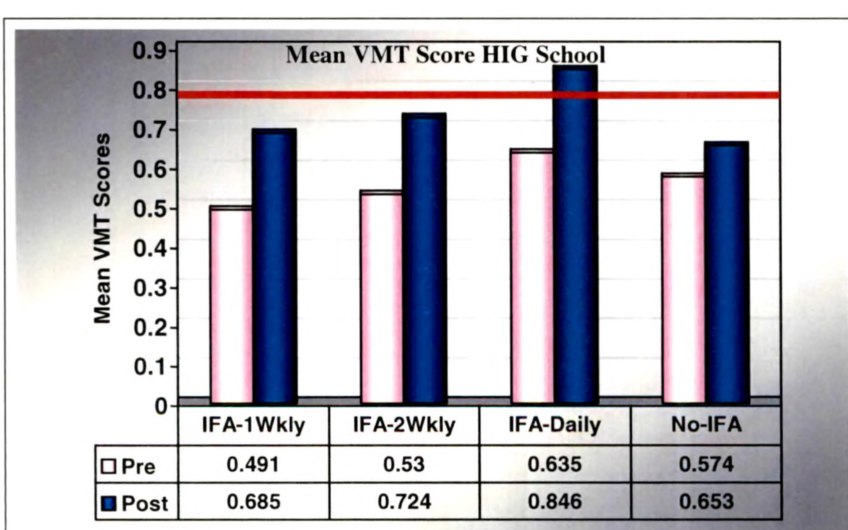
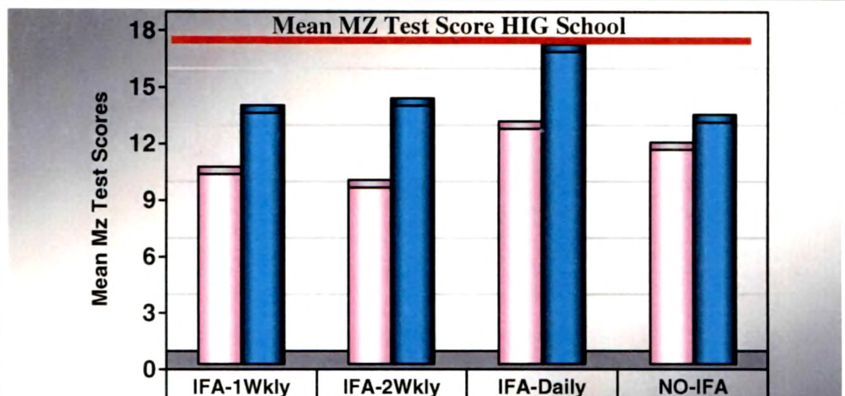
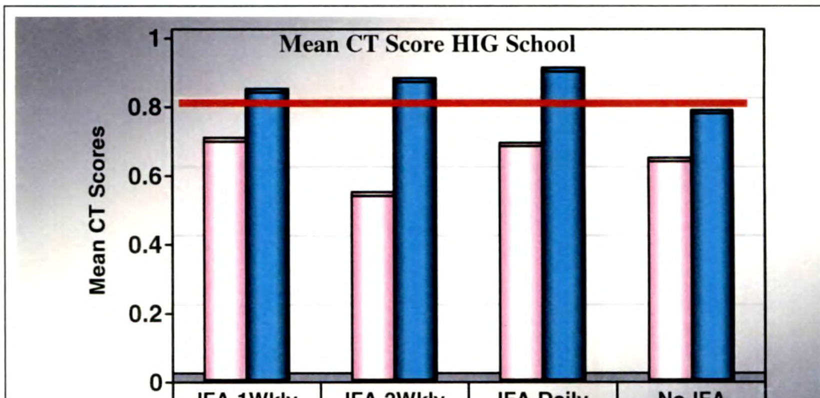


Figure 4.3.30: Mean Maze Test Scores Before and After The Intervention: Comparison Between HIG and LIG Girls



	IFA-1Wkly	IFA-2Wkly	IFA-Daily	NO-IFA
Pre	10.09	9.38	12.5	11.38
Post	13.34	13.71	16.57	12.85

Figure 4.3.31: Mean Clerical Task Scores Before and After The Intervention: Comparison Between HIG and LIG Girls



	IFA-1Wkly	IFA-2Wkly	IFA-Daily	No-IFA
Pre	0.692	0.534	0.678	0.634
Post	0.834	0.865	0.895	0.773

Discussion

In brief, the findings indicate that daily and twice weekly iron folate supplementation is comparable as regards significant impact on cognitive functions of girls in the pubertal phase of development. Once-weekly IFA consistently performed less satisfactorily in all the cognitive function tests. The girls with good compliance showed a similar trend. Further, higher extent of Hb gain seems to have better impact on cognitive function test scores. In all the CF tests, the scores were higher among those who gained more than 1 g/dl of Hb than those who gained less. Similarly, initially anemic girls benefited more from the more frequent dose regimens with daily supplementation showing better impact.

When supervised trials and ensuring compliance may not be feasible, daily IFA supplementation may be more beneficial with regard to improvements in cognitive functions in this age group. But if compliance can be ensured in a school setting (e.g. with help of class monitors and sensitization of the teachers) the IFA-2Wkly regimen may show good impact at less cost and greater sustainability.

Yehuda and Youdim (1989) reported that those who receive iron for iron deficiency anemia commonly report improved memory, attention, mood, and higher levels of energy before any improvement in hemoglobin indices occurs. Our findings of the study also report that daily and intermittent iron folate supplementation improved short-term memory, attention and concentration of girls in the pubertal phase of development. The beneficial impact is especially enhanced if the compliance to IFA tablets is improved.

Available literature shows that the intake of macro- and micronutrients may have individual and/or interactive effects on brain and cognitive development. Cross-sectional studies indicate that there are associations between stunting, IQ, and school performance in children after controlling for key confounding factors such as socioeconomic variables (Grantham-McGregor 1993, Upadhayay et al 1995).

Literature relating to functional benefits of IFA interventions (such as cognitive abilities) among young adolescents is limited. Studies done in Indonesia in late 80's concluded that daily iron folate supplementation to anemic school children significantly improved the learning-achievement scores after three months (Soemantri, Pollitt and Kim 1985, Soemantri 1989). In one study the positive effect of iron treatment on learning in the anemic group was observed in four subject areas and among non-anemics, in two subject areas.

In another double-blind clinical trial in Indonesia on preschoolers, iron deficient preschool children (n=70) in experimental group received 50 mg elemental iron for 8 weeks; the control group received a placebo (Soewonda, Husaini and Pollitt 1989). From the pre- and post treatment psychological test data the authors concluded that IDA produces alterations in cognitive processes related to visual attention and concept acquisition, and these alterations reversed with iron treatment.

Pollitt et al (1989) conducted a double-blind clinical trial in Thailand to assess the impact of iron treatment on the IQ and educational attainment of 9-11 yr old children (n=1358) of 16 elementary schools. The children were classified into iron-replete, iron-depleted and iron deficient anemic. The Raven Progressive Matrices were used to measure IQ. A Thai language and a math test were administered to assess school attainment. A 50-mg/d tablet of ferrous sulphate was given for 2 weeks and a 100 mg/day tablet, for remaining 14 weeks. Another group received a placebo containing sweet cassava powder. An anthelminthic drug was given on the day of the blood test before treatment and 3 month after the intervention started. There was evidence of a positive association between iron status, IQ and language school achievement test.

Seshadri and Gopaldas (1989) reported four studies in India assessing the impact of iron-folic acid supplementation on cognitive performance of Vadodara School going boys and girls aged 5-8 years (2 studies) and 8-15 years (2 studies). All the studies used WISC subtests to measure the cognitive abilities. All the four studies showed clear and significant benefit in every parameter of iron status as well as in WISC scores in the anemic group. This suggested that mental abilities like attention, memory, and concentration may respond to iron supplementation.

A study conducted among Indonesian children with an aim to assess the effect of energy and micronutrient supplementation on iron deficiency anemia, physical activity and motor and mental development, supplemented children with 12 mg of iron and energy for 6 months (Harahap et al 2000). Children who received energy and micronutrient supplement (1171KJ + 12 mg iron) had higher scores in the Bayley scale of mental and motor development, and showed more matured social cognitive and emotional regulatory behaviour. Anemic children showed greater improvement than non anemic children in motor development.

In rural India, Varanasi, a study was conducted on school children (6-8 years) over a period of one year (170 working days) to study the impact of iron supplementation (Iron syrup: ferrous gluconate 200 mg) on mental function and academic performance (Agarwal, Upadhyay, Tripathi and Agarwal 1987). Tests such as object assembly and digit span showed significant improvements post intervention. Kanani, Singh and Zutshi (1999) reported a positive impact of iron folate supplementation on cognitive abilities of school children in Vadodara, India. On supplementing girls (9 – 15 yrs) with 60 mg elemental Fe + 0.5 mg folic acid for 3 months, there was a significant increase in selected cognitive tests, compared to the baseline values. These findings are in agreement to those in the present study; that is, cognitive functions improved after iron supplementation.

A double blind, placebo-controlled clinical trial in Baltimore high school assessed the effects of iron supplementation on cognitive function in adolescent girls (n=73) with non-anemic iron deficiency (serum ferritin $\leq$12 μg/L with normal Hb). Girls were randomly assigned oral ferrous sulphate (650 mg twice daily) or placebo for 8 weeks. Post intervention, girls receiving iron performed better on a test of verbal learning and memory than girls in the control group ($p<0.02$) (Bruner et al 1996). However, iron treatment had no effect on the three measures of attention. It was concluded that, even in the absence of anemia, iron supplementation improves some aspects of cognitive functioning in iron-deficient adolescent girls.

Moreover, in the present study the CF test scores of the intervened initially anemic girls increased and were better compared to control group, post intervention. Anemic girls who received either daily or twice a week iron folate tablets scored significantly better in all the CF tests than controls. Within the intervened initially anemic girls, daily supplementation group had significantly better impact with regard to improvement in short-term memory (DS test) and concentration (CT) test scores after the intervention than twice weekly and once a week groups.

Further, higher magnitude of gain in Hb resulted in higher gain in CF test scores, again revealing importance of reducing anemia to improve cognition. Findings from other literature also report that iron supplementation among iron-deficient anemic children benefits learning process as measured by school achievement test scores (Soemantri, Pollitt and Kim 1985, Soemantri 1989).

In a blinded, placebo-controlled, stratified intervention study involving 149 women aged 18-35 years of varied iron status, results suggested that iron status is associated with cognitive performance (Murray-Kolb and Beard 2007). The participants were randomized to receive iron supplements (160 mg ferrous sulfate containing 60 mg elemental iron) or placebo daily for 16 weeks. At intervention end, a significant improvement in serum ferritin was associated with a 5-7-fold improvement in cognitive performance. Additionally, a significant improvement in hemoglobin was associated with an improvement in the speed of completion of cognitive tasks. Thus, it was concluded that iron status is a significant factor in cognitive performance in women of reproductive age. Severity of anemia primarily affects processing speed, and severity of iron deficiency affects accuracy of cognitive function over a broad range of tasks.

Thus, the effects of iron deficiency on cognition are not limited to the developing brain during infancy.

In Baltimore a random double blind trial was conducted on 25 pregnant women (14 – 24 yrs) coming for prenatal care at or before 16 weeks gestation whose hematocrit was ≥31%. One group received prenatal vitamins + iron (60 mg elemental Fe) daily for one month; the other was given prenatal vitamins alone. The treatment group given iron showed significant improvement in some measures of attention span and short-term memory, including the digit symbol test (Groner, Holtzman, Charney and Mellits 1986). However, they found no correlation between any hematologic measure and any of the phychometric test scores, either initially or after one month. They reasoned that this might be due to the fact that the population was not particularly iron-deficient and had already consumed iron tablets prior to their enrolment in this particular study and concluded that had they started with a more iron-deficient sample, more striking effects might have been found.

Thus, to improve cognition, twice weekly IFA, is superior to once weekly IFA and at less cost and greater feasibility, and is likely to show a similar impact as daily IFA supplementation. Supervised supplementation, an important aspect of intermittent dosing, is feasible in school settings with active participation of class monitors, teachers. Further, young adolescent girls are accessible in primary schools which have high enrolment rates (compared to secondary schools) enabling higher coverage and better impact at less cost.

Impact on Physical Work Capacity as measured by Modified Harvard Step Test (MHST)

Did iron folate supplementation improve physical work capacity (PWC) of young school going girls? It is important to find out the impact of IFA on PWC of underprivileged young adolescent girls, who are expected to perform demanding household work and meet school demands as well. In the present study, the girls performed the Modified Harvard Step Test (MHST) before and after the supplementation program. The following tables and figures present the results on the impact of IFA on PWC of young adolescent school going girls.

Mean Change in Physical Work Capacity

Table 4.3.25 shows the mean change in the number of steps climbed and recovery time (RT) of the girls receiving various IFA regimens. The mean steps climbed were higher in all ES groups than in CS group. The mean increase in number of steps climbed was significantly higher among ES groups (21 to 29 steps) than in CS group (13 steps). The mean value increased with increase in the frequency of IFA tablets consumed, highest being in IFA-Daily, followed by IFA-2Wkly and IFA-1Wkly. The mean increment was lowest in No-IFA group after a period of a year. The mean increment in number of steps climbed in IFA-Daily and IFA-2Wkly were more than double than that in No-IFA group.

Within the supplemented groups, IFA-Daily girls had significantly higher ($p<0.05$) increase in number of steps climbed than IFA-1Wkly, but it was comparable to IFA-2Wkly. Therefore, while it is clear that girls receiving daily IFA dose climbed more number of steps in three minutes than others, however, twice weekly IFA was not far behind daily IFA as regards impact.

Table 4.3.25: Change in Mean Number Of Steps Climbed[1] and RT[2] (in min) After MHST After the Intervention: Level of Significance Between The Groups

Study Groups	Number Of Steps Climbed [1]		Recovery Time[2]	
	N	Mean change ± SD	N	Mean change ± SD
IFA-1Wkly (E1)	43	21 ± 13.53	43	-0.12 ± 0.73
IFA-2Wkly (E2)	42	27 ± 21.33	42	-0.17 ± 0.73
IFA-Daily (ED)	44	29 ± 15.61	44	-0.48 ± 0.73
No-IFA (CS)	34	13 ± 16.26	34	0.06 ± 0.60
't' Value:				
E1 vs CS:		2.28*		1.17 NS
E2 vs CS:		3.21**		1.49 NS
ED vs CS:		4.34***		3.54***
E1 vs E2:		1.53 NS		0.31 NS
E1 vs ED:		2.53*		2.27*
E2 vs ED:		0.49 NS		1.95 NS

[1]Number of Steps Climbed, [2]Recovery time (in min), NS Non Significant, *p<0.05, **p<0.01, ***p<0.001

Recovery time (RT) is the time taken (in min) to revert back to the basal pulse rate after a heavy exercise, in this case the MHST. The longer it takes to revert back to basal pulse rate; poorer is the physical work capacity. Therefore after an intervention with IFA tablets, if it has a beneficial impact, post intervention the RT should be less than the RT before the intervention. Therefore the negative sign '-' shows a decrease in the RT, which was desired, after the intervention. The mean RT was about 3 minutes before the intervention, which reduced to 2.5 minutes in IFA-2Wkly and IFA-Daily (**Table 4.3.25**). The extent of reduction became better as the frequency of dosing increased. The RT in IFA-1Wkly and No-IFA group was negligible.

The improvement in recovery time (RT), i.e. decrease in RT was significantly better in IFA-Daily than No-IFA group. Although there was decrease in RT in IFA-2Wkly and IFA-1Wkly, this was not significantly better than No-IFA. There was slight increase in the RT of the girls in No-IFA group. Thus, although single or twice weekly doses reduced the RT, a daily dose seems to more efficiently reduce the RT to the basal pulse rate after the step test among the girls.

Comparison of Younger and Older Girls

Among younger and older girls, the mean increment followed a similar trend as total sample. On comparing older and younger girls, it was seen that the mean increase in steps climbed was higher among older girls, especially among IFA-2Wkly and IFA-Daily groups, perhaps because they were climbing fewer steps at baseline. With regard to recovery time, the trend was similar among younger and older girls, where girls from IFA-Daily showed highest reduction in RT. Moreover, among younger and older girls, the reduction in RT was highest among older girls receiving daily doses of IFA tablets (-1.00 min).

Table 4.3.26: Mean Change in Number of Steps Climbed and Recovery Time (in min) After MHST in Younger and Older Girls After the Intervention

Study Groups	Younger girls (9 – 11 yrs)				Older Girls (12 –13 yrs)				Total (9-13 yrs)			
	N	Initial Mean ± SD	Final Mean ± SD	Mean change ± SD	N	Initial Mean ± SD	Final Mean ± SD	Mean change ± SD	N	Initial Mean ± SD	Final Mean ± SD	Mean change ± SD
Number of Steps												
IFA-1Wkly	34	172 ± 26.0	193 ± 23.8	21 ± 14.5	9	160 ± 19.9	185 ± 21.0	25 ± 8.7	43	169 ± 25.1	191 ± 23.3	21 ± 13.5
IFA-2Wkly	37	182 ± 41.7	208 ± 40.6	26 ± 22.4	5	159 ± 11.4	191 ± 12.7	32 ± 9.1	42	179 ± 48.6	206 ± 30.9	27 ± 21.3
IFA-Daily	39	189 ± 32.7	218 ± 27.5	29 ± 16.3	5	179 ± 34.2	210 ± 32.3	31 ± 8.0	44	188 ± 32.6	217 ± 27.7	29 ± 15.6
No-IFA	30	178 ± 26.4	190 ±23.9	12 ± 15.8	4	169 ± 16.3	187 ± 28.9	18 ± 21.1	34	177 ±25.4	190 ± 20.7	13 ± 16.2
(F-value)				5.66**				1.17^{NS}				6.80***
Recovery Time (RT)												
IFA-1Wkly	34	3.91 ± 0.83	3.79 ± 1.06	-0.12 ± 0.77	9	3.77 ± 0.83	3.66 ± 0.50	-0.11 ± 0.60	43	3.88 ± 0.82	3.76 ± 0.97	-0.12 ± 0.73
IFA-2Wkly	37	2.73 ± 0.96	2.56 ± 0.64	-0.16 ± 0.72	5	3.00 ± 1.22	2.80 ± 0.83	-0.20 ± 0.83	42	2.76 ± 0.98	2.59 ± 0.66	-0.17 ± 0.73
IFA-Daily	39	2.89 ± 0.91	2.48 ± 0.68	-0.41 ± 0.72	5	3.60 ± 0.89	2.60 ± 0.54	-1.00 ± 0.71	44	2.98 ± 0.92	2.50 ± 0.67	-0.48 ± 0.73
No-IFA	30	2.96 ± 0.72	3.00 ± 0.69	0.03 ± 0.55	4	3.75 ± 0.50	4.00 ± 0.81	0.25 ± 0.95	34	3.05 ± 0.73	3.11 ± 0.76	0.06 ± 0.60
(F-value)				2.42^{NS}				2.42^{NS}				4.01**

^{NS}non significant, *p < 0.05, **p < 0.01, ***p<0.001

Table 4.3.26 compares the younger and older girls. As regards mean increase in number of steps climbed, the trends seen were similar as in total sample, i.e. the mean steps climbed were higher in all ES groups than in CS, and within ES, the mean value increased with increase in the frequency of IFA tablets consumed. As regards RT again, the extent of reduction was highest in daily group, and became better as the frequency of dosing increased. In general, the older girls showed a better impact both in terms of number of steps climbed and reduction in recovery time than younger counterparts.

Did the Level Of Compliance Influence The Impact Of Iron Supplementation?

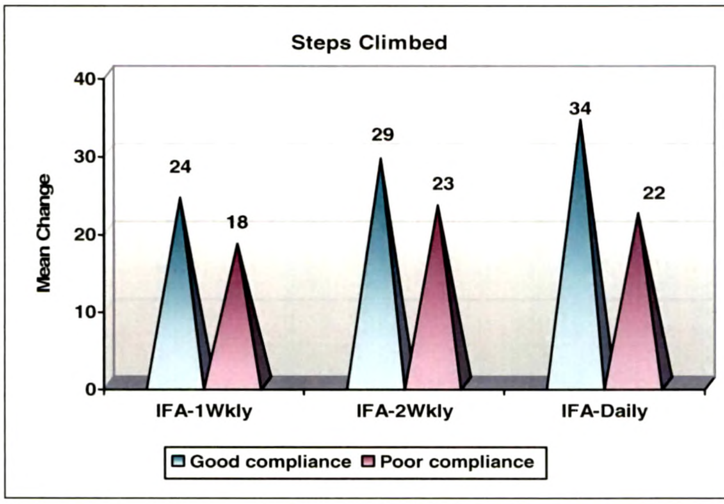
Not surprisingly, girls with good compliance showed better impact than those with poor compliance (**Figure 4.3.32**). Comparing the treatment groups, within good compliance, the increment in number of steps climbed was highest in IFA-Daily and was significantly better than IFA-1Wkly (**Table 4.3.27**). Twice weekly was better than to IFA-1Wkly. However, as regards improvement in RT, within the good compliance group, reduction in RT was better in IFA-Daily compared to IFA-2Wkly and IFA-1Wkly.

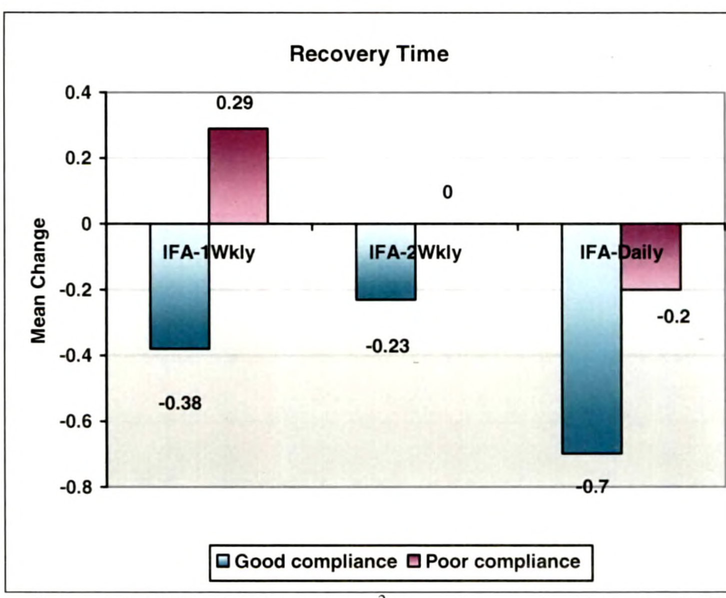
Table 4.3.27: Mean Change in Steps Climbed and Reaction Time (in min) After MHST with Good Compliance[1]

Study Groups		Steps	RT
	N	Mean change ± SD	Mean change ± SD
IFA-1Wkly (E1)	26	24 ±14.34	-0.38 ± 0.69
IFA-2Wkly (E2)	30	29 ±24.69	-0.23 ± 0.77
IFA-Daily (ED)	27	34 ±14.35	-0.70 ± 0.77
't'Value E1vs E2:		0.92^{NS}	0.75^{NS}
E1 vs ED:		2.47*	1.56^{NS}
E2 vs ED:		0.93^{NS}	2.26*

[1]Compliance of ≥ 70% of IFA Tablets, ^{NS}Non Significant, *p<0.05

Figure 4.3.32: Mean Change in Steps Climbed and Reaction Time (in min) After MHST with Good[1] And Poor[2] Compliance





[1]Compliance of ≥70% of IFA Tablets, [2]Compliance of <70% of IFA Tablets

Did The Extent Of Hemoglobin Gain Influence The Impact on Physical Work Capacity?

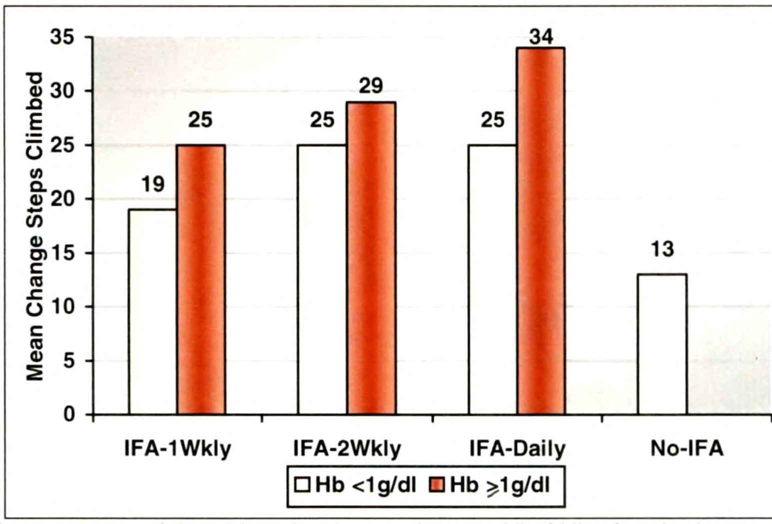
Figure 4.3.33 shows the mean increase in the number of steps climbed by the girls in the intervened girls and controls depending on the magnitude of their Hb gain. The mean increase in the number of steps climbed was higher among those who gained Hb levels ≥1 g/dl compared to those with Hb increase <1 g/dl, the difference being significant in IFA-2Wkly and IFA-Daily groups (**Table 4.3.28**). In the group which gained ≥1 g/dl Hb, the change in the number of steps climbed was highest in IFA-Daily, (which was significantly better than IFA-1Wkly group), followed by IFA-2Wkly and then IFA-1Wkly groups. The trends were similar when only good compliance girls were considered (**Figure 4.3.34**).

Table 4.3.28: Mean Change in Steps Climbed and Recovery Time (in min) In Girls who gained ≥1 g/dl vs. <1g/dl Hb after the Intervention

Study Groups	Hb Gain <1 g/dl		Hb Gain ≥1 g/dl		't' test
	N	Mean change ± SD (A)	N	Mean change ± SD (B)	A vs. B
Number Of Steps Climbed					
IFA-1Wkly (E1)	24	19 ± 15.70	19	25 ± 9.33	1.61 NS
IFA-2Wkly (E2)	26	25 ± 23.06	16	29 ± 18.69	0.51 NS
IFA-Daily (ED)	24	25 ± 13.58	20	34 ± 16.53	2.16*
't' Value:					
E1 vs E2:		1.06 NS		0.75 NS	
E1 vs ED		1.39 NS		2.05*	
E2 vs ED:		0.00 NS		0.81 NS	
Recovery Time (RT)					
IFA-1Wkly (E1)	24	0.04 ± 0.69	19	-0.32 ± 0.75	1.62 NS
IFA-2Wkly (E2)	26	0.03 ± 0.52	16	-0.50 ± 0.89	2.46*
IFA-Daily (ED)	24	-0.25 ± 0.61	20	-0.75 ± 0.78	2.37*
't' Value:					
E1 vs E2:		0.06 NS		0.62 NS	
E1 vs ED		1.51 NS		1.71 NS	
E2 vs ED:		1.70 NS		0.86 NS	

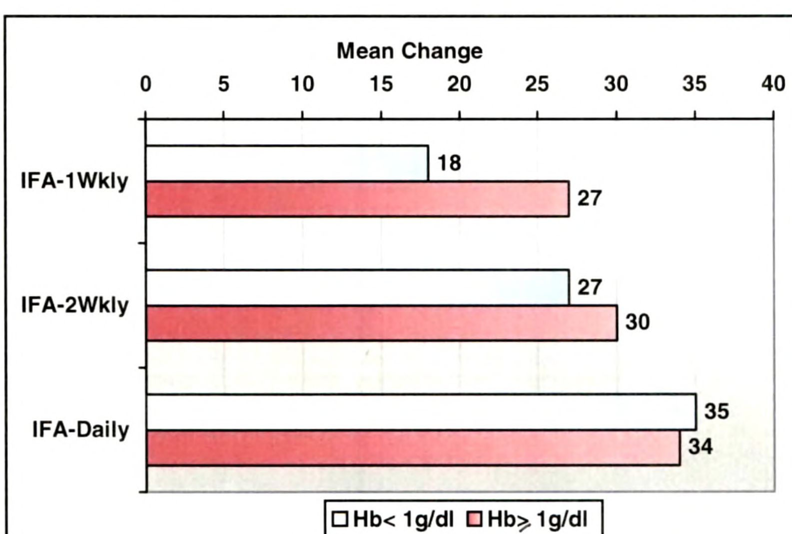
Note: In CS group none of the girls gained more than 1 g/dl of Hb after the intervention.
NS non significant, *p < 0.05, **p < 0.01, ***p<0.001

Figure 4.3.33: Mean Change in Steps Climbed Among Girls Who Gained ≥1 g/dl vs. <1g/dl of Hemoglobin after the Intervention



Note: In CS group none of the girls gained more than 1 g/dl of Hb after the intervention.
t test value: Within the intervened groups with ≥1 g/dl Hb gain: IFA-Daily vs. IFA-1Wkly: $p<0.05$, t test value: all remaining groups: $p>0.05$

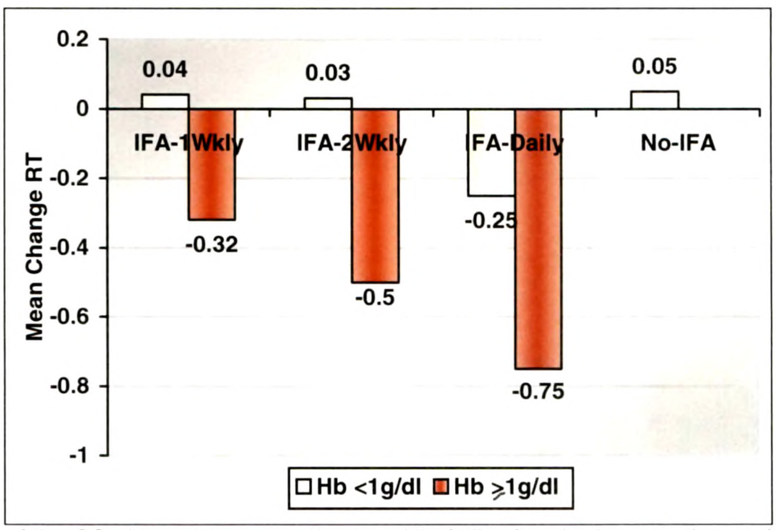
Figure 4.3.34: Mean Change in Steps Climbed Among Girls Who Gained ≥1 g/dl vs. <1g/dl of Hemoglobin after the Intervention: Good[1] Compliance Group



[1]Compliance of ≥70% of IFA Tablets

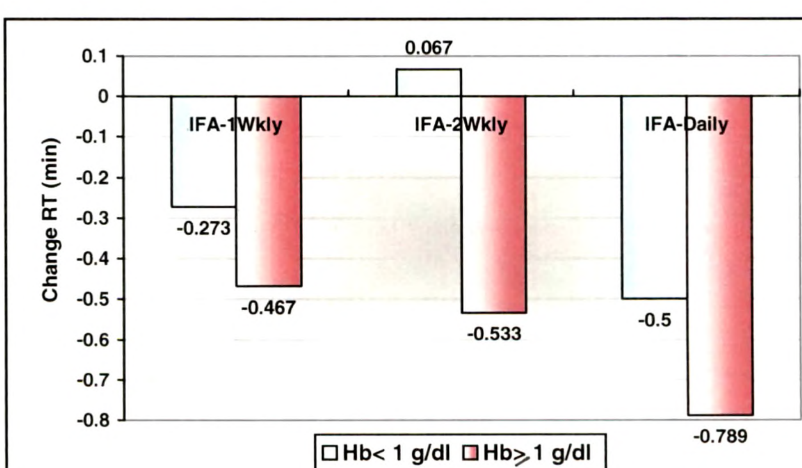
On comparing the change in the recovery time, it was clear the decline in the RT was higher amongst those who showed higher Hb increments (**Figure 4.3.35**). Further, more frequent the dosing, better the impact. Again, these trends were also seen in the good compliance group (**Figure 4.3.36**).

Figure 4.3.35: Mean Change in Recovery Time in the School Girls Who Gained ≥1 g/dl vs. <1g/dl Of Hemoglobin After the Intervention



Note: None of the CS girls gained more than 1 g/dl of Hb after the intervention period of 1 year
t test value: Within the intervened groups: all groups: $p > 0.05$

Figure 4.3.36: Mean Change In Steps Climbed and Recovery Time In Girls Who Gained ≥1 g/dl vs. <1g/dl of Hb Levels Among Good[1] Compliance Group



[1]Compliance of ≥70% of IFA Tablets

Table 4.3.29 shows that given good compliance, all intervention groups showed similar impact (not significant different from one another). One exception was with regard to increase in steps climbed in IFA-Daily compared to IFA-1Wkly, which was significant in the girls who gained <1 g/dl Hb.

Table 4.3.29: Mean Change in Steps Climbed and Recovery Time (in min) In Girls Who Gained ≥1 g/dl vs. <1g/dl Hb In Good[1] Compliance Group

Study Groups	Number Of Steps Climbed				Recovery Time (RT)			
	Hb Gain <1 g/dl		Hb Gain ≥1 g/dl		Hb Gain <1 g/dl		Hb Gain ≥1 g/dl	
	N	Mean change ± SD	N	Mean change ± SD	N	Mean change ± SD	N	Mean change ± SD
IFA-1Wkly (E1)	11	18 ± 19.43	15	27 ± 9.07	11	-0.27 ± 0.64	15	-0.46 ± 0.74
IFA-2Wkly (E2)	15	27 ± 27.66	15	30 ± 19.11	15	-0.06 ± 0.45	15	-0.53 ± 0.91
IFA-Daily (ED)	8	35 ± 7.70	19	34 ± 16.56	8	-0.50 ± 0.75	19	-0.78 ± 0.78
't' Value:								
E1vs E2:		0.94^{NS}		0.53^{NS}		1.44^{NS}		0.21^{NS}
E1 vs ED:		2.50*		1.52^{NS}		0.65^{NS}		1.19^{NS}
E2 vs ED:		1.01^{NS}		0.62^{NS}		1.84^{NS}		0.84^{NS}

[1]Compliance of (70% of IFA Tablets, NSnon significant, *p<0.05, **p < 0.01, ***p<0.001

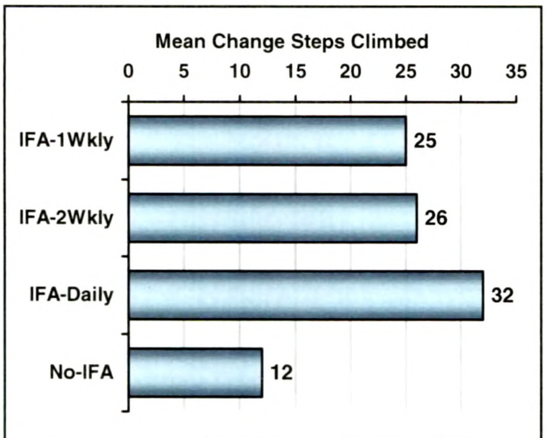
Relationship between Initial Hemoglobin Status and Physical Work Capacity

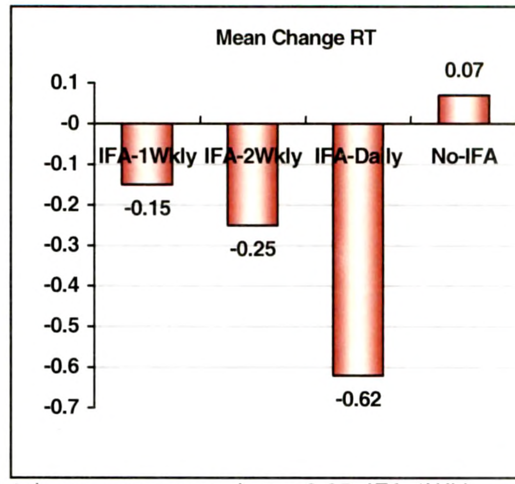
The girls were categorized according to their initially Hb status as anemic (Hb <12 g/dl) and non-anemic (Hb ≥12 g/dl) girls. Only the initially anemic girls were compared between the different intervention groups.

How significant was the impact when one group was compared with another?

The mean increase in the number of steps climbed among anemic (Hb <12 g/dl) girls in all ES groups was significantly better than in CS (**Figure 4.3.37**). Within the intervened groups, increase in number of steps in IFA-Daily was significantly higher than in IFA-1Wkly. However, the differences in the increase in steps among anemic girls in IFA-2Wkly and IFA-1Wkly were non-significant.

Figure 4.3.37: Mean Change In Number of Steps Climbed and Recovery Time In Initially Anemic[1] Girls After the Intervention

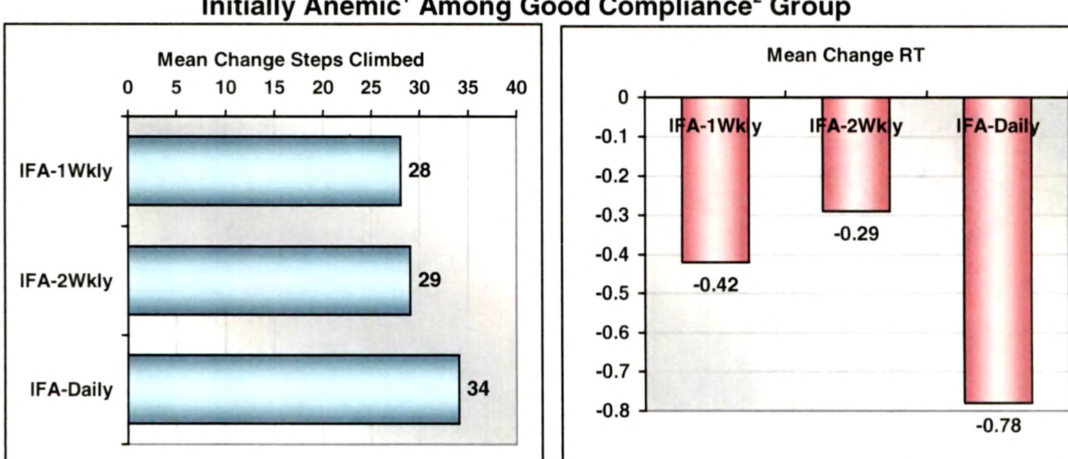




[1]Hb < 12 g/dl,
t test value: Number of steps climbed Experimental groups vs. controls: p< 0.05, IFA-1Wkly vs IFA-2Wkly: p<0.05, t test value: RT IFA-Daily vs. control: p<0.001, IFA-Daily vs IFA-2Wkly and IFA-1Wkly: p<0.05, t test value: Remaining groups: p>0.05

In terms of change in recovery time, only those who received daily doses and were initially anemic showed significant decrease in the RT compared to No-IFA, and other groups. Therefore, daily supplementation of iron folate tablets significantly improved the work capacity among anemic girls in terms of increase in number of steps climbed and decrease in recovery time.

Figure 4.3.38: Mean Change In Number of Steps Climbed and Recovery Time In Initially Anemic[1] Among Good Compliance[2] Group



[1]Hb < 12 g/dl, [2]Compliance of ≥ 70% of IFA tablets, t value RT: IFA-2Wkly vs IFA-Daily: p< 0.05

Did the Level Of Compliance Influence The Impact of Iron Supplementation?

The mean increase in the number of steps climbed amongst the anemic girls with good compliance was compared (**Figure 4.3.38**). In all the experimental groups, anemic girls seem to have benefited in terms of increase in the number of steps climbed and this difference was not significant. A similar trend was seen as regards decrease in the recovery time. However, lowest RT was seen in IFA-Daily group i.e. maximum improvement was in IFA-Daily group, which was significantly better than IFA-2Wkly group.

Discussion

Summing up this section, all girls supplemented with IFA showed significantly higher increase in the number of steps climbed than did the controls. Relatively, girls receiving higher frequency of doses showed better impact. The IFA-Daily group showed the maximum impact followed closely by IFA-2Wkly. A similar trend was seen in terms of improvement (reduction) in recovery time (RT). In girls who showed good compliance (more than 70% of the dose), the increase in number of steps climbed and RT improvement was the highest in the daily IFA group; and this trend was more marked in the anemic girls with good compliance.

Literature reporting impact of iron supplementation on different physical work capacity tests, especially on adolescents and school children, is scanty. Supplementation of 60 mg Fe/day to non-pregnant female workers in Beijing (China) reduced mean heart rate, and increased the production efficiency. Iron supplementation enabled the female workers to do the same work at lower energy cost (Li et al 1994). Edgerton et al (1979) conducted two randomized double-blind placebo-controlled trials in Sri Lanka on 20–60 years old female tea estate workers (n=199, n=18) (Hb: 10.2–11.4 g/dl). The first study group received 200mg $FeSO_4$ for one month and the second study group received 200mg $FeSO_4$ for 3 weeks. There was a net increase of 1.5 g/dl (14%) in Hb level. The amount of tea picked increased by 1.2%. Low Hb was associated with lower productivity over a year. Voluntary activity was higher in iron supplemented group than placebo (40–80%). The heart rates were significantly lower after supplementation.

In Indonesia, in a randomized double-blind placebo-controlled trial on male rubber plantation workers (n=302; Hb: <9.0 to >15.0 g/dl) in the age group of 16–40 years were supplemented with 100 mg $FeSO_4$ (Basta et al 1979). All iron status indicators significantly improved post intervention. Morbidity decreased in both groups, but more among iron treated group. Greatest increase in Harvard Step Test was reported among those most depleted at baseline, in the iron treated group. The increase in productivity was higher in iron treated group than in placebo. It was interesting to note that the physical performance outcomes (e.g. aerobic capacity, endurance or fatigue) were positively related to the social outcomes (e.g., time allocation to child care or social participation). Also these studies showed impact across all levels of iron deficiency: from iron deficiency anemia to iron deficiency without anemia.

Das and Kalita (2003) studied iron deficiency anemia and the productivity of adult coal-mine workers of Assam and supplemented them with IFA for 6 months (group 1 and group 2 respectively receiving 60 mg and 120 mg of ferrous sulphate daily). Iron supplementation significantly improved productivity variables and Hb levels. The number of days worked improved from 18 days to 24 days in 1st group and from 20 days to 25 days in 2nd group. There was also a significant improvement in coal cutting performance and money earning capacity of the workers.

Vijayalakshmi and Selvasundari (1983) supplemented young adult women with 60 mg of iron for 100 days and reported reduced energy expenditure for physical activities like walking, running, climbing, skipping and sweeping. The mean distance covered by anemic women while walking increased from 8 meters/mt to 14 meters/mt after iron supplementation. The exertion on heart as shown through blood pressure and pulse rate, also reduced after supplementation.

In rural Varanasi, UP, India, a study was conducted on school children (6-8 years) over a period of one year (170 working days) to study the impact of iron supplementation (Iron syrup: ferrous gluconate 200 mg) on physical growth, physical stamina, mental function and academic performance (Agarwal et al 1987). The supplementation did not influence the performance of children on the parameters of Harvard step test. The observation for AAPHER subtest (300 meter run cum walk) showed that the mean scores for recovery period were better for the supplemented group than controls.

Studies conducted in this department in Vadodara used Modified Harvard Step Test to assess the work performance of anemic preschool children and reported a significant improvement in the work performance of iron treated subjects compared to controls receiving placebo (Seshadri and Malhotra 1981). A positive impact of iron folate supplementation on physical work capacity of school children was seen in another study on supplementing girls (9 – 15 yrs) with 60 mg elemental Fe + 0.5 mg folic acid for 3 months (Kanani, Singh and Zutshi 1999). There was a significant increase in the number of skips done by the girls using a skipping rope compared to the baseline values. In the present study also physical work capacity improved after iron supplementation, in young adolescent girls.

Arterial oxygen content, oxygen delivery bound to hemoglobin and cardiac output are all key determinants of the amount of work that exercising muscle can do (Beard 2001), which in turn are expected to be related to iron status and hemoglobin levels. One of the key research questions that still remains unresolved is whether there is a linear relationship of iron status to work performance or is there a curvilinear relationship with a plateau? This question is centered on the notion of a critical cut-off value for the severity of anemia above which there is no relationship and below which there is a strong relationship. Viteri and colleagues (Viteri and Torun 1974) used a Harvard Step Test in a laboratory setting and showed that performance was linearly and positively correlated with hemoglobin. In contrast, Gardener and colleagues (Edgerton et al 1981) clearly demonstrated that time to exhaustion for submaximal exercise has a curvilinear relationship to hemoglobin. In animal research studies Finch and Dallman (Finch et al 1979) reported that lower intensity endurance exercise is tightly correlated with tissue iron deficiency where a curvilinear relationship is expected, whereas a brief intense exercise (Harvard Step Test) should be more tightly correlated with severity of anemia.

In the present study, the mean increase in the number of steps climbed among anemic girls in intervened groups was better than in controls. Within the intervened groups, increase in number of steps in IFA-Daily was highest, followed by IFA-2Wkly. The mean increase in the number of steps climbed was higher among those who gained atleast 1 g/dl of Hb level compared to those with less Hb gain, in all groups, with impact again being better with daily supplementation. IFA-2Wkly was comparable to daily under conditions of good compliance. In general, IFA once weekly showed least impact (though better than control) considering the indicators studied.

Dodd, Sheela and Sharma (1992) studied the effect of different level of iron supplementation on the iron status and physical work capacity of 250 anemic (Hb< 12 g/dl) Indian women (non-pregnant and non-lactating) from lower middle-income group – groups were given one elemental iron tablet daily for 10 weeks. The supplements used differed from each other either in their elemental iron content of form of iron: either 25mg or 35mg or 50 mg or 55 mg (time release dose) or 115 mg elemental iron. The performance of the anemic subjects on Harvard Step test showed a significant improvement after iron supplementation. A significant increase in the number of steps taken, decrease in post exercise pulse rate and recovery time was reported irrespective of the dosage of elemental iron used. The authors also suggested that for a better response higher doses of elemental iron might be required.

A study conducted among Indonesian undernourished children to assess the effect of energy and micronutrient supplementation on iron deficiency anemia, physical activity and motor and mental development showed greater improvement in anemic children than non anemic (Harahap et al 2000). The three treatment groups received: a high energy nutritional supplement + micronutrient supplement (1171 KJ + 12 mg Fe), micronutrient supplement + skimmed milk (209 KJ + 12 mg Fe) and a skimmed milk supplement (104 KJ + 0 iron) for 6 months. The authors concluded that the micronutrient supplement or iron in particular, increased motor activity in children who were iron deficient and anemic.

It appears therefore that not just preschool children, but even older children and young adolescents benefit from iron folate supplementation; not only with regard to their hemoglobin status, but also better work capacity. Daily as well as twice weekly supplementation has functional benefits on PWC. Once weekly IFA supplementation does not seem to suffice the iron needs so as to show significant improvement in physical work capacity. Therefore, whether intermittent (twice weekly) or daily, IDA control programs should be initiated early in school not only to improve anemic status, but also to enhance their physical work capacity.